American Foundation for the Blind

Research Bulletin 28

October 1974

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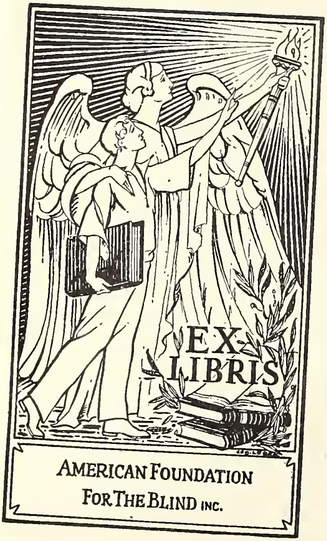
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American Foundation for the Blind

Research Bulletin

28

October 1974

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The *Research Bulletin* is a publication of the International Research Information Service (Leslie L. Clark, Director), American Foundation for the Blind, 15 West 16th Street, New York, New York 10011 USA.

Published irregularly twice a year, the *Research Bulletin* may be purchased for $1.50 per copy. Subscriptions for four issues are $6.00.

Articles in the *Research Bulletin* are abstracted in *Excerpta Medica*, *Psychological Abstracts*, and *Rehabilitation Literature* and by the Swedish Institute for the Handicapped and the Institute for Scientific Information of the U.S.S.R. Academy of Sciences.

Manuscripts and other material to be considered for publication in the *Research Bulletin* should be submitted in duplicate to the editor-in-chief. All correspondence concerning manuscripts, editorial policy, and further information about research reported in the journal should also be directed to the editor-in-chief. A set of guidelines for contributors is available on request.

All correspondence concerning subscriptions and orders for back issues should be sent to the Publications Division of the American Foundation for the Blind. Printed in the United States of America.

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Seminar Report

INFORMATION SERVICES FOR THE VISUAL SCIENCES AND RELATED AREAS

Leslie L. Clark*

The Department of Research of the American Foundation for the Blind (AFB) co-sponsored a documentation conference with the University of Pittsburgh in 1969, focusing on control of the literature on human sensory processes with several purposes in mind[1]. AFB was interested in communicating to the field an interest, dating from 1961, in documentation research; in creating an information system concerned primarily with blindness and visual impairment known to others; and in crystallizing the experience of others (system operators, present and potential) in handling this literature. In those days when large systems in particular were benefitting from the advances made in machine design, participants talked guardedly about the extension of the technology, even to the extent of seriously considering the potentiality of a network, or linkage of large systems to one another in a number of ways. The conference was concerned with defining the nature of the user population, and evaluating the operation of the systems. Concern was focused on what "big" system operators could give by way of advice to "small," or specialized system operators.

Since that time, the growth of the large systems, and their utilization of technology, has been formidable. McCarn and Leiter have described the progress in the National Library of Medicine system, MEDLINE.[2] The problems of a network system have been discussed in the context of educational information systems.[3]

A number of chronic problems remain for the information sciences to solve: the definition of user populations, the tendency for systems to become self-specific and their data bases increasingly opaque to non-specialists, the loss of the specific foci of specialized smaller systems in large systems, the lack of communication among system operators with the result that data bases and their content are not widely known, the lack of appropriate means to form networks of data bases with disparate thesauri, the inability of all but a few specialized systems to deal with full text, and so on. These problems become more acute as funds for exploring solutions to these problems become increasingly scarce. The pressures to solve the problems increase as a result of growth in the data to be controlled, and brute force methods requiring large sums cannot be exploited--thus a premium comes to be placed on refinements in thinking about the problems, and on ingenious solutions to them.

The seminar was called by AFB to focus attention on the problems mentioned above and to focus attention on their needs for a system to provide a broad range of data on blindness, visual impairment, its sequalae, its amelioration, sensory aids, etc.,

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and (to a lesser extent) on the possibilities for extending our interest to other sensory channels (deaf-blindness, deafness, etc.).

The participants were drawn from a variety of areas dealing broadly with vision, engineering, education, medicine; all were operators of information systems (past or present) and/or consultants in the area. Appendix I lists participants.

Although formal papers are not a necessary component of seminars, attempts were made to focus discussion on problem areas by posing a series of questions (Appendix II) to the participants beforehand, and by providing them with a prospectus (Appendix III) and a few key references. The broad range of potential data bases considered is listed in Appendix IV.

Though there was no specific plan for discussions at the seminar, the two-day meeting evolved as a longish period of exploration and exposition, and shorter periods of confrontation and resolution. An observer not conversant with the context of the meeting might have supposed that the attempt to deal with the large and important issues posed would have resulted in a rather desultory and inconclusive meeting. However, the rigor and activity of the Chairman; and the unusual involvement of informed participants proved otherwise.

EXPOSITION AND EXPLORATION

One of the basic themes of the meeting was that the long run is a series of short runs: if one is concerned with improving the provision of information services then it should be possible to make a listing of problems that result from existing information services. To be sure, there are problems even in the operation of well-established systems; but a few general classes of difficulties emerged from the discussion. Among them, the difficult question of whether or not to provide "hard" copy to users was viewed from the point of view of the user, the system operator, the libraries, and the holders of copyright. The basic difficulty is that local sources cannot provide full textual documentation for reference. Thus, both operators and users must obtain full text from the information systems directly. The problem becomes more acute as the scope of the data base of the systems widens. Clearly, users want documents: a ratio of 9 to 1 in the case of the Visual Science Information Center (VISC), but only some 5 percent have access to large document collections. About 95 percent of the references issuing from that service are to some 280 journals, some of which are commonly inaccessible to users. Some 50 to 70 percent of the journals are reasonably accessible, but only to users in academic communities.

In general, it may be said that users of information systems want documents, not references to documents. Short of outright disregard for copyright regulations, there is no easy solution to the difficulties posed by this demand for full text, and it continues to be an unresolved problem for almost all system operators.

A second broad problem, reflecting the concern of earlier conferences, is that of lack of direct access to data bases. The increasing complexity of information systems, the special vocabularies used in indexing, the limited time frames available for data base inquiry, and so on--has resulted in an almost universal practice of interposing intermediaries between the user and the data base. Few systems indeed allow users direct access. Some, like MANAGE, especially suited to the needs of researchers in nuclear medicine, become so well suited to the needs of a particular researcher who organizes them that, although they are perpetuated, they are rarely used. The rules for access become complex, one must reinterpret one's own query into the cognitive structure of the system, and be prepared to sift through much material to find the answer to the original query. It is difficult for a trained researcher; one can only imagine the plight of a naive user of such a system!

Nevertheless, there are now attempts to create systems which not only permit, but even encourage, interaction of user with system in real time; the Audio Response Time Sharing

System (ARTS) is one. So far, the system is "up" only for relatively simple editing and clerical tasks; it remains to be seen whether information intermediaries (information "brokers") will be needed to accomplish more complex searches. The Vision Information Center at the Countway Library at Harvard, which encouraged on-line interaction with users, is no longer operative.

The success or failure of direct access to the system by the user may also depend on the efficiency of retrieval techniques of the system itself; non-Boolean strategies for entry, and familiarity with the general type of literature to be accessed, are important variables here. This is the approach used with the Lehigh University LEADERMART system; here, one logs in, types in a command to initiate retrieval, and from then on the system engages in a dialogue with the user to lead him through the system and the result is a list of documents answering the original query. Typical search time is nine minutes. This unusual system can be used with minimal instruction.

Such systems also depend critically on the type of user population for whom they are constructed--and here one encounters another of the chronic problems mentioned above, namely, the degree to which an information system can satisfy the needs of disparate user populations. Interactive systems appear to act either as "creativity amplifiers," or as "learning environments." If one confounds these two functions, then one also tends to confound the role of the information broker or specialist. At the moment, it seems difficult to design systems economically to undertake both functions. The more normal arrangement, and one that seems to be a rather general model for information systems, is to have an information specialist serve as an intermediary between the system and the user; users are then allowed access (if at all), if: (a) they are sophisticated in the use of the system, (b) know the data base, and (c) can be system specific in making inquiries of the system. Only by "going to school" in this sense can one bypass the function of the information specialist. Users are generally disinclined to become this familiar with the operation of large systems.

These problems may be amplified in the case of systems using full text in the data base, such as ARTS, and here one obviously must make provision for the option of using the information specialist as broker or not (depending on whether there are constraints by standard indexing language, for example).

Even for systems depending on abstracts or citations--by far, the most common type of data base--studies of the biographies of documents indicate that perhaps only one in 20 survives beyond a five-year period. Further studies of this type might indicate ways in which we can handle the burgeoning mass of information to be dealt with, but there is no doubt that the difficulty is complex and, so far, purging of data bases seems to be the exception rather than the rule.

Throughout this set of considerations runs the one of user population. There are many reasons for an information system, and many needs that it is designed to serve. There may be a need to identify reviews of the literature; to initiate a retrospective review of one's own literature; to indicate recent relevant papers in an area; to construct a listing of projects for "current awareness." It is necessary also to identify the level of competence needed for reading and interpreting the literature stored. The levels of needs of differing user population tend to be idiosyncratic for different user populations. Most systems tend to be selective of user population, either by default or by design. It is obviously easier to design systems than to program users. The question is, however, whom are we trying to serve?

One constraint is economic: the size of the data base and its comprehensiveness. To the extent that we can define the needs of a community of users and the size of the data base necessary to accommodate those needs, we can serve that community. The difficulties in defining the needs of the users and the composition of that population are major, and have not been solved in a general model. Yet a system without a broad base of support from users will quickly encounter problems of survival. It is still uncertain whether this depends also on measures of user satisfaction, or whether this in turn is a function of effectiveness of presentation of a system to a funding agency. In this sense the continued support of an information system may be said to undergo a political transformation beyond the boundaries of criteria considered rational for the operation of information systems. Given this, what can systems operators do individually--given the scarcity of funds; what can one do in the short run to help solve these problems? It would seem that one way would be to publicize what systems *do* exist in fact, since there are no such compilations available. An agreement was reached at the meeting to do just this and the results appear in Appendix V, System Descriptions. The set of descriptions will be disseminated in a variety of ways, through IRIS.

It is clear from the descriptions that among the difficulties the user may face in utilizing the services of many systems that we have listed in Appendix IV, the foremost are time and cost. A secondary difficulty is central access. The first is exemplified by the University of Georgia system, which "spins" once a month; hence the average wait for a response to a query is two weeks. The second factor is exemplified by the instance of teletransmission and computer terminal requirements; this factor may be diminished with increased utilization of Wide Area Telephone Service (WATS), and by technological developments now under way which will in time make it possible to locate terminals (at least in large libraries) economically.

The secondary difficulty is being solved in a variety of ways, principally through the acquisition by some large systems of parts of the data bases of other large systems. An outstanding example is that of the SUNY/ Biomedical Communications Network, which is based on MEDLARS, and will soon add one to two years of abstracts from such bases as ERIC, Psychological Abstracts, Excerpta Medica, Biological Abstracts, and SPIN.

Note that this system, and almost all other large systems, deal almost equally in data bases with abstracts and with literature citations. Very few systems even consider full text storage. In fact, only one has been operational for some years: the LITE system, in the legal field, sponsored by the Defense Department and other federal agencies. Costs are unknown to us. About 10^8 words are stored. The capability of current technology in mass random access memories tends to rise by approximately an order of magnitude every decade.

It is interesting to note that of the large systems we have been discussing, none is addressed to the general public. Most are oriented toward the researcher; a few are addressed to that "middle range" comprising the researcher outside of his particular specialty, or the informed or sophisticated professional person. We must depend on the abstracts themselves, or an interpretation of them, to satisfy the information needs of all others. Simply combining data bases does not work, since one must be familiar with the key words of the data base (if they exist); and the vocabulary of the user of a special collection must be suitably interpreted. It would appear that an information broker is still required for optimal use of almost all systems. To combine data bases is possible, though very difficult. One could begin with a modest number of synonyms. In fact, the Brain Information Center at UCLA does use a subset of terms from MEDLARS, although the vocabulary is built around a core of MESE, along with new data entered by the Center itself. One cannot simply merge data files if the aim is the appropriate organization of knowledge.

CONFRONTATION AND RESOLUTION

Described thus far are our complaints about difficulties of organizing and operating information systems, and of our dependence on computers. The remainder of the meeting focused on refining two ideas: the development of exchanges of descriptions of current systems, both general and specialized, having to do with vision and its impairment and, to a lesser extent, with other sensory systems and their impairments, and the creation of what might be called a "poor man's network,"--cooperative linkages which might be created at low cost, and which allow forwarding of requests to other systems for response. One might ask whether it is possible to construct standing search questions, for possible merging with other data bases, for example. It is also interesting to observe that during the last decade, the time spent on demand searches for the scientific community has become less and less important in at least one important center, UCLA. It is debatable how general this experience is, but it is clear that current "alerting" services are considered far more valuable to users. These do not come from computer searches at all, but from a sophisticated group of "editors," who scan the literature and compile annotated bibliographies which are eventually published by the centers. Perhaps this is in part a reflection of some of the nonrational considerations mentioned previously. Thus, administrators in Washington tend to feel that "bibliographic work" is somehow second-class, and that "synthesis and analysis" is more important. The hope is, I would expect, that "someone else" would do the "bibliographic work" which is a necessary prior step to "synthesis and analysis."

The availability of machine-readable text which might be used at a number of locations to test for indices of retrieval power was mentioned as a possible step in negotiating such a "poor man's network." Among these sources of data, one might mention the recreational literature used for automatic braille transcription at the American Printing House for the Blind (APH); several kinds of compositor's tapes (although they need cleaning up); and Stedman's Medical Dictionary, 1972 edition. The Third Edition of Webster's Dictionary was put into machine readable form and compiled at Lockheed; CA has tape with and without typesetter's marks and with instructions for computer typesetting; the ACS typesetting tapes exist for primary journals in some cases. The Random House Dictionary and the Webster's Collegiate Dictionary were put into machine-readable form (tape) under public funding, and should constitute another valuable resource.

In discussing what might best be done to construct an information system to deal with vision and blindness, it became increasingly clear that the VSIC offered the best nucleus--a foregone conclusion to those who had been familiar with this possibility before the conference. The most appropriate ways to accomplish such a goal were closely examined. From an operator's point of view it would be a mistake simply to "tack on" literature acquired elsewhere, and to provide this uncontrolled output in response to queries of the system. One would then have two levels of quality, and it would be a pity to compromise the present system simply to broaden its perspective. Actually only modest additional resources would be needed to accommodate most of the literature on blindness at Berkeley: an additional person, some changes and additions to the thesaurus, and an accretion of the data base. Nevertheless, some of the possibilities for using material indexed elsewhere will be explored cooperatively. There was some feeling that a breaking point is identifiable, beyond which the current quality levels would have to be compromised to take account of the literature. The number lies somewhere between 5,000 and 100,000 documents added per year. But for an addition of, say, $25,000 per year, one could accommodate 3,000 documents a year with the same quality level as at present.

The proposed system would satisfy the population of researchers and function well for the researcher/practitioner--those who serve as "gatekeepers" for the flow of, and interpretation of, research results to the practitioner community, but it would probably not satisfy the needs of the practitioner community per se without "brokers" to interpret the results of searches for them. One possible solution would be to allow the ARTS system to address the modified VISC data base; although at present there are difficulties posed by the fact that the VISC system is off-line, on the opposite coast, and entry is remote.

Here it was evident that, considering the range of systems, and the differing modes of response to queries, it would be useful to have a listing of the kinds of questions that are best answered by operating systems--along with the kinds of questions that current systems cannot answer. The hope is that potential users would get a "feel" for the kinds of queries that the systems are best adapted to handle.

It might also be interesting to consider an expansion of interest beyond vision and blindness, say, to rehabilitation in general, or to other types of impairments.

The cooperative ventures discussed during the meeting--between the VISC and Lehigh, and between each of these and ARTS--make particular sense in view of the large cooperative programs now under way, such as the Harvard-MIT biomedical engineering project, that would constitute a natural market for the resulting product. This is in addition to the potential utilization of a more broadly-based system by practitioners and laymen.

To initiate the cooperative program, IRIS agreed to receive, duplicate, and disseminate the descriptions of systems, and the lists of answerable and "unanswerable" example questions. Such efforts may also sensitize funding agencies, since they are often most interested in cooperative enterprises. Eventually, descriptions of systems operating outside the USA should be added.

CONCLUSIONS

It would probably not be difficult or expensive to add the blindness literature to one of the information systems now operating; or, indeed, to add parts of the blindness literature to more than one of the presently operating systems. Any ideal information system does more than store and retrieve literature; in this sense it is neither a library nor a school: it collects, stores, supplies, and creates information. It may do this in several modes, acting as a creativity amplifier for the researcher, or a learning response environment for the nonspecialist or uninformed researcher. But it is obvious that we need now, and in the foreseeable future, the option of using "information brokers" who can translate the output of the information system to the ultimate user's own language. It would not be reasonable to expect that interpreters of the literature to the practitioner will utilize the information system to gather materials that can be interpreted in terms, say, of solving the problems of a classroom teacher of the impaired.

Even for gifted interpreters of this kind--those exceptional individuals Margaret Booker at the University of Texas, D. Erikson of the CEC in Maryland, or Dr. Blackhurst in the field of mental retardation--the kind of information systems permitting them to function optimally have not yet been created. The dream of the 1960's, the capability of sitting at a console and addressing transparently all the relevant data bases in the nation, no matter where they might be--has not been realized. We are making slight progress in that direction, but even if the "on-line community" concept (which grew out of the work at MIT, and was successful there) is not realized, we can at least begin to approach it. One step might be a kind of centralized brokerage, or call director computer, which might handle the output from a large number of centers where there are discrete data bases. It appears doubtful that a national or international data base will ever be economically feasible.

Nor does successful communication among data bases depend crucially on the development of computer technology. After all, the most crucial elements in cooperation are the human beings who operate systems. It thus appears attractive the more one examines the idea that the "poor man's network," a cooperative enterprise in the special arena of vision and visual impairment, might serve as a model. The model might help to explore the difficulties in conceptual organization of sets of information, in duplication of documents or listings, in the different grades of interpretation necessary to respond to queries, in constructing outputs suited to the needs of the various audiences (research, practitioner, laymen) using the system(s). We know that almost any technique of information retrieval will work on small data bases; but we still cannot determine whether one retrieval system or another works better in large data bases. Many of the tasks that the field set out to accomplish, among them direct question-answering on the part of nonspecialists, and retrieving a synthesis from stored data, are still beyond our reach. Obviously, despite the great growth in technological sophistication, we are very much in a trial-and-error stage in providing appropriate information at appropriate times to appropriate public.[4] At the moment, it appears that we are still at the formative stage in which data bases are "multiply convertible" to a standard format.

The hope is that the cooperative ventures we have proposed may have value beyond that of immediate relevance to those communities interested in vision, blindness, technological application, and rehabilitation after visual loss. IRIS has agreed to act as a dissemination point for cooperative ventures among VISC, ARTS, SUNY, and the Lehigh system. We shall also try in the following months to compile information on the appropriate sources for information related to a variety of inquiries, by identifying appropriate "brokers" matched to the information needs of the several publics served by the field (the researcher, the practitioner, the individual laymen). We shall, with our colleagues, try to determine the kinds of queries that can, and cannot, be answered by the information systems now extant. We shall try, again with the help of others, to publish whatever booklets and pamphlets might help to make this information more widely available. We are encouraged that at SUNY queries are accepted in the natural language of a user, then interpreted in the specific language of the system.

In sum, it would appear that the utility of the special interest collection is still very great, both for responding to inquirers of the system, and for exerting pressures on large systems to deform their vocabularies and data bases so that appropriate responses with a minimum of false drops can be made. Moreover, there is still considerable room for experimentation in low-cost cooperative ventures among system operators to overcome the obvious difficulties in merging of files and in sharply and precisely defined responses to questions posed to operating systems. This seminar did much to provide examples of ways in which such ventures could be undertaken. Unlike most meetings, it opened interesting perspectives toward accomplishing some of the modest goals posed, rather than pointing out the chronic difficulties in the way of cooperation that will yield only to the sustained pressures of basic research. Yet the nominally applied projects discussed have implications for basic research exciting in prospect, even in these days of highly sophisticated technologies. Indeed, because this is so, we have chosen to publish the summary of this meeting in a journal, rather than separately--emphasizing that we will be publishing in the future a series of papers reporting on the results of the proposed cooperation.

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APPENDIX I

A SEMINAR ON INFORMATION SERVICES FOR THE VISUAL SCIENCES AND RELATED AREAS

The Yale Club, New York City
June 18/19, 1973

Invited Participants

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APPENDIX II

Possible Agenda Topics for a Seminar on Uses and Limitations of Documentation Research in Human Sensory Processes

1. What is the nature of the public to be served?

2. What are their needs?

3. How does one measure their satisfaction with services provided?

4. What are the options (organizational, technical, and technological) for providing this service?

5. Do we have measures of cost vs. user satisfaction for each of these options?

6. Based on the above, what would be an ideal typical information resource for the public involved?

7. How much will it cost?

8. If we cannot afford the ideal typical system, and must reduce our aims, then:

   a. what compromises in speed, coverage, and depth are incurred?

   b. what is the level of support likely to be for each of these compromises?

9. More fully, what are the current political, social, and attitudinal constraints on funding of exploratory or demonstration projects reflected under 8(b)? How are these related to the compromises described under 8(a)?

10. To what extent can one expect to build up a mosaic of capabilities, to match the system configuration suggested by topic 6 and/or topic 8, by creating a network of parts of larger systems? More generally, have advances since 1968 changed our expectation that technology per se cannot provide the means to achieve optimum systems without very large cost-per-response or per-search?

11. What are the advantages and disadvantages of organizing an information resource having inherent capability to conduct research on information *using*? Would current funding prejudices permit incorporation of this capability in planned systems?

12. Does the development of ARTS* alter any of the above?

13. In a period of cutbacks in funding of research and of service provision, is there a transitional, but cheaper, system that can be designed to serve the public, allowing conversion step by step to the kind of system described in 6 through 9? What stepped program could be drawn up?

14. What are the latent functions of information systems (educational, through interactive modes; instructional/political, through providing multibias access to literature in underdeveloped nations)?

15. Operationally and politically speaking, how can we become conscious of and manipulate the positive feedback accruing from familiarity with information systems, using information systems, and disseminating knowledge about their existence and utility?

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*Audio Response Time Sharing system, developed by Dr. Kenneth Ingham of the Protestant Guild for the Blind, Watertown, Massachusetts.

Prospectus

for

A Seminar on Information Services for the Visual Sciences and Related Areas

PURPOSE

To discuss improved information services for the visual sciences and related areas. The seminar title implies wide applicability to other areas concerned with the sensory processes, of those methods and techniques developed for vision and vision impairment.

It is hoped that the following questions will help to crystallize these concerns.

1. What are the inadequacies of existing retrieval services? What examples can one give of important retrieval and information access difficulties that exist now, using both conventional and nonconventional systems?

2. What literature collections should the user have access to? (Appendix IV is a partial listing.)

3. What options are there in hardware and software configurations to deal with the information we wish to find?

4. Given the collections specified above, and some options of system configurations, what do we want a retrieval and information system to do? If we were to interpret from our empirical knowledge of what we know of hardware and software capabilities, and our knowledge of the collections we wish to utilize--that is, if we were to construct an "ideal-typical" system--what would it look like? And, if an ideal-typical system is impracticable, what is feasible?

5. In what ways can we assure continuity of interest in building an information system--including the most appropriate funding mechanisms for it? Answers to the first question posed could help to make clear not only the importance of developing new and more adequate systems, but in continuing to operate them.

The answer to these questions are so important that we feel they merit consideration in a conference of specialists and in the light of current experience.

DISCUSSION

While the issues hinted at above would be worth considering and discussing at any time--and, indeed, acquire a special importance for refreshing the outlook of those of us involved in information provision for years--we are particularly intrigued with the possibilities recently opened up by advances in hardware now becoming available. These advances make possible the preservation of the distinctive features of "special interest" collections, while allowing access to large bodies of data collected under broader guidance. In combining them all, one can conceive of a constellation comprising large computers, telecommunications via radio or wire links, the use of local user terminal minicomputers, and microprogramming. (Microprogramming is, strictly, "software," but it makes possible an increase in the computing power of minicomputers, and also a widening utilization of local buffer data storage on tape, on disc, or similar forms.) One can think of many different combinations of these components, but a given system utilizing them all would make possible the generation of a retrieval system with many advantages: interactive capability, flexibility in adapting to changes in user language, periodic automatic updating of the local data base from a remote source, and the potential of interconnection among systems in networks. Since 1968, when we last looked at the status of the art vis-a-vis sensory research information processing,* we have noted many significant developments; one recent example is a conference report on "networking" in the journal *Behavioral Science*.**

Coping with the entire range of interests covered by the term "sensory research" entails many difficulties, even were one to restrict the primary emphasis to but one sensory impairment. This may actually underscore the need for intelligent help in controlling information location. We are in the paradoxical position, in blindness research, of seeking answers to everyday practical problems at the very frontiers of scientific knowledge. Perhaps this is but another way of saying that vision is such a richly complex channel of information flow that only the deepest understanding of it is adequate in the attempt to make up the sensory deficit involved in blindness and severe visual impairment.

One of the least happy consequences of this fact--at least it appears to us a fact--is that to achieve the greatest utility of scientific knowledge for the ultimate consumer, the impaired individual, one must take continual account of the most highly developed domains of inquiry. The problem may be easier to think about if one asks the question, "How can we provide a suitable substitute for direct visual input when we must deal with an unseen environment which itself cannot be adequately specified?" This is, after all, the situation of the astronaut or aquanaut. A formidable task, indeed; and yet it is but part of the greater consequences entailed by blindness. It is small wonder, then, that we attempt to track knowledge growth in fields as disparate as bioengineering and technology transfer, tactile displays and the flight behavior of bats, the electroencephalographic records of adventitiously blinded rabbits and the navigation of cave fish, the constraints on cognitive development of early sensory impairment and the deficits in socialization without visual contact between humans.

This disparity is suggested by the listing of data bases in Appendix V. We believe that it has now become possible to devise ways of coping with this enormous range of information in rational ways that can open up specialized information collections in useful ways to researchers, who are most often in the position of laymen in areas of work only slightly different from their own.

In an effort to structure, but not determine the conduct of the seminar, the following considerations might be poses to participants, on the basis of the foregoing considerations.

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*Proceedings of the *Conference on documentation and information retrieval in human sensory processes*. A. Kent, G. D. Stevens, and L. L. Clark (Eds.). New York: American Foundation for the Blind, 1972.

**"Networks in higher education: Proceedings of the EDUCOM council meeting seminar," *Behavioral Science*, September 1971, 16(5), 490-510. (See especially the "Summary" of J. C. R. Licklider.)

APPENDIX IV

Considerations

for

A Seminar on Documentation Research and the Human Sensory Processes

Literature Collections (Data Bases) to be Included

The list may be incomplete; and the listings for Groups B and C are meant to be illustrative only.

Group A - Should be included in entirety.

- Excerpta Medica - Ophthalmology**
- Vision Index (Berkeley)*
- Vision Index (Harvard)*
- IRIS Index

Group B - Should be included in entirety, or else those parts selected by broad searches (especially in case of large collections).

- Excerpta Medica - Bioengineering**
- Medlars*
- Compendex (Engineering Index on tape)**
- Psychological Abstracts**
- NINDS/Brain Research Information Center (Los Angeles)*
- Science Information Exchange**
- ERIC*
- Selected electronics journals (e.g. IEEE Transactions on Man-Machine Systems)
- SPIN (American Institute of Physics)**
- New York Times Information Bank**
- USGRA (U.S. Government Report Announcements) (selected)**
- Biological Abstracts*

Group C - Essentially like Group B, but the "collection" may be less well defined.

- MIT Quarterly Progress Reports, and similar limited distribution documents
- Institute of Scientific Information (U.S.S.R.) publications
- Handikappinstitutet/ISRD/ICTA Catalog of Technical Aids (Sweden)
- SSRC/Social Science Data Archives
- University Microfilms (some broad subset)
- Polish Academy of Sciences (document abstracts)
- Reports of the Euratom Sensory Aids Group (Rome)

*These entries are in machine-readable data base form.

**These entries are in machine-readable data base form and include abstracts.

APPENDIX V

System Descriptions

Visual Science Information Center
School of Optometry
University of California
Berkeley, California 94720

Telephone: (415) 642-4647

Visual Science Information Center (VISIC) is a computer-based bibliographic information service offering rapid bibliographic access to the world's literature on vision. Its services are available to the public.

Services and publications. Vision index; demand searches; SDI profiles; current awareness; bibliographies.

Coverage. Vision literature in journals, books, reports, theses, audio-visual materials, and other serials in several languages is regularly surveyed, indexed in depth, and stored in a computer data base. The subject content of each document is carefully analyzed and assigned subject terms from the Visual Science Information Center Thesaurus. Information services and publications are generated from this data base. The data base begins with publications released after November, 1970. Approximately 10,000 citations are added annually.

Visual Science Information Center Thesaurus. The Thesaurus is the controlled authority list of subject terms employed by VISIC's staff for indexing purposes. These terms are also the primary basis of demand search question formulation. The Thesaurus is frequently revised.

Vision Index. A printed index issued quarterly, with annual cumulation. Each issue contains author and subject sections. Each quarterly issue contains approximately 2500 individual citations. Annual subscription price: U.S., Canada, Mexico, $20.00; other countries, $21.00. Volume 1, number 1, March, 1971.

Demand searches. Retrospective one-time bibliographies prepared in response to subject oriented questions submitted by users. Demand searches are achieved by submitting the question to the data base via VISIC's information retrieval system. Demand search questions may be restricted by publication language, type of publication, publication date, and author, if desired.

Selective Dissemination of Information (SDI) Profiles. "Demand searches" run against the data base at regular intervals, monthly excluding citations retrieved on previous updates. An SDI Profile service is a type of current awareness service which allows the user to become aware of, routinely and quickly, citations in subject areas in which he has a continuing interest. The monthly interval is intended to insure currency. An effective SDI Profile requires feedback from the user to evaluate the relevancy of the retrieved citations. A user may have one or more SDI Profiles.

Current awareness publications. Publications issued regularly on selected subjects broad in scope, e.g., contact lens. Subscription price varies with subject and publication frequency.

Occasional bibliographies. VISIC publishes occasional bibliographies retrospective to the beginning of its data base. They are available in multiple copies.

State University of New York
Central Office Computer Center
99 Washington Avenue
Albany, New York 12210

Telephone: (518) 457-2906

SUNY Biomedical Communication Network

The State University of New York (SUNY) Biomedical Communication Network, operational since 1968, is the most comprehensive online retrieval system for biomedical literature in the world.

Through membership in the SUNY Network, users may have access to the complete MEDLARS journal file produced by the National Library of Medicine. The SUNY-MEDLARS data base contains all those citations appearing in *Index Medicus*, the *International Nursing Index*, and the *Index to Dental Literature* from 1964 to the present and is updated monthly.

Citations from 1970 to the present may be printed online at the user's access terminal. Citations from 1964-1969 are requested online but printed offline at the Computer Center in Albany and mailed to the user the following day.

Citations are retrieved via *Medical Subject Headings* (MeSH), a controlled subject vocabulary used to index the citations for input into the file. A search may be further refined by scanning for certain authors, title words, or journal titles.

Membership in the SUNY Network is based on an annual subscription fee plus leased-line charges from the user's location to the Computer Center and terminal rental charges (unless a user elects to supply his own access terminal).

The average annual cost per user is approximately $7200. This annual fee entitles the user to unlimited access to the data base at any time during the 35-hour operational week, with offline searches available at no additional cost.

Searching hours are presently from 9:00 a.m. to 4:00 p.m., Monday through Friday.

The Network searching system operates on SUNY's IBM 370/155 computer in Albany, and the user interface is provided by IBM's new interactive software program called STAIRS.

International Research Information Service
American Foundation for the Blind
15 West 16th Street
New York, New York 10011

Telephone: (212) 924-0420

Established 1963. Staff: Leslie L. Clark, Director; Zofja S. Jastrzembska, Assistant Director, two clerical and nonprofessional.

International Research Information Service (IRIS) is a part of the Department of Research of the American Foundation for the Blind, a national nonprofit consultation and research agency. Created with the help of federal funds, IRIS maintains and distributes a descriptor index of basic and applied research in areas of visual impairment. This is a collection of codified information obtained from researchers throughout the world and from international literature in the fields of technological and psychosocial research into blindness. IRIS also publishes a quarterly *Research Bulletin*, prepares bibliographies, state-of-the-art reports, and evaluations. The primary purpose of IRIS is to supply researchers, especially sociologists, neurophysiologists, electrical engineers, and professionals such as teachers and consulting psychologists, with needed information from a broad range of natural, behavioral, and technological sciences, bearing on problems arising from sensory impairment, and especially visual impairment.

Scope or subject coverage. Sensory research; sensory communication; simulation of living systems; human engineering for sensory aids; testing and analysis of technical devices for the visually impaired; research and development of visual prostheses; aids for the severely visually impaired and the deaf-blind;

community studies of attitudes in the visually impaired and sighted populations; statistical and demographic data on visual impairment, evaluation research, psychological and psychophysiological effects of sensory impairment.

Input sources. Worldwide scientific literature, project reports, acquisitions lists, unpublished memoranda, personal visits, and correspondence. Conduct of conferences and seminars.

Holdings of recorded data. Document collection incorporates some material from the American Foundation for the Blind; books; journals in English, Russian, Italian, Spanish, French, and German; and research and technical reports.

Serial publications. *Research Bulletin* (quarterly)--by subscription; *AFB Research Index Supplements* (quarterly)--available by subscription on a yearly basis (temporarily suspended for lack of funds).

Nonserial publications. *AFB Research Index*--a 3-volume looseleaf set composed of a *Dictionary of Descriptors*, a *Scan-Column Index*, and a *Bibliography*. Various special bibliographies, reports, and proceedings are also published.

Other services. Interlibrary loan; bibliographic research; reference and referral services; state-of-the-art compilation; copying; (very limited) translation.

User restrictions. Services available to all qualified researchers.

Brain Information Service
University of California, Los Angeles
Center for the Health Sciences
Los Angeles, California 90024

Telephone: (213) 825-6011, 825-3417

Established 1964. Staff: Michael H. Chase, Director; Louise Darling and Victor E. Hall, M.D., Co-principals; Pat L. Walter, Assistant Director for Information Services; four information analysts (professional); two programmers; one editor; seven and three-quarters administrative and clerical.

The Brain Information Service (BIS) was established in 1964 under contract with the National Institute of Neurological Diseases and Stroke (NINDS). Working in cooperation with the UCLA Biomedical Library, it was charged with the mission of identifying, indexing, storing, retrieving, repackaging and disseminating information in the basic neurological sciences. Special emphasis is placed on the analysis and synthesis of information by supporting scientific conference workshops and reviews, providing summaries of scientific meetings, and adding annotations to citations of the primary literature. Bibliographic services focus both on the control of current publication as well as on providing retrospective literature coverage. The Service attempts to reach the worldwide community of neuroscience researchers, teachers, and students, and towards reaching this goal has built up a current mailing list of 14,000 individuals and institutions.

Scope or subject coverage. The basic neurosciences: neuroanatomy, neurophysiology, neurochemistry, neuropharmacology, neuroendoctrinology, and central nervous system correlates of behavior. Information relating to behavioral psychology and the diagnosis and treatment of neurological disorders is not within scope.

Input sources. The staff scans journals (6642 current serial titles at the end of 1973), books, reports, and other primary literature received by the UCLA Biomedical Library, as well as selected secondary sources, as input to the current-alerting publications. All references appearing in these current-alerting publications are added to the BIS retrospective literature data base, as well as in-depth indexed material within scope from books (especially multi-authored ones), from "core" journals (ca. 15), and from any journal not indexed by the National Library of Medicine (NLM). These citations are merged with monthly MEDLARS tapes received from NLM, which contain all citations on the central nervous system, electrophysiology and other selected parameters. BIS indexing utilizes a specialized controlled vocabulary of approximately 26,000 terms, of which approximately 11,000 are major terms. Literature of all languages is covered, and titles are given in English and the vernacular. Scientific meetings are the input for the conference and the research report series. Reviews and bibliographies written or compiled by scientists outside the BIS are frequent input for BIS publications.

Holdings of recorded data. The data base consists of approximately 300,000 citations stored on three discpacks, with numerous back-up tapes. The BIS does not hold a document collection; the primary and secondary literature it uses are almost entirely those of the UCLA Biomedical Library.

Serial publications. *Perspectives in the Brain Sciences*, a monographic series; Vol. I: *The Sleeping Brain*, M. H. Chase (Ed.), 1972. Six current-alerting publications available on subscription: *Biogenic amines and transmitters in the nervous system; Neuroendocrine control mechanism: Hypothalamic-pituitary-gonadal system; Sleep bulletin and sleep reviews; Memory and learning--neural correlates in animals; Memo of current books in the brain sciences*, with quarterly *Index to book reviews; Index to current (EEG) literature* (published by Elsevier, in the journal *Electroencephalogr. Clin. Neurophysiol.)*. Five quarterly recurrent bibliographies: *Neuroimmunology; Proteins in the brain; Inborn errors of metabolism; Contingent negative variation; Cerebral evoked potentials*, all available on subscription. Four annual cumulations of the current-alerting subject bulletins, all with author and KWIC indexes, *Sleep research*, an annual cumulation of the previous year's literature citations, reviews published in *Sleep reviews*, and the current year's abstracts of the annual meeting of the Association for the Psychophysiological Study of Sleep.

Nonserial publications. Seventy-nine reference bibliographies, more than half with annual updates; reviews, some updated on a regular basis and published in looseleaf form; research reports, based on meetings, lecture series, or workshops; conference reports, 33 to date; atlases and laboratory guides. The BIS publishes an annual *Announcement* which lists all publications and services. All publications except the *Announcement* are sold for a nominal fee.

Other services. Demand bibliographies based on the data files from 1969 to the present are available for $25.00 per search. Bibliographies can be manually edited and augmented, if so desired.

User restrictions. Services and publications are available to all scientists, clinicians, teachers and students in the neuro and related sciences.

American Systems, Inc.
123 Water Street
Watertown, Massachusetts 02172

Telephone: (617) 923-1850

Kenneth R. Ingham, President

The ARTS System

The Audio Reponse Time-Sharing (ARTS) Service Bureau consists of a large vocabulary, multilined audio response or voice response telecommunications system coupled to a minicomputer-based time-sharing system, and is intended to permit the blind and other physically handicapped to use remote controlled programs which permit them to read, write or manipulate information.

The time-sharing system portion of ARTS can be looked upon as a general purpose time-sharing computer to which the standard computer peripherals such as fixed- and moving-head disc, line printer, magnetic tape, etc., may be attached. In addition, it operates with dynamic memory paging and protection as well as user high-speed swapping. In effect, the operation of the system may be looked upon as essentially the same as that of a standard visually oriented time-sharing system. This portion of the system, also termed the applications computer, operates programs such as Basic Form Generation, Editors and Justifiers along with a powerful and flexible file storage retrieval system. The input/output of the time-sharing system is controlled by an American Systems, Inc., speech teleprocessing system which accepts the character information for the 16 or more operating lines and carries out a language translation to produce connected speech output. The standard method for input to the system is via a full alphanumeric keyboard with an expanded Touch-Tone character set.

With the speech and time-sharing systems working together blind operators, from their home, school or office, may telephone the computer and using the audio keyboard, command programs to "read" text, edit text, or accept typed input for storage. Whole text or abstracts supplied to the ARTS storage media may be accessed by the various ARTS users over the telephone system or may be reproduced in braille and/or ink print.

Editor's Note: Other system descriptions not listed on this report were not received in time for publication.

TRANSLATION OF VISUAL INFORMATION INTO AUDITORY CODES

Bjarne Fjeldsenden*

Most of this article was written during the period 1970-1972, and is composed for the most part of extracts from the theoretical part of a larger piece of work whose focus is on transformation of information from one modality to another. The points of view are basically long-range and detached from immediate practical considerations; so despite new research, the fundamental ideas of this essay should not require much change.

If one takes the point of view that a blind person should navigate in the physical environment as skillfully as a normal person with unimpaired vision, we are still very far from reaching this aim. For instance, the Ultrasonic Torch, and, later, the Sonic Glasses of Kay, and the projection of TV pictures on to the skin, either mechanically or electrically, as done by Bach-y-Rita, brings one closer; but it is, I think, overoptimistic and oversimplified to believe that these devices can perform anywhere near as well as the eye can. It seems appropriate to mention the enthusiasm in the Fifties over translation of one language into another via computer. Today one admits underestimation of the complexity of the task. I think the Kay and Bach-y-Rita devices are very important and necessary steps in the right direction, but they are the beginning, like the first generation computers, not the ultimate answer to blind mobility. I think one should be very conscious of not freezing the development at a certain stage by committing oneself too fully to a certain device. First, new and advanced technology opens up new avenues all the time, and second blind people differ enormously as far as aptitude to learn mobility and other skills goes, so a device may suit one person but not another.

At times it can be useful to stand back and try to see the forest.

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*Huseby Off. Skole for Blinde, Oslo, Norway.

Part 1

General Theoretical Considerations

In the discussion which follows, it will hopefully be quite clear that the human auditory system is far better equipped to handle certain classes of auditory material than others. It should be kept in mind that this paper attempts mainly to answer the question of the extent to which the auditory system in man can replace the visual system. All the experiments are concerned with "visual" information presented in an auditory code, but as the skin also can convey information about the "visual" world in a consistent manner, it will be discussed briefly, and compared with the auditory system. Various perceptual problems will be discussed from an information-processing point of view, and the concepts and notions, more than the strict methods, of information theory will be used.

MODES OF PERCEPTION IN ANIMALS

One tends to think of perception as either a visual or an auditory process. It seems more appropriate to think of perception as data collecting and processing, which enhances the chance for survival of the organism in question. Not the form, but the relevancy and accuracy of the information is of paramount importance, and the organism's capacity to make an adequate response to the received information.

Examples will be given of animals that get information about the environment in a rather unusual form, illustrating that there are unusual ways by which information may be obtained. The visual world may be the "real" world for man, but not necessarily for certain animals.

Different types of bats gather information from the environment by emitting ultrasonic sound of frequencies that mostly range from 20 kHz to 120 kHz in pulses of 3- to 50-millisecond duration. The duration of a pulse varies from one type of bat to another. Some bats can send up to 200 pulses-per-second and the sound emitted is reflected and received back. In other words, they utilize the radar principle. The accuracy of the bats' sense in insects, and in particular to moths, has been observed experimentally. They seemed capable of discriminating among different types of moths, and the reaction of the bat when a moth changes direction, is also very fast, indicating a very good or direct connection between the perceptual apparatus and the muscles controlling this particular type of behavior (Pye, 1963; Webster, 1963, 1966). One may say that the data processing and execution were highly efficient. But, it was also found (Webster, 1963, pp. 59-76) that moths could detect sound waves ranging from 3 to 150 kHz, and when hearing the bats' signals, they started to fly in an erratic or random way, making it more difficult for the bats to catch them. It may be mentioned that bats do have eyes, but they make little or no use of vision. Fifty meters seems to be the maximum range for the bats echolocating system (Pye, 1963; Webster, 1963, 1966).

The rattlesnake has a highly sensitive infrared sensing mechanism which can respond to changes in temperature in its environment of one thousandth of a degree, sufficient to sense the presence of another animal (Gerardin, 1968, p. 95).

The torpedo fish sends out field-producing currents of 100 Hz. Receptor neurons in the skin of the fish are highly sensitive to the pattern of electrical field strength resulting from the interaction of the emitted impulses with surrounding objects. Field changes of only 1×10^{-6} V/ft^2 can be detected. In this way the fish can get vital information about surrounding objects and behave accordingly (Wooldridge, 1963, p. 57).

COMPARISON OF DIFFERENT SYSTEMS

One difference between the bat and the torpedo fish, on the one hand, and the rattlesnake and most other animals, on the other, is that the former group emits energy and produces a signal to get information from the environment, while the latter receives information without having to spend energy. The merits and demirits of the two modes of collecting information is interesting from various points of view.

An organism which produces its own signal is independent of energy radiation from the environment, and is consequently better suited for specific situations. The bat, for instance, operates mostly in darkness, and the torpedo fish would have a distinct advantage in murky water compared with fish dependent on visual information. One may also ponder whether it is not easier to decode omitted signals that interact with the environment when the same organism is both sender and receiver. One would think that from the point of view of parsimony the same structure in the brain connected with forming the signals would also be engaged in decoding them. There is evidence from research on humans that the brain areas associated with producing speech also are involved in decoding it (Luria, 1966, p. 99).

It seems compatible with common sense that a system relying on energy radiation from the environment has to be more complex to decode data than a system designed to extract from the environment certain relevant features that it selects itself. This seems to be highly relevant to pattern recognition in building devices which can recognize patterns. Should the computer be linked to photosensitive cells which give indirect information, or should it be linked to gadgets that can give more direct information such as distance data based on a type of radar principle? A general answer may not be possible. It may depend both on the task and specific conditions. What applies to man made systems may apply to living organisms. But while artificial systems are still in their infancy, the systems of living organisms have been in existence for thousands of years. It appears that both computer people working with pattern recognition, and people working in the area of perception may contribute to our understanding of how information is processed by humans and other animals.

INFORMATION THEORY AND PSYCHOLOGY

The ideas and formulas of information theory have their basis in communications language and were first formulated in 1948 by Wiener and Shannon. The two most important concepts are "information" and "bit." Attneave (1959, p. 1) defines information as ". . . that which removes or reduces uncertainty." Cherry's (1957, p. 306) definition is "The least number of *binary digits* (yes, no) required to *encode* some particular message (or alternatively to specify its selection from an alphabet)." Binary digit or bit is defined by Cherry (1957, p. 303) as ". . . a code which employs two distinguishable sign only (binary digits)." "Bit" can have the form of yes/no, on/off, black/white, etc. In its basic form, it can be expressed: $H = \log_2 A$. A is the number of alternatives, and H is the amount of information in terms of bits. It can also be written: $H = \log_2 \frac{1}{pi}$

where pi stands for the probability that event pi will occur. One can, for example, consider language from an information theoretical point of view. If each word had a probability of 1/1024 of occurrence, then each word would contain

$$\log_2 \frac{1}{1/1024} = 10 \text{ bits of}$$

information. (Language is not like this. The probability of occurrence of different words is different, and the words in a sentence, where they usually occur, are interdependent. This makes the specific formula above invalid in this particular case, but the formula and the example illustrate basically what a bit is.)

INFORMATION CAPACITY OF HUMANS

Perception can be considered as an information handling process and one aspect of this is information transmission. Jacobson (1950, 1951) made an estimate of the information capacity of the eye and the ear. For the eye, he first calculated the number of acuity squares by assuming that the eye had a maximum acuity of 1/100 of a degree, at the same time taking into consideration that the acuity was less when distance from the fovea was increased. He based his calculations on Wertheim's data (Jacobson, 1951a, p. 293) and arrived at an estimate of 240,000 acuity squares. He further assumed that each square could be in an on/off position, and that they could discriminate between states (e.g., black and white). In other words, each square could transmit one bit of information. He assumed also that the eye could react 18 times/second. This gave one eye an information capacity of 240,000 x 18 = 4.32×10^6 bits/sec (Jacobson, 1951a). Color is not included in this figure. If it had been, the figure would of course have been higher. If one takes this a step further and assumes that each square, instead of being able to make only two discriminations, could make 1024, this would give 4.32×10^7 bits/sec.

It is of interest to compare this figure with some physiological data. The optic nerve has approximately one million nerve fibers (Graham, 1965, p. 51), but one would strongly suspect that there are individual differences. The number of receptors in the eye is in the order of 75×10^6 to 150×10^6 (Graham, 1965, p. 47). According to Jacobson's (1951) estimate, each nerve fiber has an information carrying capacity of 4-5 bits/sec.

An estimate for the ear gives 0.3 bits/sec per nerve fiber for the cochlear nerve and ". . . is clearly due to the greater independence with which the optic nerve signals are produced, in contrast to the prevalence of cooperative signals in the auditory bundles," (Jacobson, 1951).

Assuming that one eye has 130×10^6 receptors and each receptor is able to discriminate between two alternatives, the eye could have an information capacity of $130 \times 10^6 \times 18 = 2340 \times 10^6$ bits/sec. The difference between the last figure and Jacobson's (1951a) is that Jacobson's data are from a behavioral point of view, while the last figure is calculated from a simplified physiological point of view. One reason for the discrepancy in figures is that the receptors in the eye are highly interdependent. One may get an indication of how the various receptors in the eye are interrelated by the following (from Graham, 1965, p. 51): ". . . it has been estimated that in the middle and far periphery approximately 100 rods converge on 17 diffuse bipolars, which in turn converge on a single ganglion cell (Vitter, 1949). Diffuse polysynaptic bipolar cells, as well as diffuse ganglion cells, make up a converging system which may provide the neural basis for both facilitation and inhibition."

Jacobson's (1950, 1951) procedure for the calculation of the information capacity of the ear was as follows: he first calculated how many frequency discriminations a human could distinguish between the range of 30 to 16,000 Hz. Then he calculated how many intensity levels there were within each of these elementary signals or frequency groups. For example, at 2000 Hz, a person can make 325 intensity discriminations, which will convey 8.3 bits of information. The average between 30 and 16,000 HZ was 7.7 bits. The number of discriminations would be 1450 along the frequency scale. He further assumed that a human could make four discriminations-per-second. The capacity of the ear from these data would be 1450 x 4 x 7.7 = 44600 bits/sec, assuming that all signals were independently and simultaneously perceived, but this is not so. By taking into consideration masking effects, Jacobson arrived at 8,000 bits/sec for random sound and 10,000 bits/sec for loud sounds. (The reason that loud sounds give a higher figure is that more frequencies can be heard.) He also calculated the total number of monaural sounds to be 330,000.

These calculations were set out in great detail, but rest on certain assumptions and certain data which are far from adequate. One of the basic assumptions is that all the frequencies are presented simultaneously, but only one intensity discrimination can be detected within each frequency group.

One might argue with respect to this assumption that one does not know if a particular frequency could be detected if all the frequencies were present simultaneously. Even if masking effects were considered, it probably would only mean that two or more frequencies which interfered with each other when presented alone, were eliminated in the final count because they could not be distinguished in that particular combination. One may argue that the ear can only react to a far more limited number of frequency groups than 1450 at the same time, because only a limited number of cells in the organ of Corti can react or be stimulated simultaneously. This could be supported by a more general argument; that the ear is a "sequential sense," while the eye is regarded as a parallel processor.

Jacobson, aware of inaccuracies due to lack of empirical data says, "The results obtained may well be off by a factor of two or so, but may serve as guides to our ideas on the capabilities of the ear," (1951, p. 468). He may be a bit optimistic with respect to this assessment, but his general approach seems sound and worthwhile.

TRANSMITTING CAPACITY OF CNS

Many experiments have been conducted to determine the human brain's capacity for transmitting information. With respect to unidimensional stimuli, almost all studies, some herein mentioned, have found that man can transmit between 2 and 3 bits of information; many of the studies showed values of up to 2.3 bits. It should be noted that perfect transmission of 5 alternatives corresponds to 2.32 bits. The stimuli to be recognized could be lines of various length, squares of different sizes, positions of a pointer between two end markers, pure tones, various loudness levels, etc. Other conclusions based on this type of study were that it did not matter much if the number of alternatives were increased or if the stimuli were far apart on the dimension used.

If one increases the number of dimensions on which the stimuli vary, one gets different results. For example, one experiment (Attneave, 1951, pp. 73-75) that had six dimensions and five steps on each dimension, found total information transmitted per stimulus presentation ranging from 3.2 bits for the poorest third of the subjects to 7.9 bits for the best third. Attneave (1959, p. 75) makes the following comment: ". . . the number of dimensions on which stimuli vary appears to be an extremely important psychological variable."

For reasons other than psychological, MacKay (1950, 1952) proposed several years ago that two *kinds* of information--structural and metrical, or *logon* content and *metron* content--might profitably be distinguished in any body of data. The term *logon content* means essentially dimensionality or degrees of freedom. *Metron content* is some function of the number of discriminable steps or categories on each dimension or *logon*. These two concepts may be useful, but do not answer the question why a stimulus attribute becomes a *logon*. These two concepts seem quite applicable to what is discussed above.

In these experiments, involving both unidimensional and multidimensional stimuli, no fixed time limit has been used as a rule. Other investigations have calculated transmission-rate-per-second.

Two experiments on central data processing and transmission were discussed by Attneave (1959, pp. 67-80). Quastler and Wulff estimated the rate of information transmission by expert pianists. Since music is ordinarily highly redundant, random sequences of notes were prepared. The range of alternative notes varied from 3 (1.6 bits-per-note) to 65 (6 bits-per-note). An estimated transmission of about 22 bits-per-second was the maximum obtained. An optimal range of alternatives seemed to be anywhere between 15 and 37 notes. With as many as 65 alternatives transmission rate declined. The basis for this decline may have been largely on the motor side, since so great a range of equiprobable notes made for large "jumps" on the keyboard between successive keys. The maximum transmission when typewriters were used with 32 alternatives was 15 bits-per-second.

Quastler and Wulff also estimated that the maximum rate of impromptu speaking is about 26 bits-per-second and the mean rate about 18 bits-per-second. In silent reading transmission may be as high as 44 bits-per-second.

When one estimates the amount of information in the example above, one uses the word as the basic unit. Words can be regarded as consisting of phonemes, and phonemes can be described from a binary point of view. The first linguists to present a fully binary description of phonemes were Roman Jakobson and his collaborators (Cherry, 1957, p. 95). The attributes chosen by Jakobson, et al., have been called distinctive features:

1. vocalic/non-vocalic;
2. consonantal/non-consonantal;
3. interrupted/continuant;
4. checked/unchecked;
5. strident/mellow;
6. voiced/unvoiced;
7. compact/diffuse;
8. grave/acute;
9. flat/plain;
10. sharp/plain;
11. tense/lax;
12. nasal/oral.

Each phoneme can be represented by cubic cells lying in a hyperspace of twelve dimensions. If one accepts the above description, then each phoneme contains 12 bits of information. Therefore, if a person can understand 3 words-a-second, and there are on the average 3 phonemes in each word, then a person can receive 12 x 3 x 3 = 112 bits/sec. This calculation assumes that different phonemes are independent. This does not correspond to reality, but is a useful approximation from the point of view of comparing various types of data processing. If one uses the letter as a unit, uses the same assumptions as above, and in addition assumes that each word consists of 6 letters, then one gets 4.7 ($\log_2 26$) x 6 x 3 = 84.6 bits/sec. In this case a letter is described as unidimensional. If one assumes also that each letter had 12 dimensions, one would get 84.6 x 12 = 1015.2 bits/sec. The point of discussing phonemes, letters, and words in this way, i.e., by considering them as primitives or basic units of speech or print, is to present an idea of the complexity of the data processing involved in decoding these two manifestations of a language.

Experiments by Sumley and Pollack (Attneave, 1959, pp. 76-77) showed that a subject could respond almost as fast when he or she had to choose between 256 words as between 2 words. The difference was only of the order of 10 percent, but obviously the rate of information transmitted increased, because a choice between two words only gives 1 bit of information, while a choice between 256 gives 8 bits of information.

One thing became fairly clear from these experiments and from thinking about problems in this area, that only a very restricted number of choices or decisions can be made consciously per second. When we read, for example, we may read with a speed of 5 words-per-second, and an estimate of information transmitted in silent reading gives 44 bits/sec. This stands in stark contrast to, for example, Jacobson's results. Can these results be reconciled so that they do not contradict each other?

Before answering, it is necessary to differentiate between the terms *information transmitting* and *information processing* capacity. *Transmission* seems to imply that data passes through an organism without being altered; while *processing* indicates that something happens to the information, that is, the output is different from the input. Transmission seems to be a mechanical process, a process which can be explained quite easily from the basic elements. Consider, for example, a voice transmitted over a telephone line. According to Fourier's theory the voice could be considered a composite of sine waves so that, in this instance, it would seem correct to talk about a mechanical transmission. What about a parrot that can repeat certain words? Is this a mechanical transmission of information? Not entirely. Some complex processes that we know very little about must take place between the auditory cortex and the motor cortex which enervates the vocal muscles of the bird. The word coming from the parrot will probably also be somewhat distorted compared to the original utterance. One may conclude that some information processing has taken place between input and output, even if the parrot's "parroting" of a human word sounds or appears to be mechanical.

As a third example, consider a person reading aloud to another. The reader may utter the words in what to him seems a mechanical process, but it is a highly complex process. Some million receptors in the eye may be involved, and some hundred thousand bits of information may be transmitted on the level discussed, for example, by Jacobson (1951a). But it is not this information that is transmitted to the listener. Information on this level cannot be transmitted from one person to another. What is transmitted to the listener is a highly refined or processed product--words.

When contrasting transmission in an electromechanical system like the telephone with transmission of information from one human to another, as in the example of the reader and the listener, one may say that the telephone system transmits information on the same level of complexity all the time, while a human decodes the input into a highly refined or processed product, and on the basis of this product transmits a very different and highly complex signal to the receiver.

In information transmission in humans, it should be kept in mind that much depends on how well one processes the incoming information. If it is easy to process, it is also easy to transmit to another person. But if a person cannot transform the input into a meaningful unit, his capacity to transmit this information to another is very limited. The limit seems to be around 2.3 bits with respect to raw data, as exemplified by the studies on unidimensional stimuli mentioned earlier.

Attneave (1959, pp. 42-80), in extensive discussions of transmission of information in humans, seems to have overlooked that stimuli vary enormously in complexity and in the ease with which they can be processed. These are very important points when considering how well humans transmit information. If information can easily be processed by a human, it also can easily be transmitted in most cases. A word among hundreds or thousands can easily be understood and transmitted by a human, while most people would have difficulty in identifying one tone if they were presented with more than five.

In answer to the question raised earlier; are Jacobson's (1950, 1951, 1951a) reported results compatible with Attneave's (1959, pp. 67-80), one can say "yes." The explanation is that they are concerned with two entirely different levels. Jacobson's transmitted information appears in one of the first links in the perceptual system, and this information transmission is something we cannot be directly aware of. We do not know which receptors or acuity squares have been stimulated when we have seen a chair, for example. But Attneave's type of information is easy to become aware of, and is, in most cases, a highly refined or processed product, as in the case of words.

What seems interesting is that by contrasting the figures of 4.3 x 10^6 bits/sec with figures of the order of 2 to 50 bits/sec, one may get a clear idea of the enormous amount of data processing that takes place on what may be called the perceptual level, and appreciate that only highly processed data reaches the brain. For each word read, 10 million receptors may have been activated, but we react to the "finished product" as one unit, gestalt (or whatever term one likes to use).

The gestalt psychologists most vigorously and clearly highlighted this problem. Their summary was that "the whole is more than the sum of its parts." They formulated laws and principles, about how we organize the world; two very important laws were those of "nearness" and "similarity." These laws gave what might be considered a reasonable explanation of why we perceive the world the way we do. The type of primitives they referred to would be elements like dots and lines; units that already had been through a fair bit of data processing and open to introspection or the awareness of a person. Other parts of the theories do not fit in with experimental data, such as field theory and the concept of isomorphism. Their idea was that there is an electrical field in the brain corresponding to a "real" world outside the observer. This theory was tested by inserting gold pins and also gold strips into the visual cortex of monkeys. These devices were supposed to disturb or "short circuit" the electrical fields. No disturbance or defects in pattern perception could be detected (Lashley, et al., 1951). In spite of this result, the gestalt psychologists' way of looking at perceptual problems may still be said to be valid.

THE SEARCH FOR BASIC UNITS

It seems true to say most sciences look for building blocks on which theories can be built. In physics the atom is one of the basic units; in chemistry, the molecule. In principle one can predict "chemical behavior" on the basis of physical theories, but in practice most of the equations that would have to be solved are too complex, even with present day computers.

In visual perception the receptor seems to be a natural unit to start. It is not difficult to look at them under a microscope (Luria, 1966, p. 129). Finding out how they are organized or linked together is, however, another problem. It has been possible to observe a limited number of receptors, but this approach has made it fairly clear that one gets only a very inadequate idea of its functional organization. The bipolar and amacrine cells form a highly complex network in the eye, and physiologists and other scientists working in the area are very reluctant to draw any general conclusions.

Jacobson (1950, 1951, 1951a) starts on a somewhat higher level than the receptor, and the advantage of using the "bit" as a unit is that it is independent of a particular physical structure and can be based on how many discriminations a system can make per unit of time. This approach also makes it possible to compare one perceptual system directly with another. It is very important to have a reasonably clear estimate of the basic information capacity of a particular perceptual system to be able to predict or calculate the maximum performance that can be expected, but it is just as important to know how good this system is in organizing these barely noticeable differences.

Psychology has no basic concept that is accepted or has been fruitful to the same degree as the atom or molecule, but "bit" seems to be a useful term if properly used. One advantage is that it can be used on all levels of analysis--but one would have to be careful in specifying what level one is discussing, and not discuss different levels at the same time.

At this stage it may be worth taking a look at some studies that tell us something about the more primitive elements or building blocks of our percepts. This evidence is of both a physiological and a psychological nature.

Hubel and Wiesel (1966) have made many experimental recordings of the reaction of cortical cells to visual stimuli. They have shown that the eye responds to formal characteristics of stimuli--to such things as edges, curves, and straight lines of different slopes. A large proportion of their experiments have been on cats. One experiment illustrates the specificity of retinal cells in this animal and how they can be considered among the first links in the data processing. A cat was presented with a narrow slit or line of light 1/8-inch wide and three inches long. Only when the line had a certain orientation, i.e., when it was placed in a ten o'clock-four o'clock orientation, did the cortical cells in which the electrode was placed respond vigorously. One may say that it reacted to "straightness." In addition, a certain orientation was necessary: a five- to ten-degree deviation in orientation of the line reduced the response markedly.

Hubel and Wiesel (1966) have in other experiments shown that there are "on/off" zones in the retina of cat, and that stimulation of one area inhibits the adjacent area. They also found that a line separating two areas differing in brightness gave the most efficient response if the line fell exactly on the boundary between the "on/off" zone in the retina. Furthermore, they reported that moving stimuli were very effective as stimuli. Some cortical cells responsed most vigorously to slow moving stimuli (1°/sec or lower) and other cells to a rapid movement (10°/sec or more).

Data from these types of experiments tie in nicely with results in "stabilized vision experiments." If the same spot on the retina is stimulated for 10 to 15 seconds or longer, parts of the stimulus fall away, such as the top part of a letter or a line, or a curve, that form part of a letter.

If one accepts the gestalt psychologist's notion of "good figure," it may be said that a straight line and a curved line, is "a good figure" or "a good gestalt." These straight lines and curves, then, may be considered as building blocks in the visual system. "A good figure" or "a good gestalt" may in this context mean a stimulus configuration that is easy to process. That is, the eye has a lot of straight line or curve analyzers, so the stimulus can be dealt with easily and effectively by the organism, and a simple signal can be sent to the brain. If the eye could not process the stimulus as one unit, many signals might have to be sent to the brain, and it would be more difficult to form a meaningful percept or building block out of which more complex ones could be built. Whether these primitives are something the organism is born with probably depends on what animal on the phylogenetic scale one is considering. The lower down one goes, the more likely it is that the analyzer can be attributed to "nature" rather than "nurture."

A recent experiment by Blackmore (1970) with a kitten brought up in an environment of only vertical stimuli indicated that the cat only developed vertical line analyzers and not horizontal ones. This experiment should be seen in the context of an experiment by Hubel and Wiesel (1963) reported by Gibson (1969, p. 235), in which two visually deprived kittens, 8 and 16 days old, had responses in the receptive field strongly resembling those of mature cats when exposed to patterned stimuli: "Visual experience is thus not necessary for the organization and development of striate nerve cells and their functional connection." But they found that prolonged rearing without patterned light did cause them to deteriorate. Lack of stimulation may lead not simply to a failure in forming neural connections, but on the other hand to the disruption of connections that were there originally" (Gibson, 1969, p. 235).

In view of these results one would expect that a certain type of stimulation of the human eye would be necessary if the eyes were to develop feature analyzers such as those people seem to use in the recognition of letters. This argument is quite compatible with the point of view that one has an inborn figure-ground mechanism in the visual system. If that mechanism did not exist, we would not be able to form any units at all.

The experiments discussed above are concerned with some of the basic building blocks in the visual system. Evidence also exists to support the notion that organisms have an inborn capacity to perceive global aspects of a stimulus. This seems to be more apparent the lower the position in the phylogenetic scale.

Tinbergen's (1952) experiment with the mating behavior of the stickleback fish seems to illustrate this point. What triggered off mating behavior was a certain form of a certain size and red color on a particular part of the form. Tinbergen does not say whether any learning had taken place, but on the findings put forward it seems fairly safe to assume that this particular behavior might well have occurred when the fish was in the mating season regardless of learning. Fish are very poor in learning almost anything, so even if they had had the opportunity to learn, it would be difficult to see how they could have learned this complex behavior. Consequently it would seem reasonable to assume that this behavior is "instinctive" and that the stickleback reacts to global aspects, i.e., form and color, of the stimulus.

Another example is that of frogs. They react to a dark stimulus that moves across the field of vision by sticking out the tongue--if the stimulus is dark, of a certain size, and moves with a certain speed. This stimulus corresponds to insects which are the frog's main food supply (Wooldridge, 1963, pp. 48-50).

Hess' (1956) experiment with imprinting in ducks produces some evidence that not all animals are "wired in circuits" in every respect from birth. They can learn a global aspect of a stimulus if the learning occurs during a short critical period of their life.

Sutherland's (1964) experiments with octopuses indicate that this animal has a rather limited capacity for learning. It can discriminate between vertical and horizontal, but not two thick lines which lean respectively 45° to the left and to the right. To discriminate whether an object is in a vertical or horizontal position is probably of survival value to the octopus, and this mechanism is probably innate or easily learnt early in life. It can therefore discriminate between these gross aspects of a stimulus in a reliable way.

An experiment reported in Forgus (1966, p. 167) showed that two vertical parallel lines were seen together 73 percent of the time, while a diagonal line between them was seen together with the left line only 22 percent of the time. One interpretation of this is that the two parallel lines belong to one system while the oblique line belongs to another system. That is, different analyzers process them and send the information to different functional parts of the cortex.

Senden's (1932) investigation of people with congenital cataracts regaining their sight after an operation, indicates that humans also have an inbuilt capacity to react to global aspects of a stimulus. Hebb (1949, p. 21) has pointed out that "...what Senden does show is the fact that patients always responded to certain objects as wholes and could on occasion detect differences between objects even in spite of nystagmus, and that there is a primitive or innate figure-ground mechanism." This, though, does not mean that the cataract patients can identify objects. Hebb claims that unity and identity have different determinants. If one of the patients were to recognize, say, a triangle, he would count the corners. Learning was also very slow, and there was no, or very poor, generalization. It is tempting to argue that because perceptual learning did not take place in a critical period of the patient's life, the capacity to generalize, i.e. shape constancy, did not develop or was severely handicapped.

Forgus (1966, pp. 27-28) divides the perceptual process into five stages:

1. Detection of light and change in light energy.
2. The gross discrimination of figural unity.
3. The resolution of a more clearly differentiated figure.
4. The identification of form.
5. The manipulation or modification of form, as in social perception and problem solving.

Stages 2 and 4 seem to correspond to Hebb's "unity" and "identification" respectively. It seems wise to consider the list more as an attempt to conceptualize what is happening in a perceptual process rather than as absolute categories.

COMPUTERS AND PSYCHOLOGY

A third type of experiment in pattern recognition is related to the use of computers. One may say that one tries to simulate perceptual processes in certain areas by linking sensing devices such as photoelectric cells to the computer. Different approaches are used, but often one classifies the methods as either a template or a feature analysis method. Most pattern recognition programs also allow for a certain amount of learning. Computer programs can be considered to be theories of how humans perceive patterns. The template method basically "sees" which pattern in the device most closely matches, say, a letter. The patterns used have often been either letters or numbers. Another approach has been to pick out characteristics of the pattern, such as straight lines, curves, and crosses, and to give these features varying weight. A certain set of features is then likely to be a given letter or pattern. A combination of these two methods is also used to some extent.

My purpose here is not to give an account of computer-aided pattern recognition, but to point to certain similarities between this approach and physiological and psychological approaches to pattern recognition. The most obvious similarity seems to be in what, with varying names, have been called analyzer, operator, feature, n-tuples, etc. They might be regarded as the building blocks of the perceptual system. These features have to be combined. In the computer this is done by elaborate programs. In living organisms very little is known about the mechanisms which bring about a percept.

Another factor which also seems to be of importance is the process(es) by which a rough idea of the whole gestalt is arrived at. For humans, Forgus' account, above, gives a fair idea. For computers, one tries to "normalize" a pattern by bringing it up or down to a standard size, or getting at some of the gross or main features of letters with some variation of the template method.

The various pattern recognition programs are very far from as powerful as the human eye, but they may give us some idea how part of our visual system works. And they may help towards clearer and more explicit theories which can be tested.

Part 2

Plasticity of Living Organisms

The higher up one gets in the phylogenetic scale, the more plasticity there seems to be in the organism. Man seems able to learn almost anything. He learns to write, read, adjust to the world when seen upside down as in Ivo Kohler's (1964) experiments, speak, understand Morse code directly, and so on. Considered from a rather superficial point of view, one gets the impression that everything can be learned; that different elements can be formed into gestalts or rearranged. But there is evidence that certain types of stimulus material are harder to organize--form gestalts of--than other types. For example, one can mention the experiences one has had so far with the Optophone (which transforms each printed letter into a sound pattern), the ultrasonic torch, and attempts to get people to decode speech sounds when presented visually, as on a screen. It does not deny that the last mentioned example can be of great help in teaching deaf and mute children to talk. But it would be very hard to understand speech when presented in a visual form without any preprocessing of the data; it would just be a lot of meaningless curves to the child. What extensive training could do is an open question.

ARTIFICIAL SPEECH

But the crucial point can be exemplified in the question, why is it easy to understand speech, but difficult to understand the Optophone? Since the Optophone is a device that gives a different sound pattern for each letter, it could be said that the auditory mechanism and the brain have a structure that makes it easy to process (or understand, if you like) speech sounds, but not the type of sounds produced by the Optophone. Max Clowes (1966, p. 345) puts it this way: that "it is the absence of higher-order auditory forms in the Optophone display which militates against its success." To make this very important point clear, a third example may clarify it. Wooldridge (1963, p. 164) says, "with respect to speech, the conclusion that we all employ the same areas of the cortex must appear to us to be rather remarkable, in view of the obviously artificial and acquired nature of the function." One may assume that he would use the same argument with respect to understanding speech, that it is "obviously artificial and acquired." This is very contrary to Chomsky's (1966) concept of language. Basically, Chomsky would say that we are born with the aptitude of understanding speech and producing speech. It is *not* foreign or artificial to humans, but a natural integral and very important part of the human structure. If not, we would need more than a lifetime to learn one language.

If learning to speak and understanding of speech were not "natural," we would never learn it to the extent we do. Part of our organism is particularly well suited to this type of information processing. It is easier for a person to produce speech sounds than arbitrary sounds or noise even if the vocal chords of the person could do it. In the same way, it is easier to make sense out of speech than out of the sound from the Optophone because we may assume there is an underlying structure more suited to cope with this type of information. There is obviously room for variation indicated by the fact that there are three to four thousand different languages in the world. Speech sounds, though, will belong to a restricted group of sound patterns that may be defined in physical terms.

In the following discussion the above mentioned points will receive more detailed consideration.

The first part will present evidence for the flexibility of man's learning capacity, and the latter part present some data that indicates a limitation--that everything is not learned with equal ease. This way of discussing the problem does not imply a dichotomy, that is, that certain things can be learned and other things cannot. Rather, it implies that certain stimulus material is more "natural" to learn than others. Normally, we learn what is "natural," but at times we classify it as "artificial," as in the above example from Wooldridge, but from some sort of superficial criteria. One seldom encounters "real artificial" stimulus material in a learning situation. We are learning what is behaviorly important and the organism generally has a structure that makes it well suited for this type of learning.

TRANSFORMED VISUAL INPUT

Stratton, in 1897 (Bartley, 1969, pp. 400-402), was the first person to study how humans adjusted to inverted vision. The results indicated that humans could learn to recode the distorted visual input relatively quickly. Ivo Kohler (1964) has made more extensive studies in this field, and in the following some of his findings will be reported and discussed.

Kohler (1964, p. 31) mentioned that a "very interesting investigation by a Russian had been reported in *Universum* (1950 No. 2). According to this paper, patients suffering from cataracts regained their sight when their corneas were used as focusing screens for projecting real images. By the time those images reached the retina they were right side up. This, however, did not disturb the patients, who, so the author maintains, soon began to *perceive* objects as right side up. Apparently, inversion of the retinal image is not a necessary prerequisite for veridical perception."

This is a general statement that sounds rather convincing, but not elaborated upon with respect to data and methods. Kohler set out to investigate this and other types of distorted visual input. The first experiment he reported took place in February 1947 and had a duration of six days. The subject used spectacles through which he saw the world inverted. Kohler (1964, p. 31) reported, "At first, this subject saw everything inverted, could not grasp objects without making errors, was extremely unsure of himself, and had to be escorted at all times. After three days, marked improvement was noted in all respects. On the fourth day, the subject went on a bicycle trip, on the last day he went on a ski excursion. During all this time, however, his perceptions were only sporadically right side up, things appeared right side up only when they were simultaneously touched, when a plumb line was used, or when they happened to be in the subject's vicinity." After having removed the spectacles at the end of the six days, the subject reported having apparent movement experiences and slight spells of dizziness. Occasionally, and only for a few minutes after the removal of the spectacles, did the subject see objects as inverted. In other words, the readjustment was rapid.

Shortly thereafter a second experiment is reported by Kohler (1964, p. 32); duration nine days, same spectacles but a different subject. After four to five days, the subject reported remarkable changes, and that the vertical dimension had become lost. For instance, two adjacent heads, one upright, the other inverted, were both reported as upright. One may say that the principle of economy seemed to operate here. It also seems to illustrate very nicely the fact that the visual system does not work like a camera. One may also interpret this result from the point of view that the visual system identifies things on the basis of a lot of perceived dimensions, and that ordering it upright or inverted is not very important, and not an outstanding feature for the visual system. When we have identified a thing, we know how to react to it. We do not have to decide if it is upright or inverted.

A third experiment (August, 1950) is reported by Kohler (1964, p. 33); duration 10 days (123 hours). The same spectacles and the same subject as in the previous experiment were used, but this study focused on the period of transition during which upright vision first began to emerge. The first experience the subject had of seeing something as reinverted, was when he touched the object with his hand. In other words, by touching the object with his hands, he managed to see the object as upright with the spectacles on. It was a sudden transformation. Gravitational pull and familiarity with objects seemed to be other factors that contributed to veridical perception; that is, helped the subject to see the world upright.

In these three experiments with inverted vision it looks as if four to five days are enough for a subject to make an almost perfect adaptation to the distorted input, and two to three days are enough to recover completely from it again.

Another series of experiments by Kohler (1964, pp. 34-42) involved the use of prismatic spectacles (wedge prisms):

1. January, 1933, duration 10 days. "The subject wore binocular prismatic spectacles whose angle at the apex was 15°, the bases arranged to the left. All signs of behavioural difficulty disappeared after only one day" . . . "After ten days of continuously wearing the spectacles, all objects had straightened out and were no longer distorted." After removing the spectacles, the subject experienced impressions of curvature distortions and apparent movement. Aftereffects lasted for four days.

2. February, 1933, duration 12 days. The same subject as above wore a pair of spectacles of which only the bottom halves were prisms, the top halves being ordinary glass. After 12 days integration of the two images occurred sporadically.

3. April, 1933, duration 22 days. This time the subject wore a monocular prismatic spectacle with a 15° angle. Perceptual aftereffect was transferred to some degree to the other eye which had been covered during the entire experiment. This should clearly indicate that higher cortical processes are involved.

4. November, 1946, duration 124 days. Kohler himself was the subject in a binocular study. Worth noting is that aftereffect interfered with normal vision for weeks, and "that those aftereffects which had taken longest to build up were the ones which persisted longest."

5. April, 1947, duration 50 days. The upper part of the spectacles used distorted vision 10°, the lower part was normal glass. After 10 days there was a gradual adaptation to the prism without concomitant disturbances of normal vision. The subject's vision had become differentially adapted to both conditions.

This recorded series of experiments indicates that the visual system somehow manages to adapt to a distorted input with surprising plasticity. The transformation process is something that takes place mainly on the perceptual level and most of the learning takes place without awareness.

A third series (Kohler, 1964, pp. 42-46) of experiments were with colored glasses, of which two will be mentioned:

1. January, 1947, duration 20 days. The subject wore a pair of spectacles of which the left half was colored blue and the right half yellow. In the course of the experiment, it was noted that both colors subjectively faded away. This suggests that the same retinal areas became simultaneously adapted to complementary stimuli. Looking to the right (without spectacles) resulted in increased sensitivity to blue, and looking to the left, the same sort of sensitivity to yellow.

2. March to April, 1947, duration 8 plus 19 days (with a two week interruption). The spectacles were ordinary glasses covered with a red diagonal stripe one centimeter wide. This stripe was "overlocked"--that is, it faded away after some time--but a green beam was reported for three to four days after removal of the glasses on the corresponding spot.

From the above, one is struck by the workings of the visual system and man's amazing adaptability, or, put differently, the organism's remarkable ability to learn to make sense out of distorted visual input. How does it happen? There is not a satisfactory answer to this question; that is, no theory that can explain what is taking place with any degree of detail and confidence. But one becomes aware that an enormous amount of data processing takes place, and this mainly of an unconscious nature. It may be worth mentioning some of Kohler's comments (1964, p. 123) on these experiments. "The retinal area becomes the isomorphic equivalent of mnemonic details by 'sorting' all excitations according to the circumstances governing their recurrence, and not by merely summating them unselectively. If it did that, adaptation to alternating complementary stimuli (opposite distortions) would be completely impossible. . . ."

". . . the link between the original optical data and the situational factors is established not directly but in a roundabout way, via after-images which are sometimes enhanced, sometimes suppressed." This should clearly indicate that man's visual system cannot satisfactorily be explained as "wired in circuits," or a camera; that is, a mechanical type of theory seems utterly inadequate.

Further, Kohler says (1964, p. 127): "It is time we give extra thought to this whole phenomenon of *increasingly veridical perception* which always occurs when experimental spectacles of any kind have been worn for some time. What is the advantage when a taut string, for example, begins to look straight to us no matter how curved the corresponding retinal image may be? Or when a rigid substance keeps its rigidity no matter how elastic it has been made to appear with the spectacles?"

"We are confronted here with a peculiar relationship between optical and physical facts. We always find that it is the physical dimensions of things which have a tendency to become visually correct." A bit later (pp. 127-128) he says: ". . . in the process of adaptation, it is always the world with which we are familiar which wins out in the end. It does so in the interest of simplicity and economy."

One paragraph later, on page 128, Kohler goes on to say: "What good is a theory of sensation which is not applicable to complex situations and which necessitates our formulating *ad hoc* hypotheses every time some incidental condition is found to be present? Yet this is precisely the state that the study of perception has been in."

It might be added that this adaptation helps the organism to adjust to the environment. One may say it has, ultimately, survival value. But at the same time it is surprising to what extent the subjects in these experimental situations could adapt. Experiments with animals indicate that their adaptability is very restricted or cannot adapt at all when they receive distorted visual input. In man it appears as if the input can be anything, and, provided there is opportunity for learning so that the distorted input can be related to reality, man seems able to make sense out of it. This is the type of conclusion one is tempted to draw from Kohler's experiments.

One would, on the basis of these studies, think that man would be able to learn to relate to the physical world in an adequate way when given this information in an auditory code and if appropriate training was implemented. But before formulating any hypotheses in this respect, more relevant material will be examined.

WHAT MAN CAN LEARN

Another example of the visual system's "ability to learn" is given in Bruner, Goodnow, and Austin (1956, pp. 46-47). The authors tell how a person trained in histology learned to distinguish corpus lutum from the surroundings. The person was trained to see it as a gestalt: "What is happening here is a recording in the stimulus input in terms of those features of the object perceived that make possible the reconstruction of the remainder of the object. Such reconstruction is possible because in fact the defining features of most objects and events are redundant with respect to each other." In other words, the eye can extract a multitude of features from an object or an event and piece them together in a way that is desirable. These features then will, after some time, form a gestalt for us. In other words, we organize part of our surroundings for a particular purpose that is useful to us.

Reading

Learning to read is a third example of how we form gestalts. At first a person has to learn to discriminate among 26 letters if he or she is living in an English-speaking country. After a rather short time this is learned and then the process of uniting the letters together to form words begins. This is a somewhat lengthier process, but can still be learned in a matter of a year or two. With further practice, one is able to take in perhaps a whole sentence with one glance. Higher order hierarchies are thus built up.

It is in a way surprising that these artificial signs that we call letters can be strung together in such a way; perhaps the letters are not *that* artificial. The gestalt psychologist would talk about "good figure," implying that certain configurations are easier to perceive than others, and letters seem, to some extent, to be of such a kind. Perhaps they are also made in such a way that they are maximally discriminable within the limits of economy, that is, they do not take up too much space and are easy to print or write. But this objective again may be contrary to, or at least not helping, their incorporation in an organic way into a larger gestalt, a larger hierarchy. It seems to be true, to some extent, that the speed of reading approaches an asymtote, say after five years, even though special training methods can attain more. If one, for example, considers how humans can perceive a picture or an object as a gestalt, even if they cover a bigger area of retina than, say, a page of a book, one must admit that that type of perception is more effective. When we consider that we need perhaps two minutes to extract the meaning from a printed page, one is reminded of the Chinese proverb that one picture is better than a thousand words.

In spite of these reservations, it is surprising to what extent one can build up gestalts in reading. The reason for this is that we read much faster than we could possibly do if we paid attention to each letter. Certain types of dyslexia or aphasia make us aware of how vulnerable this system is. Small or perhaps undetectable organic injuries or malfunctionings can upset this learning process, rendering a person unable to build up these gestalts, or to make it a much harder task.

Writing

Writing has much in common with reading, but speed here is limited by the speed with which we can move the hand. Initially, when we learn to write, we have to pay a lot of attention to how we form a letter, but after some years of practice it is enough just to think of the word, or, what is more common, a string of words or a sentence, and the right letters are formed.

Writing is in one way exactly the opposite of reading. While in reading we gather information from many letters and organize them so that the end product is a meaningful word or an idea, the writing process starts from an idea and the end product is a string of letters. But both processes involve an organization of an hierarchical nature. Both processes imply the organization of a gestalt or an idea of a unitary nature within the organism.

Speech

To understand speech and to speak can, in principle, be considered to be very similar to the reading and writing process. While the letter can be considered to be the basic unit in reading and writing, the phoneme can be considered the basic unit in speech. Bruner, et al. (1956, p. 249), indicates that the phoneme is often called the smallest unit of speech that "makes a difference" to a listener or a speaker. The gestalts built up here are of the same type as in reading and writing, which is natural enough. Speech precedes reading and writing. The latter is basically built up on the base of the spoken word. So listening and speaking is a way "natural" to man, while reading and writing are "artificial." With respect to speed, it is surprising to discover that on the input side, the "artificial" input, reading, is two to three times more efficient in taking in words than the ear; while on the output side, it seems to be the other way around.

PERCEPTION

Still, with respect to all the four functions--reading, writing, listening and speaking--it is clear that an enormous amount of data processing or organizing is taking place, and that almost all of this organizing is taking place on what may be called the perceptual level. Most of this data processing is taking place without the awareness of the human involved in it.

As far as the learning process goes, it seems to be more of a conscious element in the four processes just discussed than in the adaptation that took place in Kohler's (1964) experiments. One may say it is more a cognitive process which is involved in learning to read, write, speak, and understand the spoken word than in learning to adapt to distorted visual input.

It is not difficult to find examples of animals that cannot learn perceptual tasks. The chicken that cannot learn to pick the grain when the visual field is displaced 7° to the right or to the left with prisms (Hess, 1956) is one clear example of limitation in learning capacity of perceptual tasks in animals. However, with respect to man, things are rather different. It is difficult to find good examples that illustrate limitation in man's learning capacity. One area that does give good examples is work in relation to reading machines for the blind.

UNDERSTANDING SPEECH

Studdert-Kennedy and Cooper (1966, p. 317) are in agreement with others (Attneave, 1959, p. 80) when they say, "Normal speech may be comfortably followed at a rate of more than 200 words-a-minute. The listener handles some 40 to 50 bits of information a second. *This rate is an order of magnitude greater than listeners have achieved with non-speech code* so far developed. There seem to be two main reasons for this. First, speech signals are multidimensional and their dimensions are not arbitrary: they are determined and organized by characteristics of the articulatory apparatus that generates the signal. Second, a reason closely related to the first, speech signals form a complex pattern of overlapping, or shingled cues, *a flowing auditory display of which elements are provided to the listener in parallel rather than in series*" (italics added). This should support the view that the ear of a human is specifically well suited to process speech sounds. One may contrast this with the following: "Nye modified the conventional Optophone to permit variations in the number of dimensions in the display. He found that an increase in the number of dimensions could improve rate as well as accuracy of identification. But performance was still poor--less than two bits/sec with the more successful display" (Studdert-Kennedy and Cooper, 1966, p. 322).

Why is it that speech is easy to understand? "To sum up, we have argued that the only known acoustic signal adequate to the coding of written text for easy and rapid assimilation is speech. The advantages of speech stem from its intricate, multidimensional pattern of overlapping cues, determined and organized by the articulatory apparatus. *Some other satisfactory set of dimensions and principle of organizations might be found.* However, there is no rationale for the search and we seem little closer to the discovery today than we were fifty years ago. We are therefore inclined to accept our fate and to give our attention to the development of a reading machine that talks" (italics added) (Studdert-Kennedy and Cooper, 1966, p. 323). This seems to emphasize that we know very little about the perceptual mechanisms that underlie our processing of speech. The authors have earlier in the same article pointed out how one sound is dependent on sounds both before and after for its meaning. In other words, the sound elements are highly interdependent.

SPEECH SYNTHESIS

Work has been done in the field of synthetic speech. Studies on acoustic cues for speech perception made it possible in the late Fifties to consider the use of the cues in a set of rules that could be applied to a text (written in phonetic transcription) and would generate synthetic speech from it. The rules for the synthesis were drawn up by Liberman, et al. (1959), and Cooper, et al. (1963). The conversion of a phoneme sequence into intelligible speech was done in a rigidly prescribed manner, so that a computer could be used to synthesize speech essentially by these rules. The use of a computer to synthesize by essentially these rules was demonstrated by Gerstman and Kelly (1961). Studdert-Kennedy and Cooper (1966) seem to say indirectly that these methods may produce some bizarre sound sequences that remind us little of English. English, unfortunately, is not a language that always goes by the rules for pronunciation, because 20 percent of English words have their own unique pronunciation. Accepting this, one would expect 20 percent "bizarre sounds" to be generated! Many other languages (for example, Spanish) would be better in this respect, since letters are pronounced consistently far more often than in English. Another problem in reading machines is to develop a pattern recognizer that can recognize all or most types (fonts) of letters, but this is a different problem.

Riley (1966, p. 420) reported that the two best of six subjects reached a reading speed of 5.5 and 4.0 words-per-minute after 200 training lessons on the Optophone. Each lesson lasted about one hour. This can hardly be called an encouraging result. Another study at Batelle Memorial Institute quoted by Riley gave an average score of 12 words-per-minute for 3 subjects. They were ten years younger, on the average, than the subjects in Riley's study, and of normal intelligence. The subjects in Riley's group ranged from 110 to 141 IQ on the Wechsler Adult Intelligence Scale. Age, and probably more important, a slightly different "set up," were the main reasons for the discrepancy in results.

As these results indicate, one is far from having a reading machine that is of practical use for normal reading. What is needed is to have some data processing device between "the raw sound" and the receiver. Research data on the salient psychological dimensions would help, given relevant information, in constructing such a device.

THE BRAIN AND DATA PROCESSING

To gain further insight into various types of auditory data processing, it seems worthwhile to take a look at some of Luria's (1966) work. He began by discussing localization in the brain--of areas that have certain functions as compared to the view that the brain is able to do all sorts of functions. Luria takes no dogmatic stand, in the sense that he points out that this is not an either/or question. He emphasizes, for example, that what is called a "function" is a highly complex process. The following seems representative of his attitude: ". . . a sensation is always an active reflex process associated with the selection of the essential (signal) components of stimuli and the inhibition of the nonessential subsidiary components. It always incorporates effector mechanisms leading to the tuning of the peripheral receptor apparatus and responsible for carrying out the selective reactions to determine the signal components of the stimulus. It envisages a continuous process of increased excitability in respect to some components of the stimulus and of decreased excitability in respect to others," (Granit, 1955; Sokilov, 1958). In other words, sensation incorporates the process of analysis and synthesis of signals while they are still in the first stages of arrival. These concepts, so fundamentally opposed to the previous hypothesis of dualism (the passivity of the first physiological and the activity of the subsequent psychological stages of perception), constitute the principal distinguishing feature of the Pavlovian view of the sensory organs as analyzers. According to this view, from the very beginning the sensory cortical divisions participate in the analysis and integration of complex, not elementary, signals. The units of any sensory process (including hearing) are not only acts of reception of individual signals, measurable in terms of thresholds of sensation, but also acts of complex analysis and integration of signals, measurable in units of comparison and discrimination. The sensory divisions of the cortex are apparatuses responsible for this analysis, and indications of lesions of these apparatuses are to be found, not so much in a lowering of the acuity of the sensations, as in a disturbance in the analytic-synthetic function," (Luria, 1966, pp. 97-98).

Luria is not quite explicit about the use of the term "signal," but other parts of his writing seem to indicate that he considers them somewhat more complex than the Just Noticeable Difference (JND). The passage quoted can be considered an explanation, on the physiological level, of how a person learns to see a cell, by combining the various features or signals from a complex stimulus. (Compare Bruner, et al., mentioned earlier.) Both Bruner's (1956) and Luria's (1966) point of view seem to be that a person can combine and form a gestalt or chunk out of whatever array of stimuli he chooses to pick. In other words, they seem to support "nurture" rather than "nature." One implication, from this point of view, would be that one can expect a person to learn to understand "visual" information in an auditory code when trained to do so.

While Luria's remarks may be regarded as evidence for the brain's plasticity, the following points to its specificity: "In the context of the present description one further fact, well known in clinical practice but not yet amenable to psychological and physiological explanation, may be mentioned. The disturbance of phonemic hearing as a result of a lesion of the temporal region is not necessarily associated with a disturbance of melodic (musical) hearing; in fact, the latter is more commonly preserved. Conversely, as several writers believe, (Feuchtwanger, 1930; Ustvedt, 1937; Ombredane, 1945; etc.), a lesion of the right temporal region, and (according to other findings) a lesion of the left temporal pole, does not affect phonemic hearing, but may lead to impaired discrimination between tones and rhythms and manifestation of amnesia. This finding implies considerable selectivity of disturbances of complex cortical functions in the presence of circumscribed brain lesions. However, the relationship between a disturbance of phonemic hearing and a disturbance of musical hearing requires further, careful investigation," (Luria, 1966, pp. 112-113).

In support of the point that music and speech are processed partly by different mechanisms, the following may be mentioned. G. Selby, in a paper entitled, "Localization of the Parietal Lobe Function and Dysfunction," in an interdisciplinary symposium on cerebral localization at the Royal North Shore Hospital of Sydney, Australia on the 5th April, 1970, told the audience that he had had a 72 year old man as a patient who could understand music or a melody either when it was hummed to him or when he was reading the notes, but that the same patient had a very poor understanding of speech and printed material.

The unique position of speech is very well expressed by Luria (1966, p. 100): "Modern linguistics tell us that the articulated sounds of speech differ radically from sounds not related to speech. Two features characterize the sounds of human speech. In their origin and structure they are always organized in a definite objective language system, and consequently, they are special, generalized sounds. Physiologically they are always complex and are produced with the aid of the phonation-articulation apparatus, without which they can be neither pronounced nor perceived."

With respect to the point that there are common mechanisms in speech and listening, G. A. Miller, in discussing what is universal in languages across cultures, points to the fact that we alternate in speaking and listening, and he says: "Perhaps there is some limit imposed by the agility and alteration, perhaps some critical component of the speech apparatus must be actively involved in the process of understanding speech. . . ." (Miller, 1965, p. 95).

The above evidence indicates rather clearly that speech sounds are easier to process for a human than other types of sounds, perhaps with the exclusion of musical sounds. What are the underlying features of musical and speech sounds that make them easy to form gestalts? It would be of interest to investigate other types of sounds with respect to how easy or difficult they are to organize.

General Discussion

Humans are highly dependent on information from the environment, and the eye is the most important and effective transmitter and transformer of various types of information. Two classes of information are especially important. One is information that enables us to move around; the other is symbolic information, most often in the form of ink print or pictorial displays. One has to approach these two classes of information separately for blind people. Some people have concentrated on building reading machines for the blind, others have put efforts into devices that would aid a blind person's mobility. The two groups do not seem to interact significantly. They listen to each other at meetings, but work in one field does not seem to influence work in the other.

COMPARISON OF EXPERIMENTAL RESULTS AND THEORETICAL EXPLANATIONS

The present analysis started out with the notion that both problems, mobility and reading, could be considered as information-processing and collection. The auditory modality was chosen for study.* One experiment gave support to the notion that two types or classes of sound have much in common, psychologically speaking. A correlation of 0.65 between "15 Shapes"# and part one of "Wing's Standardised Tests of Musical Intelligence" seems representative for this experiment (Appendix 1).

Another experiment shattered this notion. The correlation between the same part of the musical test and the score on an obstacle course using the Ultrasonic Torch was 0.18 (Appendix 2).

The basic and main, formal information-carrying aspect of the sound from the ultrasonic torch is pitch, but one cannot be sure that this is so psychologically. Listening to the sound from the Torch and to musical sounds gives, subjectively and psychologically speaking, very different experiences. One factor involved is that the Torch produces the sound in pulses, so the sound is coming and going the whole time. Another is that the sound is very complex and diffuse and does not have the clarity and definition of musical tones. A third factor is that pitch may easily be confused with loudness, because the torch seems to have a maximum loudness at about five feet from an object. So, even if the main information-carrying feature is variation in pitch, it seems very hard for a person to pick out this aspect of the stimulus. To be able to do this may require long training and/or a special set of aptitudes. The low correlations among the three Torch Tests: Obstacle Course, Distance, and Recognition (Appendix 2), indicate that it is not only a matter of processing auditory information; that is, auditory information processing does not seem to play an overwhelming role. If that had been the case, one would have expected these three tests to correlate more highly with each other because the sound from the Torch in all the three test situations may be considered to be similar.

Assuming that each of the three Torch Tests has a reasonable reliability, one will have to conclude that

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*Supported by a grant from the University of Sydney, Australia.

#"15 Shapes" was a test in which the subject was asked to identify 15 shapes described auditorially. A mechanical contour follower was connected with an oscilloscope so that when the contour follower went up a slope, an increasing frequency was heard, and a decreasing tone was heard when it descended. A horizontal plane gave no alteration in frequency. The subjects were trained for about one hour.

other factors than the auditory aspects of the test situation were of importance, because of the low correlation between the three Torch Tests. One can see that the correlation between language and music is low, and this also applies to the correlations between the Torch Tests and these two aptitude tests (Appendix 2). One would think that these three groups of tests--the Torch Tests, the language test, and the music test--had a reasonably high intercorrelation, because they all have sound as a key feature, an important element, in them. But the data indicates that psychologically these three test groups have very little in common. It seems consequently rather meaningless to speak about auditory information processing as if this is a unidimensional concept. The three types of sounds discussed are all transmitted by the human ear, but after that these sounds are apparently dealt with by different functional systems within the human organism. Both 15 Shapes and music seem to measure fairly pure and simple aspects of the sound stimuli; the musical sounds and the sounds in the 15 Shapes Test are similar, psychologically speaking, and each to quite an extent belongs to a closed system that is fairly independent and an end in itself, while both language and the Torch Tests seem to be heavily involved with other structures of the brain. Language is integrated with the cognitive structures. Without that connection man would probably not have been able to develop a symbolic and objective language system. One of the requirements of the test situation with respect to the Torch Tests, the Obstacle Course in particular, was that the sounds from the Torch were to be linked up with motor behavior. There probably is no antecedent in the human nervous system that may facilitate these alien sounds being processed; nor in being connected in any specific favorable way with the relevant part of the motor cortex. So the Torch sounds are probably propagated through the brain in a rather diffuse way, trying to link up with the appropriate motor areas. How well a person learns in such a situation is probably more dependent on higher order strategies, of which the subject may be conscious or unaware, than on any specific aptitude. In theory this could be tested (that is, how the signals or electric impulses were propagated) if one had microelectrodes in various parts of the brain, and then observed which area became aroused by the different types of stimuli. An EEG would probably also give information of value. One way of approaching the problem would be to use the conceptual framework outlined by Luria (1966, pp. 70-77). The main point he makes is that different tasks require different functions, and these functions can be considered as consisting of small data processing units. The various units are different with respect to importance for various functional systems, and lesion, malfunctioning, or poor performance of one unit can influence the whole functional system in various ways. This approach could be suitable for computer simulation.

In Kohler's (1964) experiments, the subjects learned relatively quickly to react appropriately to the transformed visual input. The Ultrasonic Torch can be considered as giving a transformed auditory picture of the physical world, but few people learn to decode this information in such a way that it greatly improves their mobility. What applies to the Torch also applies to the Optophone (Clowes, 1966; Riley, 1966). That is, they do not learn to use this information efficiently because it is too difficult to decode with sufficient speed. There is a clear contrast between the performance of the subjects in Kohler's (1964) experiments and the subjects in the experiments where the Ultrasonic Torch was used for mobility purposes.

The subjects in Kohler's (1964) experiments could do things like skiing and bicycling after about four days. These activities are considered rather complex, and require a fair amount of information from the environment. This information had to be processed, coded, or understood forthwith by the subject if these activities were to be performed successfully. No activity of this complexity has been tried, to the present writer's knowledge, using the Ultrasonic Torch for guidance or monitoring of behavior. The most proficient Torch users can walk down the street or on a pavement almost as fast, efficiently, and safely, under normal circumstances, and in a familiar environment, as a sighted person. But these blind people normally have had at least several months' training and experience with the Torch, and only a few seem to reach this stage of skill. One inherent restriction with respect to the Torch is that its maximum range is 30 feet. This probably makes it necessary for a blind person to adopt a different strategy for his mobility behavior than the person who sees the world inverted. One would think that orientation in particular is more difficult with the Ultrasonic Torch, while a person can orient himself or herself almost as easily in spite of seeing the world inverted. The range of sight would be the same as under normal circumstances.

When comparing the Ultrasonic Torch with the Optophone, one gets the impression that the former has been somewhat more successful than the latter. The author has observed only three out of fifteen blind people trained for at least some months in using the Torch who could be characterized as good Torch users, while the rest seemed to be equally well or better off with a cane or a guide dog. Out of another group of 12 visually handicapped people having three lessons with me in Oslo in using the Ultrasonic Torch, one managed after this training to walk along a guideline made up of grass and soft bitumen (the type used on a racing track) as fast and confident as a sighted person walking with more than average speed. He went blindfolded because he had some vision, and could be characterized as musical, intelligent, average in sport, and openminded. At least 3 students out of 102 could be categorized the same way. Maximum reading speed with the Optophone after extensive training is low (10 to 25 words-per-minute), (Smith, 1966, p. 367). The impression one gets from the literature is that the only person who seems to use the Optophone extensively and for whom it is a practical proposition is Miss Jameson, (Dufton, 1966, pp. 317-407).

One may ask *why* the subjects in Kohler's (1964) experiments performed better than people using an Ultrasonic Torch. Two points can be made:

1. The recording of the transformed visual input is a relatively simple process or task. For instance, inversion of the retinal image has no basic consequence for veridical perception (pp. 29-30).

2. The visual areas of the cortex would most probably still have the same good connections with the motor areas relevant for mobility in spite of the transformed visual input.

The first point is probably the most important one. Going back to the auditory input one realizes that two problems have to be overcome. One is to find auditory stimuli that easily form gestalts, and the second is to link these perceptual gestalts to the other structures relevant to a particular function. With respect to the reading function, the problem seems to have been solved in principle, in that reading machines for the blind have so far been most successful when speech-like sounds have been used. The superiority of speech-like sounds over other types of auditory displays has been clearly demonstrated, (Clowes, 1966, pp. 344-350).

Consider for a moment that another class of sound stimuli other than speech sounds such as Morse Code was used in a language system. That is, are the speech sounds unique with respect to suitability for linking up with the cognitive structures of the brain? Would it be harder to integrate other types of sound structure with the cognitive structure related to language? There is evidence to suggest that this could be realized. One can use the objective language system for reference and meaningful units, despite the varieties of signs, as found in patterns of letters and the Morse Code. The most crucial factor seems to be that a gestalt or unit can be easily formed at the word level. But how would "an Ultrasonic Torch with a spoken word output" be for mobility? This question can actually mean two things. One is a Torch that actually acts like a human being, say the air traffic controller that "talks down" a pilot under poor visibility conditions. This probably conveys to the pilot a totality, as words become translated into the spatial positions of the aircraft. Such a Torch is not a practical proposition. Technology and science have not advanced that far. But say one could construct a type of Torch that could give a speech-like output, that was easy to organize in the same way as speech sounds are easy to organize into words. Would it be easy to link these gestalts up with the appropriate motor areas in the brain relevant for mobility? Would it be possible to get a good dancer to perform the same movements when directed by words instead of music? It seems doubtful. Words seem adequate when it comes to general behavior and to gross aspects of mobility behavior, but when it comes to the finer nuances of movement, music seems to be more effective. One may interpret Luria's (1966, p. 99) writing as support for the present argument, even if Luria seems to have a general tendency to argue that everything can be associated with everything else. The consequence of the argument put forward here would then be that one should try to make the sound from an Ultrasonic Torch or a corresponding device more like musical sounds, while the present consensus to make reading machines that give speech-like output seems to be a sound one.

MOBILITY

The discussion above has been general in the sense that it has concentrated on what type of auditory output is most compatible with the human perceptual and motor systems in devices constructed with blind people in mind when these devices are to be used for reading and mobility. It seems reasonable to assume that orientation or keeping direction is an important part of the mobility function. Experimental results (Appendix 2) give some support to this notion. Other researchers in this field have been aware of the problem, and at least three different devices designed for this particular purpose have been constructed. Jacobson's (1963, Vol. 1, pp. 193-197) device was based on a magnetic compass. Swail's (1963, Vol. 1, pp. 199-204) was developed from radio receivers with ferrite rod antennas because of its extreme directivity, and Kohler's (1966, pp. 215-219) used galvanic stimulation that affected the vestibular apparatus. Kohler's (1966) idea in particular seems interesting. His device requires no learning and would probably have an advantage over the other two devices in real space. If the burden of keeping direction is taken away from a blind person, more concentration can be devoted to avoiding obstacles. So it seems quite feasible to use a directional device in connection with the Ultrasonic Torch.

The eyes in a human are so effective in monitoring our behavior, mobility behavior included, that they do this almost always without our awareness. When we walk from A to B we do it automatically and think of other things when we walk. If a blind or blindfolded person tries to do the same with the help of an Ultrasonic Torch, it requires full concentration, and certain things in the way will be uppermost in the mind of the blind traveler. When speaking to blind people one gets the impression that what they fear most is holes in the ground, or that a relatively level surface suddenly goes steeply downwards--like a flight of stairs. This would suggest that a device like the Ultrasonic Torch should have special feature detectors built into it. To do this successfully a careful analysis of the physical environment would have to be carried out beforehand to find out what is behaviorally important for safe and reasonable efficient mobility. Besides holes in the ground, one can think of other things that it would be important to detect if safe travel is the objective: fast moving objects such as cars, motorcyclists, and bicyclists. Sharp edges and low obstacles are also often things that could endanger travel. It is important that the whole physical environment relevant for traveling be considered as *one* system, and that "the Ultrasonic Torch system" should be constructed with this in mind.

The point of view that the environment or ecology should be systematically studied is expressed in a general way by Brunswik (1966, pp. 510-511):

> . . . I have advocated that in psychology research not only individuals be representatively sampled from well-defined "populations" but also stimulus situations from well-defined natural-cultural "ecologies" (Brunswik, 1947; 1949); only by such "representative design" of experiments can ecological generalizability of functional regularities of

behavior and adaptation be ascertained. Representative sampling of situations from the ecology allows us to take cognizance of the occasional major failures that result from the fallibility of perceptual cues or behavioral mean while at the same time fully recognizing the favorable cases also. Generalization of the achieved degree of success to the ecology as a whole becomes possible with the use of the routine technical criteria for sampling statistics hitherto confined to differential psychology."

How is sampling of the environment to be performed? Brunswik in an early size-constancy experiment gave the following indication, (1956, p. 44):

> . . . randomly sampled from the normal environment of a university student, stopped in her daily routine. . . to write down her estimates of the extension that happened to be most prominently attended to by her as "figure" in her visual field of the moment, as well as of other elements of the situation, shifting from one of five attitudes to another.

How useful would this approach be applied to a blind person? The basic notion of sampling of the physical surroundings in which the blind person is traveling seems sound, but to simply stop the blind traveler at random time intervals seems rather pointless. It seems necessary to consider not only the actual travel paths of a blind person, which often are very restricted, but what their future travel paths would be. That is, what should be considered is not only what the blind person is doing, but what he or she would like to do if they could do it safely and with confidence. Conceivably, one could follow a blind person traveling under various conditions deemed representative of the type of traveling relevant for a particular blind person, to see what type of problems he got into, and what would be needed to solve them. For instance, a different type of traveling aid system might be needed for a person living in the country as compared with one living in a city. For instance, a farmer who wanted to detect his animals could have a torch with built-in infrared sensing mechanism, and one who traveled a lot in city areas could have a device that could detect "walk" at traffic lights by being able to discriminate between green and red.

The general approach and consideration when building sensing devices and other aids for the blind should be that man and the environment should be considered as two interacting parts in an overall system.

Technological and scientific developments have made many of the things just discussed potentially possible. For instance, it is essential that minicomputers that seem necessary for partial processing of incoming data be small. An indication of how small they may be built is given in this excerpt from *The Australian*: "Theoretically, it is possible to store one million bits-an-inch by magnetic bubble techniques, but the present constraints are how to make the host material, garnite, large enough and defect-free" (Bennett, 1969). Small and efficiently integrated microcircuits (which consist of, for instance, *and* and *or* gates, which can process information in less than one millionth of a second, and that have dropped dramatically in price in the last few years, due to mass production) make minicomputers which can be used in connection with mobility aids for blind people a feasible proposition. The system of detectors and minicomputer(s) should be built in a hierarchical way, so that configurations in the environment, such as a sudden drop, would give a clear signal that could not be ignored because it represented a potential physical danger to the blind and would make a person stop immediately. This signal could then be given top priority. Hopefully a blind person may one day put on a suit that would be a combination of a sensing device and a minicomputer.

COMPARISON OF SENSE MODALITIES

One very important problem to consider is what sensory system can best replace the visual system. The Ultrasonic Torch can give a resolution power of about 1° within a range of about 10 feet (Kay, 1963, p. 152).

As mentioned earlier one can also detect if an object is approaching or going away, down to an accuracy of 1/4" under optimal conditions. This would correspond to a resolution power of about seven minutes. The eye is considered as having a resolution power of one minute, but the fact that astronauts reported seeing details of things on earth which would require a far greater resolution power of the eye than expected, and, therefore, indicates that the method and the form of the stimulation are important variables. The Ultrasonic Torch could provide a rather detailed picture of the physical world *if* the subject could use all this information, but it is quite clear that only a fraction of this information is used because the sound is not compatible with the human auditory system. Starkiewicz and Kuliszewski (1963, pp. 157-166) experimented with an Elektroftalm. "The Elektroftalm is an apparatus to enable the blind to recognize objects in their surroundings through the use of the action of light rays coming from the objects upon photosensitive elements." The stimuli were tactile elements operating on a pressure principle, so that increasing light intensity was converted into proportionally stronger pressure. They used 80 elements and reported a resolution power of 2°, but because of the deterioration of part of the equipment, no clear indication of how easily the subjects formed images was reported. Muratov (1965) used photoelectric devices equipped with sound signalization with some degree of success. Bach-y-Rita (1972) used a TV camera and tactile vibrators in a 20 x 20 display placed on the subject's back. Results indicated that the subjects learned to form images rather quickly. What would be the information processing capacity of the skin when a display such as the one just described is used? Given that the skin can discriminate between five different frequency levels and five different intensity levels, and that all the 400 spots could be separated from each other, the information capacity would be

$$(\log_2 5 + \log_2 5) \times 400 = 1840 \text{ bits.}$$

If the same assumption is made as was for the ear, that is, four discriminations-per-second, one gets

$$1840 \text{ bits} \times 4 = 7360 \text{ bits/sec.}$$

The calculated capacity is close to the information capacity of the ear, but far from that of the eye. The same system, with 400 vibrators, would have a resolution power of about 1° if it covered an angle of 20°. Does the skin have a greater capacity than indicated by the figure just mentioned? "We have found that experienced subjects can resolve stimulator tips spaced between 5 and 10 mm on the trunk, and closer elsewhere. This indicates that over 10,000 points may be available on the approximately 4000 cm^2 area of skin of the trunk. This would permit 100-line television picture projection, providing a relatively high resolution display" (Collins, 1971, p. 2). On the same premises as before, this will give a capacity of 7360 x 10,000/400 = 244,000 bits/sec. The area of skin of the whole body is approximately 18,000 cm^2 (Montague, 1971, p. 3). Using this whole area on the same premises as before will give 244,000 x 18,000/4,000 = 1,098 x 10^6 bits/sec. Now we get near the capacity of the eye (Jacobson, 1951a), and this figure of the skin also stands in a reasonable proportion to its capacity if one considers the number of sensory fibers from the skin entering the spinal cord by the posterior roots is well over half a million (Montague, 1971, p. 3). It may be worth noting that by presentations of patterns, the acuity of the skin area can be greater by a factor of 10 compared with two-point limen studies (Bach-y-Rita, 1972, p. 16). Miller (1956, p. 89) reported some results from an experiment by Geldard, who measured the channel capacity by placing vibrators on the chest region. According to this experiment a good observer could identify about four intensities, about five durations, and about seven locations. This would give

$$[(\log_2 4 + \log_2 5) \times 7] \text{ bits} = 30$$

bits if each point or location could transmit information independently of another point. Otherwise if they were interdependent, that is only one point could receive at any specific time, the information capacity would be

$$\log_2 (4 \times 5 \times 7) \text{ bits} = 7.13 \text{ bits.}$$

As one of the dimensions was duration, and the typical "duration period" is 0.1 to 0.5 seconds in this type of experiment (see Hahn, 1963, Vol. II, p. 178) one would not expect more information than 60 bits at the most to be transmitted per second. Using frequency as a fourth dimension, and granted that a person could identify any one of five frequencies correctly, would give

$$[(\log_2 4 + \log_2 5 + \log_2 5) \times 7]$$

bits = 46.51 bits of information under the most favorable assumption. The 7.13 bits seem to correspond more to what the skin can identify, while $1,098 \times 10^6$ bits corresponds more closely to what the skin can transmit and is based on JND's. The reason for this type of discrepant figure has been discussed earlier.

When considering how the visual system can best be replaced, it looks as though the information capacity as expressed by Jacobson (1950, 1951, 1951a) is a less crucial question than how easily a person can learn to form images or gestalts of the information he receives. It is of course necessary that the various senses can make enough discriminations and have adequate resolution power, but the usefulness of this data is limited if a person cannot combine them into meaningful units or gestalts within a reasonable period of time. It is rather easy to get a fairly clear idea of how fine a discrimination we can make, and satisfactory data is available in this respect. But when it comes to the question of how we organize these primitive units, rather little is known. The type of knowledge we do have is mostly based on indirect data.

With respect to those aspects of the physical world important for mobility, the cutaneous modality seems to have some advantage over the auditory sense. Why? Both vision and the sense of touch are in constant interaction and have to relay precise information to the brain about the physical world. The sense of touch and vision are interacting and have much the same sort of relation to the physical world. Audition does not give any direct precise information about physical objects. However, one difference between vision and touch is that the tactile system is only concerned with things that are close to us and of a limited size, while the eyes are involved with both near and far objects of various sizes. Therefore, it may be that the skin is relatively good for forming images, but not very good at judging the distance of various objects on the same basis as the eye, for example, with cues such as "overlapping." A display on the skin that signalled the distance of an object along the intensity dimension, and light as high-frequency signals and dark as low-frequency signals, seems to be one approach that may be worth following up. To do this one could use an Ultrasonic Torch device or laser beams for collecting distance information, and a device like that of the Bach-y-Rita (p. 261) for image formation. How feasible such devices will be in the foreseeable future will depend on developments of the types discussed. With respect to reading, the auditory sense seems most suitable seen against the background of developments in this field (Clark, 1963, Vol. 1, pp. 205-479; and Dufton, 1966, pp. 317-407).

The various human senses have far greater capacity to make discrminations than to organize them in a way that one commands them. Even if man is far better at perceptual and cognitive learning than any other animal, there are still very clear limitations to what extent we can organize or form gestalts of the sensory stimuli that impinges upon us. Each sense modality has its own area of strength, in which it is very good at organizing sensory stimuli. Psychologists among others are interested in finding out what the underlying mechanicsms are for the organizing process. This knowledge and recent developments of fast microcircuits and computer science may make it possible to build devices that do part of the organizing process, and deliver the partly processed stimuli constellation to the sensory modality best suited to decode this particular product.

One possible approach to get a better idea about the potential of the various senses to organize incoming information would be to look at the size of the primary reception area in the brain of a particular sense. One could hypothesize that the bigger the area, the more data processing could be done. Or in other words, the better the sense would be in learning to form gestalts. One weakness with this particular approach could be that one does not know enough about how various senses or areas in the brain cooperate or interact. Another unknown is how much data processing is taking place in the peripheral system. At present it looks as if the psychological approach, which also seems to be the simplest and most straightforward, is the most fruitful. The cutaneous sense, in particular, seems to need more research attention from the point of view of organizing ability with respect to physical stimuli that impinge upon the skin in various patterns. It is still too early to say anything definite about how the skin will compare with the ear as a replacement for the visual system, but if it turns out to be at least as effective as the ear, it would be an advantage, and recent evidence (Bach-y-Rita, 1972) points in that direction. In this way, the ear could be free for other essential functions, but it could also very well be that they could be given complementary functions in regard to mobility.

DIRECT STIMULATION OF THE BRAIN

What type of experience is likely to arise if the visual cortex is stimulated? Penfield and Roberts' (1959, p. 31) work gives some indication: "Stimulation of Broadman's area 17, which forms the banks of the calcarine fissure, causes the patient to see lights, shadows, colors usually moving or twinkling in the visual field." The people referred to here were sighted subjects. What about blind people? Shipley (1963, p. 249) has discussed this: ". . . even in longterm blindness cortical phosphenes can be generated by direct input signals." Later he says:

> Phosphenes in themselves do not constitute vision, though they may be visually exciting and psychologically reassuring to the blind. It is unwise to delude ourselves that they do. Visual forms cannot be evolved from gleanings of meaningless stimuli. The way to study form perception is by use of forms. The gestalt psychologists have shown long ago that forms can be elaborated neither phenomenologically nor physiologically by the mere adding up of raw elements (flashes). Forms are emergents above all else.

> In 1953 Krieg first suggested that artificial visual perception in blind persons could be achieved through direct electrical stimulation of central visual structures. He pointed out that a spatial map of the external field of vision is projected onto the visual cortex of the brain in such a way as to permit a crude type of form perception by patterned electrical stimulation of the cortical surface. (Sterling, Bering, Pollack, and Vaughn, 1971, p. 1.)

The most important findings of Brindley and Lewin (1971), and Brindley (1971), using a 52-year-old female with 80 electrodes implanted into her visual cortex, was that she reported seeing light or phosphenes in connection with 39 of them. They were *commonly a single very small spot of white light at a constant position in the visual field*, but for some electrodes it was two or several such spots, or a small cloud. The authors found the results promising for the prospect of making a future visual prosthesis.

The results seem more promising than most people probably would have predicted beforehand, but still it seems safe to conclude that direct electrical stimulation of the visual cortex to give a blind person sight at best is something that belongs to the distant future.

THE ROLE OF THE BRAIN

The mind-body problem is a very old one. One consequence of this dichotomy is that the type of research that follows from this conceptualization tends to correlate experience with a physiological event that can be observed directly or indirectly. In other words, one tries to relate a physical event to a psychological event and considers this as a proper and ultimate goal in itself. Is this a fruitful approach? Sperry (1964, p. 410) for one argues that one should look at the problem differently, and sums up his point of view on this matter:

Utilization of this motor approach immediately helps us to view the brain objectively for what it is, namely, a mechanism for governing motor activity. Its primary function is essentially the transforming of sensory patterns into patterns of motor coordination. Herein lies a fundamental basis for the interpretation, direct or indirect, of all higher brain functions.

He also says that we need to look into the relationship between the sensory-associative functions of the brain in relation to its motor activity, and analogizes saying that the output from a machine is usually more revealing of the internal organization than the input.

Sperry's point of view is brought forward for two reasons: one is its relation to the discussion above about the necessity of linking up the sensory-associative area with the motor area in the brain. It seems to be of some importance to study these links. The second reason is related but more general, and can be tied in with the discussion above. It is important to analyze the environment with respect to what is behaviorally important, but it is also important to know how to enervate the muscle action necessary, e.g., to avoid an obstacle. It may be that a vibrator or another form of stimulation on the ankle probably would be more efficient in signaling a curb and get a blind person to lift his feet than if the same signal was transmitted to the ear. For one thing, the subject would probably be much more quickly aware of what part of the body was in a sort of danger and could take appropriate action accordingly. Stimulation or signaling of this nature would seem to be more effective than, say, auditory stimulation because it seems to be more compatible or in line with a person's "natural" behavior.

The notion that we can learn something about perception by looking at our environment and finding out what is behaviorally important, and from motor activity by looking at what sensory information the brain needs for doing the right types of movements or motor acts, have this in common: they point to perception as having a functional role. This point ought to be kept in mind when one tries to create devices that can give the blind information about the "visual" world, but at the same time one must be aware of the strengths and weaknesses of the various sense modalities.

FUTURE RESEARCH

This problem has been implicit and discussed in most of the last section, but it may be worthwhile to be explicit about what the author sees as the most fruitful approach in more general terms and briefly take up things that have not been mentioned earlier.

The various disciplines or subjects seem to be rather strongly compartmentalized, and people working in one area seem to know little about what research workers in another area are doing. If one wants to improve blind people's mobility, and capacity to receive information from print, one should first gather together all the people who could make a contribution to a solution of these problems: psychologists, computer scientists, engineers, physiologists, doctors, architects, town planners, and politicians, among others.

The guidelines with respect to how information can be extracted from print seem to have been laid down along sound lines, and most of the problems in this area can be solved in principle. It is therefore more a matter of allocation of money and building of more efficient and cheaper pattern recognizer devices, cheaper computers and better computer programs, (Clark, 1963, Vol. I, pp. 205-468, and Dufton, 1966, pp. 317-387).

With respect to mobility, we are far from any satisfactory solution. Generally, it seems more worthwhile to direct the efforts towards making devices that are compatible with the human sensory system, rather than trying to find out who will be good at using specific devices such as Kay's Ultrasonic Torch or how to train people to use it in the most efficient way. One would think that much of the experience obtained in connection with space research could be useful both with respect to specific results and *how* they go about solving their problems. Basically, the astronauts have to interact in a precise manner with the environment via their space capsule. Direct use of their senses to solve problems are limited. An astronaut has to rely heavily on instruments and his machine if he is to be successful. A lot of data processing has to be done for him by computers. So one may consider space research as one area concerned with man-machine-environment interaction, and one can consider the mobility problem of the blind from the same point of view.

Although the Ultrasonic Torch resulted mainly from the efforts of one man, Leslie Kay, it is worthwhile to look into what is being done in space research. Far more money is available for this than for research toward improving the mobility of blind people. The allocation of large amounts of money and highly qualified researchers in space science would lead one to expect findings that are useful in other areas with similar problems to solve, such as blind mobility.

With respect to future research one might try to solve the mobility problem gradually by dividing it up. First, one should equip a blind person with a device that will help him to stay on course and observe whether that improves his mobility significantly. Second, one could gradually introduce devices that detect behaviorally important or dangerous features of environments. When giving information about the potentially dangerous obstacles one would have to find a code or set of codes that could easily be understood by the blind. Much research is needed to alleviate this problem. Research with respect to auditory stimuli might also contribute to development of pattern recognition devices for speech. To find out how the auditory system compares with the cutaneous sense, and how they can interact or complement each other, deserves serious attention. Interaction with the environment involves not only an understanding of the incoming information, but also the capacity to react adequately to it. This is a problem somewhat difficult to approach experimentally, but not impossible, and may deserve some attention. Presenting various classes of sounds constructed according to various models may help us to develop better theories about how we process auditory information. Computer simulation and generation of sound patterns by the computer seems to be one promising technique. Confusion matrices might be a useful tool in this context.

Further, is it of any value or help to hear a class of auditory stimuli without feedback if one has to learn this class of stimuli later? An answer or some clues to this question would be of value both for language teachers and mobility instructors training blind people to use the Ultrasonic Torch. My opinion is that giving a class of stimuli without some form of feedback, which helps to structure it, would be rather useless. Moreover, some evidence seems to exist that direct feedback is more effective than verbal. This statement is based on experimental results (Appendix 1), observation of blind subjects, and the results of Riley's (1966) study, which seemed to indicate that an active person interacting with the environment in a more vigorous way than the average person, would be a better Torch user.

There is no clear or fast way to go about solving the problems in this area, but one would believe that a world with a science and technology that can take detailed pictures of the planet Mars should also be capable of giving a blind person vital information which other people receive visually in a code that he or she can easily learn. It seems desirable that people focusing their attention on man, psychologists, for instance, should work more closely together with experts on machines (computers, electronic devices, etc.). Practical results such as aids for the blind, and theoretical results such as greater understanding of our perceptual systems and the brain, will follow more quickly and in more depth if research workers in one area are informed of what their colleagues in other areas are doing. Information theory seems to have concepts that can bridge the conceptual gap between various disciplines, and the computer seems to be one of the most useful tools for trying out or testing theories in this area. One should keep in mind that man is the crucial element; both practically and theoretically oriented research will most probably lead to greater understanding of man, hopefully to his advantage.

SUMMARY AND CONCLUSIONS

This analysis began with the notion that perception is a matter of collecting and processing information. Various animals interact with the environment through different sense modalities. The bat relies almost exclusively on the auditory sense, the rattlesnake has an infrared sensing mechanism, and the torpedo fish sends out field producing currents, and has a skin that can detect variation in the field strength. The perceptual system of each of these animals seems to be particularly suited to coping with or processing each type of information. The information capacity of a human's visual and auditory system is also compared. In trying to analyze the information, where concepts from information theory are used, one encounters the problem of what the primitive or basic unit is on which the analysis can be built. Results and ideas from psychophysiological studies, behavior studies, stablized vision studies, and computer simulation are briefly discussed. These studies point to certain units that may be useful as "atoms." To process or organize the "primitives" is an enormous task, and in humans it is quite clear that the eye is excellent at organizing the physical "visual" world around us, and the auditory modality is specially suited to process speech sounds and musical sounds. The sounds from an Optophone, in contrast, are very hard to process or "gestalt."

In an experiment (Appendix 1), a third class of sounds was introduced--that is, from an oscilloscope. This sound could be characterized as a "clear" sound increasing and decreasing along the frequency dimension. Ability to process this sound correlated clearly (about 0.65) with musical aptitude. One common and important factor seems to be the ability to analyze whether a frequency is increasing or decreasing. It was expected that this ability would be pronounced and important in another experiment (Appendix 2) also, but turned out not to be the case. Two factors may explain it:

1. The sound from the Ultrasonic Torch, which is pulsating and varied in the experiment along the frequency dimension, was hard to analyze because it was not clear; for instance, many subjects seemed to confuse increase or decrease in frequency with increase or decrease in loudness.

2. Motor behavior had to be coordinated with the incoming information, and processing of the sound from the torch was only one part of the mobility task.

Blind subjects ($N = 11$) performed better on two out of three aspects of the mobility task, that is, keeping direction and speed of walking, but walked into just as many objects as sighted, blindfolded subjects.

It may be concluded that if one wishes to build devices that transform "visual" information into other sense modalities, one would have to partly process the raw data before they are "delivered," and furthermore, explore what sense modality is best suited to a particular type of information. In this context it should be pointed out that it is important to look at a human in interaction with the environment as one system, that is, the type of things in the environment that need to be detected and effectively processed if a blind person is to cope with the world around him. It may also be useful to consider perception as the type of information needed to initiate a certain type of motor behavior which is behaviorally important.

Modern technology and science make the suggestions put forward in this discussion realistic, but research and progress in this area seems mainly dependent on allocation of resources and coordination of the efforts of people working in various fields such as electronics, computer science, physiology, and psychology. The pioneering work of L. Kay, P. Bach-y-Rita, J. C. Bliss, and G. S. Brindley, to mention a few, shows what can be done with modest resources by a single devoted and highly qualified person.

APPENDIX 1

Correlations:

Subjects* with Complete Data on All Three Tests

"15 Shapes"	No.	Wing's Musical Test 1	2	3	Sub 1	4	5	6	7	Sub 2	Total	PMA V	S	R	N	W	Total	5% level of significance
(Males	14	0.42	0.67	0.19	0.57	-0.02	0.39	-0.29	0.08	0.09	0.45	0.23	-0.17	0.47	-0.03	0.49	0.18	0.532
(Females	18	0.69	0.66	0.63	0.74	0.43	0.67	0.49	0.16	0.71	0.77	0.42	0.52	0.19	-0.09	0.46	0.34	0.468
(Both	32	0.41	0.55	0.46	0.57	0.18	0.46	0.10	0.08	0.42	0.56	0.39	0.15	0.31	0.04	0.51	0.33	0.349

Subjects with Complete Data on "15 Shapes" and Wing's Musical Test

"15 Shapes"	No.	Wing's Musical Test 1	2	3	Sub T1	4	5	6	7	Sub T2	Total	5% level of significance
(Males	26	0.46	0.78	0.53	0.72	0.25	0.31	-0.27	0.35	0.30	0.64	0.388
(Females	28	0.49	0.62	0.56	0.65	0.34	0.69	0.37	0.05	0.57	0.66	0.374
(Both	54	0.40	0.66	0.55	0.65	0.29	0.38	0.02	0.19	0.40	0.61	0.270

Subjects with Complete Data on "15 Shapes" and PMA

"15 Shapes"	No.	PMA V	S	R	N	W	Total	5% level of significance
(Males	23	0.23	0.02	0.43	0.11	0.32	0.30	0.413
(Females	26	0.30	0.39	0.34	0.09	0.43	0.43	0.388
(Both	49	0.31	0.18	0.35	0.16	0.38	0.39	0.281

*Subjects are first year students from the University of Sydney.

APPENDIX 2

Females (28), Males (29) N = 57. Correlations:

	Use of Ultrasonic Torch: Obstacle Course, 4 runs: W	ob	time	sum	Di.J.	Rec.	Anx.	Sport	Music	Lang.	Rav.	Voc.
W	1	38	27	77	42	20	-18	33	19	-06	27	18
ob		1.00	18	57	27	22	-12	23	-08	05	08	-15
time			1.00	77	-07	12	00	31	18	01	17	-01
Sum				1.00	25	23	-12	41	18	-01	26	04
Dist. Judg.					1.00	24	-09	09	10	01	09	12
Recog.						1.00	-20	33	01	03	21	-01
Anx.							1.00	-24	01	07	-06	12
Sport								1.00	07	-19	19	-16
Music									1.00	24	20	06
Language										1.00	29	33
Raven											1.00	13
Voc.												1.00

In some of the tests, high score would mean poor performance. This has been adjusted in the table, so that positive correlations mean that good performance on one variable is associated with good performance on the other variable. A negative correlation between anxiety and another variable means that high anxiety is linked with poor performance on that variable.

Key

Obstacle Course--A 48.5-meter long corridor with eight obstacles.

W--How many times a subject touched the sidewalls. An index of aptitude to keep direction.

ob--Four pairs of chairs and masonite boards placed in the corridor as obstacles.

time--Number of seconds used to walk the corridor.

Sum--w(30 sec.) + ob(60 sec.) + time. Four runs each way.

Key (Continued)

Distance Judgment--How good subjects were in judging the distance to a wall using the Ultrasonic Torch.

Recognition--Identification of 15 objects using the Ultrasonic Torch.

Anxiety--A modified version of Taylor's Anxiety Scale.

Sport--An estimate of skill in sport on a 5-point scale.

Music--Wing's Standardized Tests of Musical Intelligence. Subtotal 1 (Subtests 1 + 2 + 3).

Language--Modern Language Aptitude Test by J. B. Caroll and S. M. Sapon.

Raven--Progressive Matrices, 1947.

Voc.--The Mill Hill Vocabulary Scale.

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TACTUAL MAPPING

J. M. Gill*

Graphic representations are an established mode of communication for the sighted, but the visually handicapped have tended to rely on other forms of representation such as verbal or written descriptions. Such descriptions have obvious limitations for conveying information about complex spatial relationships.

The earliest reported method of producing embossed material was in 1517 by Francesco Lucas who engraved alphanumerics in wooden blocks. The first single-copy tactual maps were probably made by Weissenbourg in the early 18th century by sewing beads and threads on linen. In 1785 Valentin Hauy successfully embossed raised images in paper, but it was not until the last decade that maps have become widely available to the blind population. Leonard (1967) demonstrated that tactual maps could be a useful aid to mobility but no estimate has yet been made of the number of potential users.

The main problems in designing a tactual mobility map are:

1. Identification of useful landmarks.

2. Coding the information in an embossed notation.

3. Manufacture.

4. Training the user in reading and interpretation of the map.

USEFUL LANDMARKS

The identification of useful landmarks is not a trivial task since they may be dependent on the type of mobility aid used. For instance, guide dogs are trained to avoid obstacles such as pillar boxes. A landmark should have a known and exact location so that auditory and olfactory cues can sometimes be used. A further factor is that useful landmarks for the partially sighted differ considerably from those used by the blind, but research has not yet been done on this problem.

Franks and Nolan (1970 and 1971) have studied the problems of measuring geographical concept attainment which will determine when a child is ready to begin using maps. Berlá and Nolan (1972) stressed that a child's immediate environment can be used for teaching the concepts of spatial relationships, distance and scale.

TACTUAL SYMBOLS

Another problem is the lack of information about the parameters determining legibility of tactual symbols. Most research effort has been devoted to identifying sets of discriminable symbols in isolation and not in the context of a map. Other areas requiring research are:

1. Association of meanings with the tactual symbols.

2. Stimulus redundancy.

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3. Information content of symbols.

4. Information density.

5. Physical size of the map.

6. Scale--topographical or topological.

7. Optimum elevation of symbols.

8. Use of reference points and grid systems.

9. Use of keys.

MANUFACTURE

Maps can either be made centrally by a professional transcriber, or locally by teachers or sighted volunteers. The advantages of a central facility are that a higher capital expenditure can be justified in order to achieve high quality copies with a relatively low unit cost, and the operator is trained in the translation from a visual map to a meaningful tactual one. At present the majority of maps are made locally by teachers, mobility instructors or sighted volunteers, and financial considerations tend to dominate their choice of production method.

An important, but often neglected, aspect is the drawing of maps by blind people. Variation in the elevation of symbols has been found to be a useful coding dimension. There is still no satisfactory method for blind people to draw multi-height maps which causes problems in the compatability of symbols produced by different methods.

READING AND INTERPRETATION

There have been few systematic studies on the reading and interpretation of tactual maps. A notable exception has been the research by Berlá on tactual scanning strategies but these studies have been confined to pseudomaps.

It is often assumed, probably erroneously, that all potential map users can read braille. Although Gray and Todd (1968) found that 60 percent of the registered blind population in Britain could not read braille, it is not known how many are able or would wish to use tactual maps.

The area which has suffered the most neglect has been the design of maps for the partially sighted. Gray and Todd found that 70 percent of the visually-handicapped population had some useful vision. Although visual markings have been printed on tactual maps, little research has been done on the design of maps with both visual and tactual symbols.

Berlá and Nolan (1972) suggested that an ultimate practical goal would be to define those situations and content areas where maps convey either more information than a verbal description or at least convey it more efficiently.

DESIGN

Tactual maps have three categories of symbols: *point symbols* to show specific locations or landmarks, *line symbols* to designate boundaries or lines and *areal* or *texture symbols* for areas. The results of experiments on the discriminability of tactual symbols are summarized in Table 1.

Four major factors influencing discrimination are: size, elevation, form or configuration, orientation.

Size

Tactual symbols have to be constructed much larger than visual ones because of the relative inadequacy of touch as compared with vision. The difficulty in trying to define a minimum size is that difference in size may be one of the major factors contributing to legibility among point symbols.

Elevation

Variation in height has been used to differentiate between point, areal and line symbols in the context of a map (Wiedel and Groves, 1969), but James and Gill (1973) found that blind children had little difficulty in associating meanings with multi-height symbols representing steps.

Form or Configuration

Jansson (1972) suggested that the following kinds of pcint symbols are often confused:

TABLE 1

Results of Experiments on the Discriminability of Tactual Symbols

Author	Material	No. of Subjects	Linear: No. of symbols tested	Linear: No. discriminable	Linear: Length mm.	Areal: No. of symbols tested	Areal: No. discriminable	Areal: Size mm. (square)	Point: No. of symbols tested	Point: No. discriminable	Point: Max. dimension mm.	Comments
Morris & Nolan (1961)	Virkotype	96				12	5	51				
Culbert & Stellwagen (1963)	Virkotype					40	(11)	50				not full pair-comparison
Morris & Nolan (1963)	plastic	60				7	2	6				
Nolan & Morris (1963)	Virkotype	96	18	3	102				18	1	6.4	
	plastic	96	13	9	102							
	plastic	92				13	7	51				
Schiff (1967)		12				24	4	19				
		12				24	8	25				
	plastic	24							26	17	14.3	upper case letters
Wiedel & Groves (1969)	plastic		17	4		3	1		15	3		method not reported
Nolan & Morris (1971)	plastic	60	13	7	102	11	8	51				
	plastic	58							12	8	5.1	
	plastic	58							12	5	5.1	
	paper	60	21	7	102				19	11	14.0	
James & Gill (1973)	plastic	62	17	10	100	8	5	50				
Gill & James (1973)	plastic	194							30	13	5.0	

1. Evenly embossed surfaces of different form.

2. Closed contours of different form.

3. Open contours of different form.

4. Combinations of similar units.

Orientation

Research by Goodnow (1969), and Pick and Pick (1966) has shown that visually a change in shape is more easily discriminated than a change in orientation, but tactually the reverse is true.

Nolan (1971) studied the relative legibility of raised and incised tactual figures and found that students made 7 percent more errors and took 38 percent longer to read the incised figures.

Informal observations, by Wiedel (1965) and others, indicated that many blind students have difficulty in perceiving a tactual version of the visual arrow. Schiff, Kaufer and Mosak (1966) developed a line, sawtooth in cross-section, which felt smooth in one direction and rough in the other. They compared this symbol with the conventional arrow and found that either symbol was superior in simple diagrams, but the special symbol was superior in more complex diagrams. Moreover the special symbol was preferred by the blind subjects in both simple and complex diagrams.

STIMULUS REDUNDANCY

Schiff and Isikow (1966) varied the degree of redundancy in tactual histograms. They found that the most redundant presentation provided fewest errors when size differences were small. However, when size differences were large, different textures or outlines were effective means of indicating different areas.

Nolan and Morris (1971) made six pseudomaps with two different spacings between symbols and three different heights of embossing. They found that identification of points and lines was best when there was the greatest differentiation in symbol height. Identification of points was superior under conditions of maximum symbol separation.

A considerable amount of research has been done on the use of coding redundancy in a visual presentation. Rappaport (1957) found that adding redundancy degraded identification, but when irrelevancy was added performance improved as a function of the level of redundancy. Landis and Slivka (1972) suggested that a successful measure of the effectiveness of a display should be based on how judiciously an observer can utilize the information presented on a display. Furthermore, it was reasoned that if a change in format really made a difference, it should be apparent in the adequacy of decisions made on the basis of the displayed information.

TACTUAL SCANNING

Various studies (Nolan and Morris, 1971; Berlá, 1972 and 1973; Berlá and Murr, 1973) found that, in general, subjects used inefficient scanning procedures for locating a symbol on a tactual pseudomap. It was also found that performance could be improved by teaching the subjects to scan the map in a systematic manner.

All these studies used a pseudomap on which the symbols were positioned randomly. In practice a subject would probably have some idea of the structure of the display so that he could assemble any information into some form of mental image of the map.

DESIGN FOR THE PARTIALLY-SIGHTED

Nolan (1960) studied the design of pictures for large-type textbooks. He compared five different formats:

1. Simple line drawing.

2. Line drawing with areas blacked in for contrast.

3. Line drawing with blacked areas and light shading.

4. Line drawing with blacked areas and heavy shading.

5. A photo-offset print.

Using the method of pair-comparison, forty visually-handicapped children judged the relative legibility of the five formats. A tracing, consisting of a line drawing with areas blacked in for contrast, was found more legible than other formats.

Nolan (1961) followed up this work by presenting 106 teachers with illustrations produced by tracing in black and white and by photographing in black and white several pictures which were originally in color. Traced pictures were judged preferable for use in large-type books by 91 percent of the group.

Greenberg and Sherman (1970) used 45 partially-sighted subjects to compare the accuracy of discrimination of visual lines on various backgrounds. They found that white symbols on a dark background gave significantly better accuracy in discrimination than black lines on a white background. They also found that thinner lines were discriminable when using white lines on a dark background. They attributed this result to irradiation effects which help to create the illusion that white lines on a dark background appear to be thicker than they actually are.

METHODS OF PRODUCTION

The main characteristics of systems for producing multiple copies of tactual maps are summarized in Tables 2 and 3. The choice of method will depend on the ultimate use of the map and on financial considerations. Traditionally the copies are made on manila paper but this material imposes physical limitations on the design; there is a limited range of discriminable symbols, relatively low height of embossing, and paper is not suitable for outdoor use. Many of the systems developed in recent years have employed the vacuum forming of plastic sheets which are more expensive than paper but are more durable and capable of better symbol definition. Wiedel (1971) and Gill (1973) have studied the suitability of various commercially-available thermoplastics, and found calendered polyvinyl chloride gave the best results.

It has been found desirable to use more than one height of embossing but many production systems are limited to a single elevation. The optimum elevation of symbols will depend on whether the copies are monolithic, the map is for outdoor use, and on the tactile sensitivity of the user. If the production system requires an accurate visual master for each elevation of embossing, then the maps will be very expensive when only a few copies are required.

Metal Foil

A master for vacuum forming is made by embossing a sheet of aluminum foil. The map has to be drawn in mirror image on the back of the foil, which is then placed on a rubber mat and the lines embossed with a spur wheel. Textured areas can be produced by gluing sandpaper to the front surface of the foil.

String Master

A method called string master involves building up a master on transparent cellulose. Various thicknesses of string are used for line symbols; sandpapers, linoleum and fabrics are used for textures.

Wire Master

The wire master method is very similar to the previous method except that solder wire is used in place of string. Solder can be rolled to give solid, dotted or dashed lines with a triangular cross-section. This system is superior to the string method since the solder is easier to manipulate and the lines have sharper crests.

Solid Dot

Nippon Lighthouse in Japan have developed a technique called solid dot for screen printing embossed maps. The system requires no special equipment and can produce multi-colored maps. Disadvantages include low elevation of embossing and poor control over dot profile. Since the visual quality is good but the tactual quality relatively poor, the main application is for people with some useful

TABLE 2

Systems for Producing Multiple Copies

			Quality				Cost of Materials		
Method	Base Material	Method of Duplicating	Maximum elevation	No. of different elevations	Accuracy	Durability	Capital	Master	Copies
Metal foil	Plastic	Vacuum forming	C	C	C	B	B	D	C
String master	Plastic	Vacuum forming	B	B	C	B	B	D	C
Wire master	Plastic	Vacuum forming	B	B	B	B	B	D	C
Solid dot	Paper	Screen printing	D	D	C	D	D	D	D
Sewing machine	Plastic	Vacuum forming	C	C	C	B	B	C	C

A - very high

B - high

C - medium

D - low

TABLE 3

Methods of Production

	Base Material	Method of Duplicating	Cost					Quality			
			Needs accurate visual master	Time to make master	Capital cost of equipment	Cost of materials for master	Cost of materials for copies	Maximum elevation	No. of different elevations	Accuracy	Durability
Embossed zinc plates	paper	press		C	B	C	D	C	D	C	D
Sintered bronze	plastic	vacuum-forming	X	A	B	A	C	B	A	B	B
Metal and epoxy	plastic	vacuum-forming		B	C	C	C	A	A	B	B
Virkotype	paper	deposition	X	C	B	B	C	D	D	C	D
Polyvinyl chloride base	PVC	deposition	X	C	B	B	A	C	C	B	B
Photoetching	paper	press	X	C	B	B	C	B	C	A	B
Photolathe	paper	press	X	C	B	C	C	C	D	B	B
Drum embosser	paper		X	C	C	D		C	D	D	C
Relief printer	paper			D	B	D		C	D	D	D
Line embosser	paper			C	A	D		D	D	D	D
Manual engraver	plastic	vacuum-forming		C	C	C	C	B	B	B	B
Numerically-controlled machine tool	plastic	vacuum-forming		D	A	C	C	B	A	A	B

A - very high

B - high

C - medium

D - low

vision who use both visual and tactual senses to read a map.

Sewing Machine

A master for vacuum forming is made by machine sewing a fibrous material with thick thread. Areal and point symbols can be glued to the top surface of the master.

Embossed Zinc Plates

A system based on the traditional method for printing braille books involves embossing a pair of zinc plates on a special machine. The plates are used in a press for making copies on manila paper. This system is usually limited to producing maps in a punctate form with only one elevation of embossing.

Sintered Bronze Master

A sheet of sintered bronze is manually engraved to make a female master for the vacuum forming of plastic sheets. This system is capable of producing high quality maps but the bronze is very expensive and the engraving can take a few months. In practice the use of a female master gives poor control over the shape of the crest of a line or point symbol, and affects the discriminability of the symbol.

Metal and Epoxy Resin Master

The male master is made from metal and epoxy resin. Blocks of metal are used for regular shapes and epoxy resin is molded for the remainder. Since the master is not porous it is necessary to drill air holes in the master before vacuum forming plastic copies. The manufacture of the master is so time consuming that the method is only viable for enthusiastic amateurs.

Virkotype

Wet inkprint is dusted with a fine resinous powder which adheres to the wet ink and appears as a raised plastic symbol when heated. The maximum elevation is relatively low and the system only works reliably under laboratory conditions.

Polyvinyl Chloride Base (PVC)

The process involves heating resinous powders into a core of about 0.015 inches (0.38 mm) thickness. During the actual heating process, a master surface mold prepared from a photo-engraved plate applies a raised layer of pigmented vinyl that permanently affixes to the base. The map can be embossed on both sides providing an alternative to overlays (Kidwell and Greer, 1972).

Photoetching

A photographic copy of a map is placed on top of a sheet of photosensitive plastic which is exposed to ultraviolet light, and the master chemically etched to the required depth. It is necessary to repeat the whole process for each different elevation on the map. Since both male and female masters can be produced, copies can be made by vacuum forming of plastic sheets or by embossing paper, plastic, or metal in a conventional press. This latter facility can be very important when a large number of copies are required.

Photolathe

A machine developed by Jens Scheel in Germany whereby a lathe is controlled from a photoelectric scanner, is limited to a single elevation. Since both male and female masters can be produced, copies can be made of paper in a conventional press.

Drum Embosser

In principle this is very similar to the photolathe but the cutting tool is replaced by a solenoid. The system is limited to producing diagrams in a punctate form.

Relief Printer

Saab-Scania in Sweden have developed a flat-bed embosser for use in the classroom. The equipment consists of a drawing table and one, or more, reading desks. The reading desk contains a punch for embossing manila paper. The output is in punctate form with either 3 or 5 dots/cm. The picture can be either enlarged or reduced and the data stored in a conventional stereo tape. Thus diagrams could be stored on the same tape as a "talking book."

The system is still in an early stage of development, but the potential is enormous if both noise and price can be reduced. It has been suggested that this equipment might be the equivalent in a school for the blind of the blackboard in a sighted school. The capital cost would be large since each pupil would need his own reading desk.

Line Embosser

A computer line printer can be modified to produce tactual diagrams by removing the ribbon, increasing the pressure on the hammers, and by putting some rubber behind the paper. Different textures can be produced by using different characters. The physical quality of the output is poor but the significance of the system is that it can be operated by a blind user. Hallenbeck (1969) has written software for the graphical output from computer programs as well as diagrams produced by direct instructions on a teletype.

Manual Engraver

Gill (1973) developed a machine (Appendix) for manually engraving a sheet of laminated plastic; a Perspex stencil provides precise dimensions for standard symbols. An epoxy resin male copy is then used as a master for the vacuum forming of plastic sheets. The system has the advantage of low capital expenditure but it is laborious intensive since there is no interactive design capability.

Numerically-Controlled Machine Tool

Gill (1973) developed a system using computer-aided design for a map layout, and a numerically-controlled machine tool for engraving a laminated plastic sheet. The topographical information is entered into a computer from a coordinate table. Editing on the visual-display unit permits the insertion or deletion of individual lines, movement of end points of lines, and change of scale. A wide variety of line types (solid, dotted, and dashed) can be specified from the keyboard, and the operator also has control of the height of the symbols on final copies. A joystick can be used to position standard symbols. Alphanumeric text can be entered from the keyboard; the text is automatically converted to grade 1 braille, with a choice of four different cell sizes.

When a satisfactory display is obtained, output is requested. This can include output on a digital plotter, magnetic tape, or punched paper tape. A map can be stored on tape and then quickly modified at a later date. The engraving machine can either be controlled directly from the computer used in the design stage, or from a smaller computer with the data transferred on punched paper tape. The engraving machine is used for making a mirror-imaged female copy of the map on a sheet of laminated plastic. Thermoplastic copies are produced from a male epoxy-resin master on a vacuum-forming machine.

Embossed Maps with Visual Markings

It is often desirable to include visual markings on a tactual map for the partially-sighted and the sighted. The PVC base production system, used by Kidwell and Greer (1972), can produce the embossing with a different color than the background.

Transparent plastics have the advantage that visual markings can be put on the underside of the map after vacuum forming. This avoids any problems of alignment and deterioration of markings by the abrasion of use. Ink can be rolled across the back of the plastic sheet so that the embossed lines are left clear, resulting in light colored lines on a black background as recommended by Greenberg (1968).

Other methods generally involve adding the markings to the plastic before vacuum forming. Generation of the artwork can be laborious intensive unless the system is computer-based.

Ogrosky (1973) tried using mimeography with some success but the contrast was inferior to that produced by offset printing. However offset printing is only economically viable for large production runs. Photocopying, although unsuccessful to date, would keep markings from being rubbed off since the visual image is fused into the top surface of the plastic. Screen printing appears to be the best system currently available although it is laboriously intensive.

MOBILITY AND ORIENTATION MAPS

A mobility map is one which gives sufficient information for independent pedestrian travel by a blind person. An orientation map gives less detailed information about an area.

Leonard and Newman (1970) found that five out of ten subjects could follow, without error, a single route using a spatial-diagrammatic tactual map. No conclusions could be made regarding the superiority of a tactual map versus memorizing verbal instructions. In a laboratory study, Maglione (1969) demonstrated that blind and blindfolded sighted subjects could negotiate a maze with significantly fewer errors using verbal instructions and a tactual map than by using verbal instructions alone. Both these studies were done with a unidirectional route although a tactual map could also be used for the return journey.

Leonard (1967) showed that five out of six blind schoolboys were able to make a detour from a specified route and get back on route again using a tactual map. Although Leonard's work included evaluations on subjects' ability to use a tactual map to solve detour problems, it was based mainly on single-route maps. However Leonard (1967) suggested "it should not be too difficult to design more complex problems requiring the use of dimensional information; for example, choosing the shorter of two detours."

Bentzen (1971) first demonstrated that a tactual map could "enable independent planning of a variety of routes to a variety of objectives." A novel feature of the map used in this evaluation was the use of overlays to present braille information. The overlap is a separate sheet which is positioned directly over the map. Bentzen's six subjects had no difficulty using the tactual map for route planning, and navigational errors were attributed to poor travel techniques rather than inadequacies in the map. The interaction of travel performance with map reading is an important consideration in devising methods of evaluating the usefulness of tactual maps for travel. Although subjects map reading ability may be perfect, failure to detect landmarks or estimate distances correctly, results in ineffective navigation.

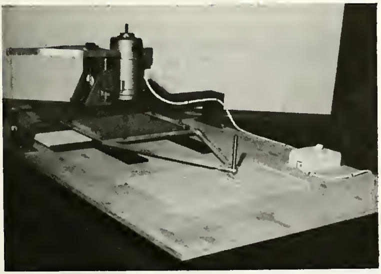
Kidwell and Greer (1972) were interested in non-visual perception of the environment and in particular the type of landmarks that should be represented on a map for the blind. They further developed Bentzen's multiple display, and put the braille on the underside of the map. They started by using mirror image braille but found that their subjects preferred ordinary braille. Their map of the M.I.T. campus uses a considerably higher information density than anything previously attempted, but they found that their subjects did not experience any major difficulties in reading the display.

An Inexpensive System for the Production of Embossed Maps and Diagrams

A manual engraving machine developed for the production of high quality tactual maps and diagrams without high capital expenditure involves:

1. The manual engraving of a sheet of paper and phenolic resin laminated plastic.
2. The production of a male or positive copy in epoxy resin.
3. The vacuum forming of plastic copies.

The manual engraver (see Figure) consists of a free-moving horizontal table with a cutter that can move vertically. The cutter, driven by a single-phase 6000-rpm motor, can be moved in the vertical axis by a foot pedal, and the depth of cut can be preset by an eccentric cam. The stylus, which is used to follow the lines on the visual map, is directly connected to the table, but a stencil is used to help the operator obtain smooth lines and precise symbols. Braille has to be coded manually, although the stencil provides for precise positioning of the dots.



The Manual Engraving Machine

The system has the following advantages:

1. Low capital and material costs (the sheet of paper and phenolic resin laminated plastic, and the epoxy resin, cost less than $2.00 per master).
2. It requires little space and can be placed on a large table.
3. It can produce maps with various elevations of embossing.
4. Braille, with various cell sizes, can be included at any angle to the horizontal.
5. Any number of symbols with various elevations, and in any orientation, can be produced.
6. Smooth curves can be drawn.

Major disadvantages are:

1. There is no interactive design capability, so the system lacks versatility. There is no facility for changing the scale, although a pantograph could be connected between the stylus and the table.
2. It is laborious.
3. The quality deteriorates for elevations over 1.0 mm.

The system can, however, produce high quality maps and diagrams without high capital expenditure, and only basic workshop facilities are required for the manufacture of a suitable engraving machine.

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DEVELOPMENT OF A SCALE DESIGNED TO MEASURE FUNCTIONAL DISTANCE VISION LOSS USING AN INTERVIEW TECHNIQUE *

Kenneth W. Haase and E. Earl Bryant **

INTRODUCTION

The National Health Interview Survey, in addition to providing health statistics on the population of the United States, carries out a research program designed to improve or to develop new survey methodologies. This paper presents the findings of one of the recent survey research activities conducted by the National Center for Health Statistics in cooperation with the American Foundation for the Blind and the National Society for the Prevention of Blindness. The purpose of this study was to develop and test three scales designed to measure functional vision loss by use of an interview technique. The scales consisted of a distance vision scale, a near vision scale, and a self-evaluation scale related to trouble seeing. This paper presents a preliminary assessment of the distance vision scale when used alone and when used in conjunction with the self-evaluation scale.

METHODOLOGY AND STUDY DESIGN

The basic methodology for the study involved the collection of data from two sources--an interview with clinic patients and an eye examination by ophthalmologists and clinic technicians which was performed immediately following the interview.

The universe consisted of patients 6 years of age and over who visited the general receiving wards of six eye clinics[1] during a four to six week period beginning in December 1972. Patients visiting the clinics for the first time were excluded.

Differential sampling rates were applied by strata and clinic such that the expected total sample size would be about the same for each clinic and for each of four visual acuity classes (better than 20/50, 20/50 to better than 20/100, 20/100 to better than 20/200, and 20/200 or worse). The sample consisted of 1,726 patients of whom 1,661 responded in the study.

CHARACTERISTICS OF THE SAMPLE POPULATION

A most important qualification of the data presented in this paper is that they are applicable to a very select population, one which contains a large proportion of visually impaired, elderly, and poorly educated people. Numerous studies have indicated that, the elderly and the less educated often have problems responding in interview surveys. Therefore, these factors should be considered when interpreting the findings of this study.

DEVELOPMENT AND ANALYSIS OF THE DISTANCE SCALE

In development of the distance scale, major consideration was given to the types of questions that would identify persons with functional distance vision loss and could discriminate between various degrees of that loss.

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**National Center for Health Statistics.

The scale consisted of the five questions shown in Figure A. The questions are ordered in the form of a Guttman Scale;[2] that is, the first four questions are ordered so that when the first negative answer is obtained, all following answers are expected to be negative. The Guttman technique permits the use of several approaches in evaluating the merits of this instrument. These include the assessment of face validity, construct validity and content validity.

(1) (When wearing glasses) can you *see* well enough to recognize a friend if you get close to his face?

(2) (When wearing glasses) can you *see* well enough to recognize a friend who is an arm's length away?

(3) (When wearing glasses) can you *see* well enough to recognize a friend across a room?

(4) (When wearing glasses) can you *see* well enough to recognize a friend across a street?

(5) Do you have any problems seeing distant objects?

Figure A. The distance scale questions used in the vision study.

Face validity, while somewhat subjective, should be the first criterion applied to any survey technique. The questions applied to this scale were "Do these questions make sense in classifying functional vision loss?" and "Do they form a hierarchy of severity?" Since the reference point, "recognizing a friend," was kept constant and the conceptual stimulus was decreased by moving the friend further from the respondent, the scale has the appearance of logically classifying various degrees of functional vision loss.

In terms of construct validity the Guttman approach permits a measurement of internal consistency within the scale itself. Each sample person was asked all of the first four questions of the scale regardless of the previous answer. For example, if a person reported he could not see a friend across a room he was still asked whether he could see a person across a street. Therefore, it was possible to determine scale-ability by analyzing the consistency of the responses. Of the 1,661 persons who answered these questions only about 1 percent responded inconsistently. Based on experience from other studies involving scaleability these findings indicate a very high degree of consistency.

The final measurement of validity is content validity; that is, whether the scale actually measures what it is intended to measure. However, before looking at the findings which compare interview data with clinical measurements, we should give some attention to the differences between these two measuring techniques. How a person perceives he can function is related to a number of factors of which his physical capability is only part. These scales are psychological measurements which will be influenced by actual visual acuity measurements. Also they will be related to the patient's own subjective evaluation of the severity of his visual impairment and the degree of effort he puts forth in overcoming it. In addition, the environment in which the person generally functions may be quite different from the clinic environment in which the examination was performed. Therefore, both measurements, assuming that they adequately represent the phenomenon of interest, are important statistics in their own right. Since the two measurements are different we do not expect a perfect association, but since they both measure the same phenomenon from a different perspective, we should expect to find a statistical relationship. In this paper we have used Pearson's phi coefficient[3] as an indicator of the degree of association between the two measurements.

If one accepts the hypothesis that persons with similar visual acuity measures can have different perceptions of their degree of functional vision loss, how then does one interpret a statistical correlation between the two measures. To some degree it must be a value judgment. But, comparisons must also be made among the different subgroups, identified by this scale to determine if the distributions of these subgroups by visual acuity are different and if these differences are in the directions expected. Further, the analysis should also include an analysis of the outliers. While we might accept the fact that a person's perception of his degree of functional vision loss can vary considerably with the measurement of his visual acuity, we could evaluate the scale in terms of the apparent inconsistencies. For example, a person who is classified by the scale as having a severe vision loss, should not be expected to have a normal or near normal visual acuity. These outliers will be referred to in this paper as potential false positives and potential false negatives.

Table 1 presents the distribution of the sample according to visual acuity by degree of functional distance vision loss as measured by the distance scale. The clinical measures in this table as in all the following tables are based on measures of visual acuity in the best eye with the sample persons using the type of corrective lens that he usually uses.

The value of phi for the distribution for the sample in this table is 0.35. This somewhat weak association (the value of phi can range from 0 to 1) is partially due to the difference in the measures as discussed

TABLE 1

Number and Percent Distribution of Sample Persons According to Visual Acuity (present corrections in best eye) by Distance Vision Scale

Visual Acuity (present correction in best eye)	Total		Distance Vision Scale				
						Can recognize a friend across a street	
	Persons*	Percent	Cannot recognize a friend at arm's length	Can recognize a friend at arm's length but not across a room	Can recognize a friend across a room but not across a street	Some problem seeing distant objects	No problem seeing distant objects
			(Percent Distribution)				
Total	1576	100.0	12.9	16.0	19.8	14.7	36.6
20/400 or worse	219	100.0	53.0	26.5	11.4	3.7	5.5
20/200 to better than 20/400	178	100.0	15.7	36.5	28.1	9.6	10.1
20/70 to better than 20/200	225	100.0	9.3	23.6	32.0	15.1	20.0
20/40 to better than 20/70	339	100.0	7.9	14.8	25.4	16.8	35.1
20/25 to better than 20/40	312	100.0	2.6	7.1	16.4	19.9	54.2
Better than 20/25	303	100.0	1.0	1.3	9.2	17.8	70.6

*Excluded from this table are 28 persons for whom the distance scale measure was unknown and 57 for whom visual acuity was unknown.

above. Also, it may be influenced by how the data are grouped. Since we have no prior evidence to indicate what scale score should be expected for a given visual acuity group, determining adequate cutting points is somewhat difficult. It can be observed, however, that for the extreme visual acuity groups, i.e. 20/400 or worse and the groups better than 20/40, there is a tendency to cluster around the scale scores that might be expected for these groups. However, for the middle visual acuity groups the distribution shows a much wider variation with no salient modal measure.

In analyzing the outliers, that is, those observations that appear to be inconsistent, we found that for the 20/400 or worse group an accumulative total of 9.2 percent reported that they could see well enough to recognize a friend across a street. Ten percent of persons with 20/200 to better than 20/400 vision and 20 percent of persons with 20/70 to better than 20/200 vision reported having no trouble seeing. For those persons with good or normal vision (better than 20/25), an accumulative total of 11.5 percent reported they could not see a friend across a street.

Table 2 shows how the sample is distributed by visual acuity measurement for each of the scale categories. Of the 203 persons who reported that they could not see well enough to

TABLE 2

Number and Percent Distribution of Sample Persons According to the Distance Vision Scale by Visual Acuity (present corrections in best eye)

		Distance Vision Scale				
					Can recognize a friend across a street	
Visual Acuity (present correction in best eye)	Total	Cannot recognize a friend at arm's length	Can recognize a friend at arm's length but not across a room	Can recognize a friend across a room but not across a street	Some problem seeing distant objects	No problem seeing distant objects
Total Number of Persons*	1576	203	252	312	232	577
			(Percent Distribution)			
Total Percent	100.0	100.0	100.0	100.0	100.0	100.0
20/400 or worse	13.9	57.1	23.0	8.0	3.5	2.1
20/200 to better than 20/400	11.3	13.8	25.8	16.0	7.3	3.1
20/70 to better than 20/200	14.3	10.3	21.0	23.1	14.7	7.8
20/40 to better than 20/70	21.5	13.3	19.8	27.6	24.6	20.6
20/25 to better than 20/40	19.8	3.9	8.7	16.4	26.7	29.3
Better than 20/25	19.2	1.5	1.6	9.0	23.3	37.1

*Excluded from this table are 28 persons for whom the distance scale measured was unknown and 57 patients for whom visual acuity was unknown.

recognize a friend an arm's length away 57 percent had a visual acuity of 20/400 or worse, while 1.5 percent had normal vision (better than 20/25), and an accumulative total of 5.4 percent had a visual acuity of better than 20/40. At the other end of the scale, of the 577 persons who reported that they had no problem seeing distant objects, an accumulative total of 5.2 percent had a visual acuity of 20/200 or worse, which is the cutting point for determining legal blindness.[4] As expected the bulk of those persons reporting no problems are clustered in the better visual acuity groups.

The vision questionnaire included a set of questions designed to obtain the respondent's self-evaluation of his vision in each eye separately (see Figure B).

(1) (When wearing glasses) how much trouble do you have seeing with your *left* eye--a lot of trouble, a little trouble, or no trouble at all?

(2) (When wearing glasses) how much trouble do you have seeing with your *right* eye--a lot of trouble, a little trouble, or no trouble at all?

Figure B. The self-evaluation scale questions used in the vision study.

These questions provide a four point scale of the respondent's self-assessment of his ability to see with each eye ranging from blind to no trouble seeing.

Although the respondents were instructed to respond to the distance scale in relation to their total vision, it is possible to hypothesize that some persons with an impairment in only one eye might respond in terms of that eye rather than their overall vision. In a somewhat similar study designed to develop a hearing scale[5] a relatively large segment of the false positives resulted from persons with little or no hearing loss in one ear who were responding in terms of their impaired ear.

To test whether this phenomenon was also present in the distance vision scale we combined the responses obtained for each person's self-evaluation for each eye to establish two categories: (1) those persons reporting at least a little trouble seeing in both eyes and; (2) those persons reporting they have no trouble seeing in at least one eye. Although there will be some reduction in the field of vision, a person who has severe vision loss in one eye but normal vision in the other should be able to see well enough to recognize a friend. Therefore, persons reporting no trouble seeing in one eye are treated as a separate group and only those persons with some trouble seeing in both eyes are classified according to their response to the distance scale. Table 3 shows how the sample is distributed by visual acuity according to this joint classification.

The phi coefficient for Table 3 is 0.36 which is similar to the association observed in the first set of tables. However, there is a shift in the potential outliers. Using the distance scale by itself we found that all but 9.2 percent of persons with 20/400 or worse reported that they could not see a friend across a street. With this joint classification 17.6 percent of this severe visual acuity group are potential false negatives, of which the bulk fall into the category of one or both eyes good. A similar increase of potential false negatives is also observed in those groups with 20/70 or worse. It would appear that some proportion of those persons who report that they have no trouble seeing in one eye do in fact have severe vision loss in their better eye. It is possible that because of the subjective nature of the self-evaluation scale, some respondents with extreme loss in one eye and the other eye impaired, but to a lesser degree, may overrate their better eye because this judgment is made relative to their worse eye. Although we plan to test this hypothesis in future analysis, at the present time we can only speculate on the reasons for these apparent inconsistencies.

TABLE 3

Number and Percent Distribution of Sample Persons According to Visual Acuity (present correction) by Self-Evaluation and Distance Scale Measures

Visual Acuity (present correction in best eye)	Total		Self-Evaluation and Distance Vision Scale					
			Trouble Seeing in Both Eyes					
						Can recognize a friend across a street		
	Persons*	Percent	Cannot recognize a friend at arm's length	Can recognize a friend at arm's length but not across a room	Can recognize a friend across a room but not across a street	Some problem seeing distant objects	No problem seeing distant objects	No trouble seeing in one or both eyes
			(Percent Distribution)					
Total	1526	100.0	11.7	13.2	13.4	7.7	9.3	44.8
20/400 or worse	215	100.0	50.7	22.8	8.8	2.3	1.9	13.5
20/200 to better than 20/400	168	100.0	15.5	32.7	24.4	7.1	5.4	14.9
20/70 to better than 20/200	213	100.0	9.4	20.7	23.5	9.9	8.0	28.6
20/40 to better than 20/70	324	100.0	5.9	11.7	15.4	10.8	12.4	43.8
20/25 to better than 20/40	306	100.0	1.3	4.6	9.5	11.1	13.4	60.1
Better than 20/25	300	100.0	0.3	0.3	5.0	3.3	10.3	80.7

*Excluded from this table are 135 persons for whom the self-evaluation scale, distance scale or visual acuity measures were unknown.

TABLE 4

Number and Percent Distribution of Sample Persons According to Self-Evaluation and Distance Scale Measures by Visual Acuity (present correction)

		Self-Evaluation and Distance Vision Scale					
		Some Trouble Seeing in Both Eyes					
					Can recognize a friend across a street		
Visual Acuity (present correction in best eye)	Total	Cannot recognize a friend at arm's length	Can recognize a friend at arm's length but not across a room	Can recognize a friend across a room but not across a street	Some problem seeing distant objects	No problem seeing distant objects	No trouble seeing in one or both eyes
Total number of persons*	1526	179	201	204	117	142	683
Total Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20/400 or worse	14.1	60.9	24.4	9.3	4.3	2.8	4.3
20/200 to better than 20/400	11.0	14.5	27.4	20.1	10.3	6.3	3.7
20/70 to better than 20/200	14.1	11.2	21.9	24.5	18.0	12.0	8.9
20/40 to better than 20/70	21.1	10.6	18.9	24.5	29.9	28.2	20.8
20/25 to better than 20/40	20.1	2.2	7.0	14.2	29.1	28.9	26.9
Better than 20/25	19.6	0.6	0.5	7.4	8.6	21.8	35.4

*Excluded from this table are 135 persons for whom self-evaluation scale, distance scale or visual acuity measures were unknown.

While combining the self-evaluation scale with the distance scale increases the potential false negatives, it does appear to decrease the proportion of potential false positives. Using the distance scale alone we saw that an accumulative total of 11.5 percent of the persons with normal vision reported that they were unable to recognize a friend across a street. By excluding those persons who reported having no trouble seeing in one or both eyes the proportion of potential false positives is reduced by 5.6 percentage points. Therefore, if we assess the distance scale as a screening device, the inclusion of the self rating scale appears to decrease its sensitivity in that it increases the proportion of potential false negatives but increases its specificity in that it decreases the proportion of potential false positives. Since in the general population only a small proportion of persons will have a vision problem, the false positives will cause much more distortion of an estimate derived from these procedures than would be caused by false negatives. In fact, if the 5.6 percent potential false positives are actually false positives, and if the same proportion were present in a national survey, the estimate for vision impairment would be doubled. However, there are reasons to assume that the proportion of false positives within a general population would not be of this magnitude. First, some of these potential false positives may be caused by other vision defects such as restricted field vision which may not be reflected in the visual acuity measurement. Although information on other vision defects is available to us, we have not had time to analyze it. Secondly, since all sample persons when interviewed were visiting a clinic for some reason related to their eyes or vision there might have been a tendency for some proportion of the study population to exaggerate their vision problem.

Table 4 presents the number of persons classified by the joint distance and self-evaluation scale distributed according to their visual acuity measures. By excluding the persons who report no trouble seeing in one or both eyes the proportion of persons with normal acuity is decreased in all of the distance scale groups. The proportion of persons with a visual acuity of 20/70 or worse is increased in all the scale response groups including those who report no problem seeing by this joint classification.

In summary, the analysis of responses to the distance scale indicates a high degree of internal consistency, which provides evidence that the order and nature of this set of questions have ordinal characteristics.

When comparing the responses from the distance scale with visual acuity measures, we found a positive but relatively weak statistical association. While combining the distance and self-evaluation scale increased the proportion of potential false negatives, it decreased the proportion of potential false positives, which is assumed to create a more important measurement problem. Although there remains a number of unexplained inconsistencies in these findings, some of which might be explained in further analysis of these data, we are generally encouraged by the distance scale's ability to classify populations according to perceived functional vision loss. Therefore, we are presently planning to incorporate this scale into the next cycle of the National Health Examination Survey to test it on the national population. The methodology will be similar to that employed in this study but the findings can be inferred to the general population.

ACKNOWLEDGEMENTS

The authors wish to thank the following persons for their help in the planning and conduct of the Vision Study: Dr. Milton Graham and Robert Robinson, American Foundation for the Blind; Elizabeth Hatfield, National Society for the Prevention of Blindness; Dr. Arthur Keeney, University of Louisville; Dr. Alfred Sommer, Wilmer Institute; Dr. Donald Doughman, University of Minnesota; Dr. Morton Smith, Washington University; Dr. Joel Kraut and E. J. Stockman, Jr., Massachusetts Eye and Ear Infirmary; James McGee, Wills Eye Hospital and Research Institute; E. A. Petrelli, New York Eye and Ear Infirmary; and Abigail Moss, Robert Wright, Beany Slater and Nelma Keen, National Center for Health Statistics.

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THE MODIFICATION OF ATTITUDES TOWARD DISABLED PERSONS: THE CASE FOR USING SYSTEMATIC DESENSITIZATION AS AN ATTITUDE-CHANGE STRATEGY

Harold W. Haddle, Jr.*

Part I: Strategies for Modifying Attitudes toward Disabled Persons: A Review of the Literature

The field of rehabilitation psychology has endeavored to study normal persons' attitudes toward disabled persons by using both naturalistic and experimental methods. These investigations can be classified into four general areas:

1. The effect of information on attitudes toward disabled persons;
2. The effect of contact on attitudes toward disabled persons;
3. A combination of information and contact on attitudes toward disabled persons;
4. The use of psychotherapeutic approaches to modify attitudes toward disabled persons.

INFORMATION AND ATTITUDES

Investigations have been made which attempt to isolate the effect of information on attitudes toward disabled persons. Some have involved merely assessing the previous experiences of the subjects while others have exposed subjects to various types of information about the disabled.

Maglione (1965) investigated attitude measures with the Attitude Toward Disabled Persons scale, Form O, (ATDP-O), (Yuker, Block and Campbell, 1960) of graduate rehabilitation students who had taken courses in a rehabilitation counseling program and compared them with undergraduate students who had had no rehabilitation courses. He found a significant difference, with rehabilitation students scoring higher ($P < 0.01$).

A study with college students, using the ATDP-O was reported by Yuker, Block, and Young (1966). The independent variable was a course in somato-psychology. Pre- and post-course scores were obtained from the following samples: college students with undecided majors, graduate students, and undergraduate physical therapy majors. Undergraduate occupational therapy majors and general psychology students were not enrolled in the course, though pre- and post-ATDP measures were also taken with this group. Only two groups showed a significant positive change: the college students with undecided majors ($P < 0.01$) and the physical therapy majors ($P < 0.05$). Both groups were involved in the course.

Using a more sophisticated experimental design, Olsen (1968) showed tape color-slide presentations to close relatives and distant relatives of spinal-cord injured and stroke patients in an attempt to modify attitudes toward various concepts. Using a semantic differential instrument, he measured, among other concepts, the subjects' evaluations of disability. Close relatives showed no significant positive change in attitudes toward the disability, but distant relatives did ($P < 0.05$). It was concluded that ego involvement was an important

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factor accounting for different responses on the part of the two groups.

A study by Palmerton and Frumkin (1969) showed negligible and partially negative results. They investigated the relationship between college counselors' knowledge about, and attitudes toward disabled persons. Eighty-one college counselors completed the ATDP and the modified version of the Haring General Information Inventory (Haring, Stern, and Cruickshank, 1958), a scale which measures knowledge about disabled persons. The relationship between knowledge and attitudes was not significant ($P < 0.088$), but there was a tendency for them to be related. The results were the reverse of those hypothesized. Greater knowledge was related to more unfavorable attitudes toward the disabled. The data led the experimenters to question the validity of the assumption of the ATDP that seeing disabled persons as different was necessarily a negative orientation.

Wyder, Wilson, and Frumkin (1967) hypothesized that the more positive information teachers possessed about the blind, the more they would see the blind as being less handicapped. The subjects were divided into four groups. One received no positive information. The other three groups received varying amounts of positive information. The Handicapped Problems Inventory (Wright and Remmers, 1961) was administered as a posttest for all groups. The attitudes which were assessed related to blind persons' adjustment in the personal, family, social, and vocational areas of behavior. The positively informed groups perceived the blind as significantly less handicapped only in the area of family adjustment. There were no differences in other areas.

In the area of attitudes toward the mentally ill, Costin and Kerr (1962) compared the results on the Opinions About Mental Illness Scale (Cohen and Streuning, 1962) of a class of abnormal psychology students and a control group. Some changes were evidenced on the OMI by the abnormal psychology students, but there is an indication that the changes were of an informational nature rather than of attitude change. For example, they did not change their views about the differences between mentally ill and normals (Mental Hygiene Ideology), but did increase in their opinion that mental illness is caused by interpersonal experience (Interpersonal Etiology Scale).

Semmel and Dickson (1966) attempted to determine relative connotative reactions of undergraduate students toward various disabilities. Type of training was a dependent variable. It was found that those students who were undergoing specialized training in special education showed no significant difference in connotative meanings of labels, i.e., blind, cerebral palsy, mental retardation, deaf, etc. from students who had completed a single basic service course in special education and also elementary education students who had not been exposed to the course.

Lukoff and Whiteman (1963) investigated whether attitudinal components differed in their susceptibility to various types of communication. This communication was basically of an informational nature. They found that some components are more susceptible to change than others and that "the components that do change are most responsive to communications which are congruent with their content (p. 9)." It was concluded that components of attitudes dealing with personal interactions are difficult to alter since the communications had no effect on those components. They further concluded that if attitude is viewed from a component point of view, attitude change becomes quite complicated.

In analyzing the above studies involving the relationship between information about disabled persons and attitudes toward disabled persons, it can be seen that most of the studies showed no significant results. It can also be seen that this type of approach to attitude change involved modification of the more superficial components of attitudes.

CONTACT AND ATTITUDES

In one of the few well-designed studies Gaier, Linkowski, and Jaques (1968) examined contact experiences of non-disabled on three dimensions: occurrence of a contact, social distance of contact, and perceived effects of disability. Without exception, it was concluded that there was a favorable effect of contact on perceptions of disability.

Jaffe (1967) got less conclusive results. Attitudes of high school seniors toward the mentally retarded were compared on the basis of the students' previous contact with the retarded. No significant differences were found for ratings on the semantic differential (affective dimension), a social distance scale, or the semantic differential strength-activity factor. The single significant difference was on an adjective check list where subjects having some contact with the mentally retarded attributed a greater number of favorable traits to the mentally retarded than subjects having no contact ($P < 0.01$). It was tentatively concluded that contact may have a relationship to the cognitive aspect of attitude but no effect on the affective dimension.

Keith-Spiegel and Spiegel (1970), with no control group, analyzed pre- versus post-change scores on the Custodial Mental Illness Idology Scale (CMI) of thirty introductory psychology teenagers from a junior college. The students spent three hours once a week for five months in various intensive interaction situations with the mentally ill in a mental institution. They changed in the direction of a "more humanistic view of mental illness and a more realistic view of psychiatric patients (p. 388)." Significance was reported at the 0.01 level.

Kulik, Martin, and Scheibe (1969) compared amount of change along attitudinal dimensions between college student volunteers in an eight-week program (40 hours per week) and control group subjects. Volunteers changed more than controls on factored-out dimensions of the Opinions About Mental Illness Scale. The volunteers saw mental patients as less abnormal than the control groups. On an adjective check list they looked more favorably toward patients at the end of the experience than did the control group, although the results on this scale were not significant.

In another study involving contact with the mentally ill, Scheibe (1965) assigned college student volunteers to a chronic ward for a continuous eight-week program. No control group was used in this study and the study was considered to be a large scale exploratory study. The volunteers indicated on the Adjective Check List (Zuckerman, 1960) more positive words and less negative words in describing mental patients at the end of the summer ($P < 0.01$).

It can be seen from a review of studies involving contact only, that there is not substantial evidence to show that contact with the disabled in itself is adequate to affect attitudes positively toward the disabled. Jordan (1971) and other studies (e.g., Morin, 1969) indicate that the nature of contact with the disabled is as important as contact itself. Contact which generally is of a positive nature tends to affect attitudes positively. Yuker, et al. (1966) also tend to agree with this assumption. At any rate, mixed results have been reported in the literature from studies which tend to be poorly controlled.

INFORMATION AND CONTACT

It has been hypothesized by Anthony (1972) that information or contact alone are not sufficient to affect attitudes toward disabled persons on the part of non-disabled persons. He contends that a combination of contact involving positive experiences and information about disabled persons provide a more potent modifier of attitudes toward the disabled in a positive direction. The following literature partially supports his contention.

Using a modified form of the ATDP-O, McCourt (1963) compared attitudes of various groups of professionally trained hospital personnel in geriatric and non-geriatric hospitals with various groups of non-professional personnel in geriatric and non-geriatric hospitals. It was found that the professional group exhibited the higher score ($P < 0.01$).

Yuker, et al. (1966) report an unpublished study which used the ATDP-O to analyze scores of student nurses before and after their participation in a course on principles of rehabilitation. There was no significant difference between pre- and posttest scores.

Warren, Turner, and Broady (1964) investigated the effectiveness of an educational program consisting of lectures, discussions, and institutional tours. Subjects were undergraduate education majors. Results showed that preference for the brain injured child significantly decreased while preference for the visually handicapped significantly increased. Both measures were significant at the 0.01 level.

In a more recent behavioral study Kennedy and Anthony (1972) compared counselors experienced and trained in rehabilitation to other counselors along a general dimension of the ability to form a therapeutic relationship with a physically disabled client. The primary independent variable was a graduate degree in Rehabilitation Counseling. Therapeutic relationship was measured in three areas:

1. Level of facilitative conditions,
2. Frequency of confrontations,
3. Client exploration.

It was found that educational training and experience in rehabilitation were not significantly related to frequency or confrontation and client self-exploration. Rather, the counselors' levels of facilitative conditions were significantly related to these dependent variables.

Higgs (1971) investigated whether the relative roles of information level and degree of contact with the disabled were related to attitudes toward disabled persons. Using three paper and pencil measures with subjects from secondary school groups, college undergraduates, and counselors and parents, it was found that in most cases subjects who possessed more information also possessed high degrees of contact and most positive attitudes toward physically disabled persons. However, the design did not allow for an examination of the relative effects of contact and information variables alone.

Downes (1967) found a significant difference in attitude scores on the ATDP for rehabilitation counselors without graduate degrees. The counselors with graduate degrees had the highest mean scores. This study also did not control for experience and contact as separate factors influencing attitudes toward physically disabled persons.

Marsh and Friedman (1972) found positive attitude change on the part of sighted high school students toward blind persons by exposure of the sighted to a five-day training program which emphasized that blind persons were normal and could travel independently. The program also exposed the subjects to various types of equipment which blind persons used in learning. Active involvement by students was stressed, such as having them role-play blind persons and walk around the campus blindfolded. No statistical significance was given in the study, but it was indicated that "the percentage of responses judged incorrect decreased (p. 47)." The primary dependent variables were attitude scales constructed by the experimenters. Although this study would primarily be considered as an informational attempt to modify attitudes, the contact factor would certainly be an important variable to consider since the students were in contact with blind students, although incidently, before and during the study.

Using college students as subjects, Chinsky and Rappaport (1970) conducted an undergraduate seminar and practicum course in mental health in which the students were exposed to instruction and actual participation in groups with hospitalized mental patients (30 hourly sessions per student). Attitudes changed significantly in a positive direction on the Adjective Check List and on an adaptation of the semantic differential.

Cleland and Chambers (1959) used a "guided tour" technique to modify attitudes toward the mentally retarded. High school and college students were taken on a guided tour of a state-supported school for the mentally retarded. Attitudes were assessed by a specially constructed sentence completion form. Attitudes did change, but not necessarily in a positive direction. The students praised the institution and staff more, but tended to see mentally retarded as better off in the institution than outside the institution.

Hicks and Spaner (1962) investigated the effects of an overall mental hospital experience in modifying attitudes toward the mentally ill. Student nurses were subjects. A control group consisted of student nurses in general hospitals who had not yet received the psychiatric phase of their training. The hypothesis that the subjects in the experimental group would make a significantly greater shift in positive attitudes toward the mentally ill during the twelve-week period was supported.

The effects of an intensive psychiatric nursing training program (eight-week) on student nurses' attitudes about mental illness on the OMI scale were evaluated by Lewis and Cleveland (1966). Change scores were measured for the students in training and a control group of students who had not been exposed to the psychiatric training. A significant difference was found between the change scores of the experimental group and that of the control group. However, the nature of the treatment was not well described and subjects were in different hospitals, thereby raising some questions regarding the adequacy of the design.

The effects of contact plus information on attitudes toward the mentally ill was assessed by Smith (1969). The subjects were student nurses. An experimental group and a control group were compared on attitudes as reported on the OMI. It was found that there was no significant difference in change scores between the experimental and control group.

In a study designed to experimentally modify attitudes toward blind-deaf persons, Rusalem (1967) found that the attitudes of a group of high school girls could be changed by their being involved in a planned program of attitude change which involved six one-hour sessions. The students were selected to form two groups: one with the most positive attitudes and one with the least positive attitudes. All subjects were required to participate in the research and would not be considered as volunteers. The information and contact experience involved dissemination of information about deaf-blindness, instruction in the manual alphabet, and situations which involved their communication with deaf-blind persons. Measures of attitude change were behavioral as well as including self-report measures. Both groups changed on behavioral measures even though the students with the most positive attitudes did not change on the self-report measures, probably due to a ceiling effect. The group exhibiting the poorest attitudes improved on attitude and behavioral measures.

Another study assessing the effect of information and contact was conducted by Anthony (1969) who studied the attitudes of counselors employed in a summer camp for handicapped children. The new counselors had significantly less positive attitudes than experienced counselors who had worked at the camp previously, on a pretest measure, the ATDP. By the end of the summer, however, the new counselors improved significantly in their attitudes toward physically disabled persons.

Anthony and Carkhuff (1970), in assessing the effects of rehabilitation counselor training found that students who had more information about and contact with disabled persons showed more positive attitudes toward physically disabled persons than beginning students.

Studies involving a combination of contact and information variables tend to produce more significant results than either variable alone. However, many of the studies using these components as dependent variables are poorly designed. The most significant studies, with the exception of the study by Rusalem (1967), required extensive contact with the disabled, often 40 hours a week, which may not be practical for the average person to engage in.

PSYCHOTHERAPEUTIC APPROACHES

One study reports an attempt to change attitudes toward disabled mentally retarded persons through use of covert reinforcement, a psychotherapeutic technique (Cautela, Walsh, and Wish, 1971). Using college students as subjects, an experimental group and a treatment group were established. A Likert-type questionnaire, entitled the Mental Retardation Opinionnaire was constructed by the authors. Both groups were pretested on this scale.

The treatment-control group subjects were asked to relax and visualize a mentally retarded person. The treatment group was given the same instructions except they were asked to imagine a pleasant scene along with imagining a mentally retarded person. A t test between pretest means failed to show a significant difference between groups. The treatment group showed a significant increase in scores at the 0.01 level from pretest to posttest while the treatment-control group did not. A possible interpretation given by the experimenters for the results was the contiguity principle. The authors concluded that it should be feasible to manipulate attitudes through techniques of behavior modification.

In a well controlled study systematic desensitization was used by Haddle (1973) as a strategy to modify attitudes toward disabled blind persons. Various paper and pencil instruments were used as outcome measures, including the ATDP, Form O, and four subscales of the Opinions About Blindness scale (Siller, 1966). No significant results were obtained although various procedural problems, which could be corrected through further research, likely attenuated the effect of the treatment and the testing of the theory that attitude change will occur if specific situational anxiety is modified.

SUMMARY

It can be concluded from the above studies that though contact with disabled persons and information about disabled persons appear to be important variables affecting attitudes toward disabled persons, the results are not conclusive. Most of the studies reviewed lack good experimental designs. Some do not utilize control groups and for many of the studies difficulties are evident in isolating the variables of contact and information. Lack of definition in treatment approaches is also evident. A further weakness, pointed out by Anthony (1972), is that most subjects were volunteers and little research has been done with age groups other than college students. A further weakness of these studies is related to their nonexistent or poorly defined theoretical bases.

Psychotherapeutic approaches also show mixed results. However, since very little research has been done using these approaches it appears that further studies should be attempted. At least, psychotherapeutic procedures tend to offer a more viable framework for experimental control than the typical information and contact paradigms.

Part II: Anxiety and Attitudes Toward Disabled Persons: A Rationale for Using Systematic Desensitization as an Attitude-Change Strategy

Anxiety or fear has an important role in the acquisition of avoidance behavior toward the disabled. Therefore, a review of the literature concerning the role of anxiety as an important construct in the acquisition of behavior and attitudes is presented here.

Disorders of human functioning are frequently attributed to "emotional" disorders. The construct of anxiety plays a central role in almost all theories of psychopathology. These theories generally assert that aberrant behavior (i.e., neurotic or psychotic) are adjustive reactions that prevent the individual from experiencing an extremely uncomfortable state which is typically labeled as "anxiety." It should be noted that Fischer (1970) points out that learning theorists and physiological psychologists generally do not make a distinction between fear and anxiety.

In psychoanalytic theory (Fenichel, 1945; Freud, 1926) symptoms are perceived as defenses which help to repress unconscious anxiety. Anxiety is probably the most important construct used in psychoanalytic theory. The learning theorists label various behavioral patterns as "anxiety" which involve some type of escape or avoidant response (Dollard and Miller, 1950; Mowrer, 1939). These responses, couched in stimulus-response terminology, are analagous to the "symptoms" of the psychoanalyst. These responses are described and sometimes measured by the physiologists in terms of anatomical and endocrine processes in the subject's body (Malmo, 1959).

The theoretical framework and literature review in this study can provide the basis for the supposition that anxiety can be a meaningful construct to explain the acquisition and/or modification of attitudes toward various stimuli, including attitudes toward disabled persons. Studies will now be considered which tend to support this position. These studies have attempted to link a concept of generalized anxiety to measures of attitudes toward the disabled.

ANXIETY AND ATTITUDES TOWARD THE DISABLED

Siller, Chipman, Ferguson, and Vann, (1967a) concluded that practically all of the studies found in the literature found some relationships, although sometimes moderate, between personality and reactions to the disabled. One of the personality variables investigated has been anxiety. For example, Meng (in Barker, et al., 1953) found in clinical practice that fear and avoidance of the physically disabled on the part of the non-disabled is widespread. He theorized that three often unconscious mechanisms are responsible:

1. Belief that disability is a punishment and a disabled person is evil and dangerous.
2. Belief that a handicap is an unjust punishment and that the disabled person is out to commit a detrimental act to counteract the injustice.
3. Belief that non-disabled persons project their own unacceptable desires upon the disabled which propagates the idea that the disabled are evil and dangerous.

Siller (1964) traces the psychoanalytic basis of negative fear-laden reactions to the disabled on the part of the non-disabled to an activation of latent fears of castration on the part of the non-disabled. Siller, et al. (1967a) refer to Chevigney and Braverman (1950) as theorizing that castration fears are involved in aversive reactions to the blind. They also cite a study by Cowen, Underberg and Verillo (1958) who hypothesized that if negative attitudes toward the blind are a function of castration anxiety, men should show more negative attitudes than women. This was true for their study ($P < 0.06$). However, high scores on anti-minority scales on the part of men led the investigators to conclude that the variable of castration fear could not be used to explain the differences in scores but that there was more of a generalized response difference between the sexes.

Siller, et al. (1967a) tested the hypothesis that high anxiety measured by the Elizur Anxiety Scale (Rorschach) was related to negative attitudes toward the physically disabled. They found little support for this hypothesis. There was also no significant relationship between the Elizur scale and other disability attitude measures such as the Attitude Toward Disabled Persons scale, "Affect," and "Intimacy" scales. The Schwartz Castration Anxiety score correlated with only two disability variables: Voluntary Contact ($P < 0.05$). They concluded, however, that the anxiety measure was not adequately tested because of the questionable validity of the personality measure. They further concluded that the theoretical position that castration anxiety or other types of anxiety are related to attitudes toward disabled persons is yet to be tested.

There were earlier studies, however, which showed a positive correlation between negative attitudes and high anxiety level. The ATDP has been used in several anxiety studies. Yuker, et al. (1960) found a negative relationship between anxiety as measured on the Weiss-Plutchik Anxiety scale and Form O of the ATDP. Persons having high anxiety had less accepting attitudes while those with low anxiety had more accepting attitudes ($P < 0.01$). A study by Arnholter (1963) reported similar results. Both studies, however, used disabled persons as subjects. Kaiser and Moosbrucker (1960), using GSR response measures, found the same relationship with non-disabled college students. Siller (1964), in testing the hypothesis that anxiety negatively affects attitudes toward the disabled, correlated data from three non-disabled samples on the ATDP-O with two anxiety measures--the Welsh Anxiety Scale and the Zuckerman Affect Adjective Check List. Five negative correlations were obtained. A negative correlation signifies a negative relationship between high anxiety level and positive attitudes toward the disabled. Three of these correlations were significant at the 0.05 level, one at the 0.01 level, and one nonsignificant. Human Resources (1962) found that the IPAT correlated negatively with the ATDP, Form O, with six groups of non-disabled college students. However, significance was reached for only one group ($P < 0.05$).

Yuker, et al. (1966) concluded that there is evidence of a negative correlation between general anxiety and positive attitudes toward disabled persons. Some studies do not reach significance, but all of the studies show a negative relationship.

The studies which have attempted to correlate a personality measure of anxiety to attitude have operated either from a psychoanalytic model or no theoretical position at all. Siller, et al. (1967a, b) have approximated a theoretical position more closely than others; however, it is difficult to translate psychoanalytic terminology into meaningful concepts relevant to the mainstream of attitude change theory. It should be noted, however, that in developing the Disability Factor Scales, including the Opinions About Blindness scale (1966), which is used in this study, they have translated hypotheses derived from psychoanalytic theory to a psychometrically-sound instrument designed to measure attitudes, even though they did not elaborate on an attitude acquisition or change theory (1967b).

Anxiety studies in the area of attitudes in rehabilitation psychology have all been of a descriptive nature. There seems to be no application of the anxiety construct to attitude change studies. Since this area has been researched with some positive descriptive findings, it appears that a fruitful endeavor would be to investigate the anxiety-attitude paradigm under controlled conditions in the context of a well-defined theoretical base.

A LEARNING THEORY BASIS FOR ANXIETY

The most widespread experimental interpretation of neurotic behaviors considers anxiety as a conditioned response stimulus which is painful to the organism. This interpretation has been proposed by Hull (1943), Mowrer (1950), and Dollard and Miller (1950). Basically, fear or anxiety is viewed as a conditioned response (CR) by classical conditioning. This occurs when a conditioned stimulus (CS) is paired with a painful stimulus. Mowrer (1950) has proposed that this CR includes autonomic components related to properties of the original stimulus which elicits pain. Furthermore, the conditioned response serves as a drive stimulus in the organism until some other response, which is instrumental, allows the organism to escape from the original environment. Hull (1943) and Miller (1948) show evidence that the CR, which is acquired through being paired with the original painful response, comes to act as an acquired drive which can be reduced by various escape or avoidance responses. In human phobias, it can be presumed that a conditioned fear drive is established in a traumatic situation and that the acquired anxiety drive (CR) continues to support avoidant or phobic responses which allow the individual to escape from the fear-provoking situation on subsequent occasions.

The relationship of anxiety to avoidance behavior is obvious in the Hullian paradigm. In Figure 1, it can be seen that the unconditioned response (UCR) occurs as avoidance behavior. In Miller's classical experiment (1948) the rat fled the white compartment into the black compartment to escape the pain of electrical shock. This was an unconditioned response (UCR) based on fear or anxiety (also an UCR) experienced as a result of the shock.

In step two of Miller's experiment, the shock was omitted to eliminate the "primary" drive of pain. The door between the compartments was closed and the rats in the white compartment showed obvious signs of agitation and fear. It was concluded that the fear responses in this stage were learned in association with the uses of the white compartment since the initial fear stimulus had been removed. The white compartment then became a conditioned stimulus (CS) and the conditioned response (CR) was anxiety since there was no way to instrumentally avoid the white compartment with the door shut.

This model can apply to human behavior as well. It is the contention of this paper that it is also applicable to attitude formation. In Figure 1, the UCS could serve as a stimulus evoking ambiguity, unpleasantness, or fear on the part of a non-disabled person as he is exposed to disability. He could have been frightened by the unusual appearance of a disabled person. He could have learned that to be disabled is to be "different" or "unwanted" and these connotations could be disturbing to him. He could fear becoming disabled himself. Regardless of the basis, the UCR may be anxiety or discomfort. This is the classical conditioning phase.

On subsequent occasions, specific stimuli (CS), such as the presence of

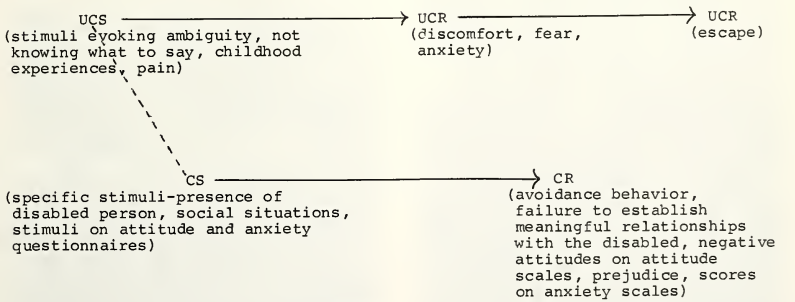

Figure 1. Avoidance Response Attached to and Initiated by the Onset of a Conditioned Stimulus

a disabled person or an attitude scale, could evoke an avoidant response (CR) on the part of the nondisabled person. His behavior may be classified as "striving away from" (Staats, 1968), which could be manifested by incongruent behavior (Kleck, 1968), anxiety, or negative responses on a paper and pencil attitude scale. These responses are largely "instrumental." Through the process of conditioning, an attitude may be formed as a means of dealing with the discomfort or anxiety.

Support is given to this affective model in attitude theory. Doob (1947) considers all attitudes as learned, mediating responses, primarily acquired through the drive-reduction principles of Hull and Dollard and Miller. He illustrates his model by considering an attitude as an anticipatory response: "If an individual, for example, dislikes a fruit or a person, he tends to avoid eating the fruit or meeting the person. Originally the avoidance occurred only after actual contact had been established and after that contact had proved to be punishing and the withdrawal to be rewarding (p. 43)."

Some research has focused on the affective component of attitude. For example, Rosenberg (1960) used hypnotic suggestion to change the affective component of an attitude. Others have attempted to establish attitudes by classical conditioning (Das and Nanda, 1963; Eisman, 1955; Staats and Staats, 1958; Zanna, Kiesler, and Pilkonis, 1970). "Higher order" paradigms typically pair stimuli such as neutral words with a series of adjectives which have evaluative meaning (Blasford and Sampson, 1964; Cohen, 1964; Goots and Rankin, 1968; Staats and Staats, 1958). "First order" paradigms typically pair a conditioned stimulus with the onset of an aversive unconditioned stimulus, usually electric shock. It has generally been found that the neutral stimuli, when paired with shock or unpleasant adjectives, are evaluated more negatively. Zanna, et al. (1970) summarized: "This finding has supported the assumption that negative affect is associated with a series of unpleasant adjectives and with shock and the hypothesis that attitudes can be established by classical conditioning (pp. 327-28)."

Systematic Desensitization as an Attitude Change Strategy

Since it has been demonstrated in the laboratory that attitudes can be established by classical conditioning techniques, it follows that attitudes may be modified by a classical conditioning technique. Insko and Oakes (1966) suggest that attitudes which are deeply rooted can only be changed by counterconditioning. The contention of this paper is that systematic desensitization, typically a counterconditioning procedure, can be applied as a strategy to change attitudes toward disabled persons.

The effectiveness of systematic desensitization as a therapeutic technique has been demonstrated. Wolpe (1958, 1969) and Wolpe and Lazarus (1966) have reported numerous case studies in which all types of neurotic phobic reactions have been eliminated through this procedure. Laboratory research has also demonstrated its effectiveness (Lang, Lazovik, and Reynolds, 1965; Mathews, 1971; Paul, 1966). Numerous studies have further shown the effectiveness of this procedure in areas that traditionally would not be considered to be "neurotic." For example, systematic desensitization has been used successfully with the treatment of test anxiety (Donner, 1967, 1970; Emery, 1969; Taylor, 1971), public speech anxiety (Woy and Efran, 1972), and snake phobias (Kimura, Kennedy, and Rhodes, 1972; McGlynn, 1972).

Systematic desensitization has not been widely applied to attitude change studies. There are no studies in the literature which include humans as attitudinal objects as does the present investigation. Only a few studies have used attitude scales as dependent variables, with snakes as the attitudinal objects (Bandura, Blanchard, and Ritter, 1969; Suinn, Edie, and Spinelli, 1969). Attitudes in both studies were conceptualized as responses on a Likert-type scale. In addition, a semantic differential scale was used in the Bandura study. Typically, the studies in systematic desensitization have placed emphasis on behavioral indices and fear schedules as dependent variables rather than attitude-type scales. It should be noted, however, that the Bandura and

Suinn studies both showed that attitudes toward snakes could be modified through the use of systematic desensitization.

THE RECIPROCAL INHIBITION PRINCIPLE

Kanfer and Phillips (1970) summarize the two essential ingredients contained in the method of systematic desensitization as proposed by Wolpe (1958)--desensitization and reciprocal inhibition:

> Two essential ingredients are contained in the method. First, the subject is exposed to a weaker form of the same CS that is presumed to have originally been conditioned to anxiety through association with potent UCS. Because of this stimulus grading, the conditioned emotional response itself is produced, if at all, at only a very low level of intensity. This feature characterizes the *desensitization* aspect of Wolpe's method. Second, a response is introduced that is antagonistic to the anxiety response, as eating was in the cats. This feature is termed *reciprocal inhibition* by Wolpe and is equivalent to conditioning a more probably competing response to the CS, leading to conditioned inhibition, which minimizes the anxiety reaction (p. 148).

Wolpe (1958) has expressed the basis of his therapy approach as follows: "If a response incompatible with anxiety can be made to occur in the presence of anxiety-evoking stimuli so that it is accompanied by a complete or partial suppression of the anxiety responses, the bond between these stimuli and the anxiety responses will be weakened (p. 71)."

Wolpe (1958), basing his theory on his studies of "experimental neurosis," contends that the unlearning of anxiety occurs best when the process of reciprocal inhibition is involved. He argues against the Mowrer-Miller hypothesis which indicates in conditioning situations that, if the cessation of an act is reinforced, drive reduction occurs. He contends that this instrumental approach is not sufficient to lessen a drive such as anxiety. He indicates that "a 'permanent' lessening of conductivity of the synapses subserving the evocation of the act in response to the particular stimuls constellation. . . is necessary for conditioned inhibition to occur (1958, p. 29)."

Extinction, according to Wolpe, is not effective when anxiety is involved. He refers to Miller's study (1950) which found that a motor habit accompanied by fear required hundreds of times to be extinguished. He attributes the poor extinction of anxiety responses with extinction techniques partly to the possibility that an anxiety response is reinforced by anxiety drive-reduction when the organism is passively removed from the anxiety-evoking stimuli (1958, p. 71).

Hypothesizing that the acquisition of anxiety is basically a physiological learning process, Wolpe concludes from his research that all positive learning involves counter-conditioning, based on the principle of reciprocal inhibition. This involves selecting responses that oppose anxiety responses. He eventually utilized three types of responses to oppose anxiety in clinical therapy. They were assertive responses, sexual responses, and relaxation responses (1958).

Although Wolpe concedes that motor responses can diminish the habit strength of anxiety responses, he prefers the reciprocal inhibition approach. Reciprocal inhibition does not involve a therapeutic attack on motor responses, but on autonomic components (1958, p. 74).

Wolpe would treat the problem of anxiety reduction by approaching the problem at the CS (conditioned stimulus) level (Fig. 1). The conditioned response (CR) of anxiety would be desensitized, or deconditioned, through systematic desensitization. If reciprocal inhibition of the anxiety response did indeed occur, a reduction of the motor response of avoidant behavior (CR) would occur through generalization. Without the use of instrumental terminology, it is difficult to ascertain exactly how this would occur. Wolpe attempts explanation by using physiological language couched in classical conditioning terminology.

If Hull, Mowrer, or Dollard and Miller approached the problem of modifying anxiety, they would focus on having the subject respond differently through extinction, which involves focusing on the CR rather than the purely classical CS (Fig. 1). In addition to this instrumental approach, Dollard and Miller (1950) would change the cue-value of the CS by some type of talking therapy which basically would be verbal reconditioning.

Whether the problem of anxiety reduction is approached from a model of reciprocal inhibition (Wolpe) or a form of extinction (Hull), the goal is the same--to help the subject to respond more appropriately to anxiety-evoking stimuli. In considering the anxiety-attitude model of the present paper the approach of Wolpe would be taken as an attempt to decondition the anxiety-producing properties of the CS (Fig. 1), with the assertion that the CR would change on attitude scales. This should occur, as Wolpe maintains, by counterposing relaxation responses against specific stimuli (CS), such as interaction situations with disabled blind persons as presented in an anxiety hierarchy.

It is doubtful that the mechanisms of reciprocal inhibition are sufficient to account for the hypothesis of this paper. This is predicated on doubt that reciprocal inhibition fully explains what occurs in the porcess of systematic desensitization (Breger and McGaugh, 1965; Weitzman, 1967). The drive reduction hypothesis offers a more tenable explanation of motor activity (response on attitude scales) than the reciprocal inhibition explanation. Alternative explanations of the process, primarily involving "cognitive" interpretations, have been offered.

Kanfer and Phillips (1970) acknowledge that systematic desensitization as a learning-behavioral approach is typically classified as a "classical conditioning" procedure. However, they do not consider the procedure as being entirely of a "classical" nature. They term it a "mixed model." This is based on the "instrumental" aspect of the method. They indicate: "The method demands, however, that an antagonistic response, toned with positive affect, also be elicited and maintained. Since such responses are usually operants, the actual operations in desensitization include elements of both learning processes (p. 149)." This is obvious in the various studies using systematic desensitization as a treatment approach. Typically, instrumental responses such as actual approach behavior (i.e., approaching snakes), and/or the instrumental act of responding to a "fear schedule" are the dependent variables.

Others offer various explanations for the mechanisms governing the counterconditioning process (e.g., Bandura, 1969). A "cognitive" model which typifies other explanations of the process has been proposed by Goldfried (1971), who considers systematic desensitization a process whereby the patient actively learns self-control rather than passively receiving the treatment. This interpretation involves the contention that much of what goes on in the systematic desensitization paradigm is verbal or cognitive mediation. Goldfried indicates that this active process is "directed toward learning of a general anxiety-reducing skill, rather than the passive desensitization to specific aversive stimuli (p. 228)." It involves . . . "the active building in of the muscular relaxation response and cognitive relabeling into the r-s mediational sequence (p. 228)." Several studies are cited by Goldfried to support this approach. They fall into four categories:

(1) Studies showing generalized anxiety and fear reduction are reported following successful desensitization (Cooke, 1966; Lang and Lazovik, 1963; Lang, et al., 1965; Paul, 1966, 1967; Paul and Shannon, 1966). The importance of these studies is found in the fact that generalized anxiety reduction occurs in respect to objects differing widely as to their stimulus properties. This finding is not easily explained by the limited amount of stimulus generalization likely to follow from the desensitization of specific fears.

(2) Another category of studies used by Goldfried to support his views is found in the phenomenon often occurring after desensitization sessions whereby the amount of transfer of fear reduction after the sessions is not complete, even though anxiety reduction

did occur during the sessions themselves (Agras, 1967; Davison, 1968; Lang, et al., 1963; Lang, et al., 1965). Successfully desensitized subjects reported experiencing tension, even though they were more able to approach the previously feared objects. The explanation for this lack of perfect transfer may be found by referring to the discrepancy between imagined situations and those in reality (Davison, 1968), but Goldfried agrees with Agras' (1967) interpretation that there may be *two phases* which explain the successful results of systematic desensitization. These are: learning in the desensitization session itself and also the changes which occur *in vivo*. This account is in accord with Goldfried's mediational hypothesis, where the subject learns techniques for coping with anxiety through treatment, but the ultimate gain does not occur until anxiety is prevented after it is completely learned by repeated trials in real-life situations. Empirical support is offered for this theory by the Bandura, et al. study (1969) which found that positive reinforcement through social modeling and guided participation procedures improved approach behavior more than symbolic desensitization.

(3) A third piece of evidence for the mediational theory is found in work on the use of drug-induced relaxation in systematic desensitization. Brady (1967), in using Brevital to induce states of relaxation, suggests that the successful use of the drug involves the client's allowing himself to relax, which lends support to Goldfried's theory that fear reduction follows from the client actively attempting to relax himself rather than. . . "simply presenting aversive stimuli when the individual happens to be in a state of relaxation (Goldfried, 1971, p. 230)."

(4) A fourth factor, which is supported experimentally by Schachter and Singer's studies with Epinephrine (1962), stresses the importance of cognitive processes involved in emotional states. Studies involving manipulation of the client's expectancy for improvement enhanced the effectiveness of systematic desensitization (Leitenberg, Agras, Barlow, and Oliveau, 1969; Marcia, Rubin, and Efran, 1969). Valins and Ray (1967) used false heart-rate feedback to manipulate subjects' cognitions of emotional arousal in the presence of aversive stimuli and were able to influence the subjects to the point of approaching the previously feared object.

These four categories of "cognitive" studies lend support to a concept of a mediating process occurring in systematic desensitization. These explanations, along with the evidence that systematic desensitization treatment involves instrumental as well as classical properties, offer support for an "integration" theory of learning which is applicable to any psychotherapeutic strategy or attitude-change strategy as well.

STAATS' "ARD" MODEL

Staats (1968) presents a theoretical model within the framework of attitude theory which offers an appropriate framework for the use of systematic desensitization as an attitude-change strategy. This framework fits the "learning-behavior theory" of attitude change as proposed by Greenwald (1968). Staats attempts to integrate various separate schools of learning theory into an overall system which he calls "social behaviorism and human motivation." His work makes an important contribution to the question of how an autonomic conditioning process such as systematic desensitization can be generalized to operant behavior, such as performance on an attitude scale.

In viewing attitude stimuli as found in one's natural environment, Staats reduces these stimuli to a limited number of themes. These themes can be summarized as functions attributed to attitude objects. These functions are:

1. The conditioned stimulus function (attitude objects elicit emotional reactions).

2. Reinforcing stimulus function (one's exposure to an attitude object may function as a reward or punishment for that person).

3. Discriminative stimulus function (whereby the attitude objects serve as a signal for the performance of an instrumental response).

This system is referred to by Staats as the ARD system, depicting the attitude-reinforcing-discriminative functions of attitudinal stimuli.

Within the framework of this theory Staats analyzes the problem of assessing human behavior with the use of attitude scales by theorizing about what occurs when a subject responds to a test item:

> The verbal test stimulus elicits an attitudinal response (because it has been paired with the actual emotional stimulus, for example) which makes the test stimulus both a conditioned stimulus as well as a reinforcing stimulus. As a consequence of these functions the stimulus will also be a discriminative stimulus controlling either a class of striving-for or a class of striving-away from behaviors, as the case may be, including the verbal behaviors of checking or writing "like" or "dislike," and so on. It is the discriminative function of the stimulus that is being measured, however, not the other two functions. It is suggested that it is because all three stimulus functions are related in the manner described, that the three functions can be assessed from observations only of the discriminative stimulus value (p. 59).

A study by Finley and Staats (1967) showed that attitude scales did provide an index of the reinforcing properties of words as do traditional test items.

The implications of Staats' theoretical ARD system for the present paper are obvious. If combinations of classical, instrumental, and discriminative controlling functions do occur in attitudinal stimuli, a connection can be made between autonomic behavior change and operant behavior; likewise, a theoretical base can also be established for using paper and pencil attitude scales to measure behavior change resulting from a classical conditioning paradigm, such as systematic desensitization.

Staats (1968) further offers a rationale for the use of behavior therapy in applied attitude change studies and offers a case example to clarify the ARD system. He suggests that behavior therapy, including counterconditioning and desensitization, involves changing the value of some of the attitudinal stimuli in the individual's system through classical conditioning principles. A person with a phobia (for Staats, a strong negative attitude) will, through conditioning, respond less intensely to the stimuli. He suggests that "simply recognizing that behavior therapy in large part consists of changing the value of attitidunal stimuli of various kinds opens a large area of research for the attitude theorist (p. 61)." Staats uses Raymond's case (1960) as an example to explain how his ARD theory accounts for the occurrence of generalized responses after a specific treatment. (Raymond's client was sexually attracted to baby carriages and women's handbags):

> After the counterconditioning (aversive) treatment he no longer approached these objects. Moreover, the treatment generalized--the patient's sexual relationship with his wife improved. When the ARD system is applied to this case, the generalization of the treatment can be expected. That is, the fetish objects and the wife may be seen as sexual stimuli in the patient's hierarchial ARD system. Thus, it would be predicted that lowering the value of the fetish objects would raise the relative value of other stimuli in the system--in this case the wife--in the three functions of the ARD stimuli, thus increasing his sexual activity.

Staats further emphasizes the importance of a system of behavioral interpretation which does not oversimplify:

> It should be indicated that without a sophisticated understanding of the ARD system, and assessment of the individual's ARD system, the behavior therapy treatment could easily be symptomatic and result in further pathology. That is, if the next strongest reinforcer in the patient's sexual reinforcing system had been people of the same sex (or some other "abnormal" social stimulus), rather than the

wife, lowering the attitudinal value of the fetish objects as reinforcers could have resulted in homosexual behavior becoming more dominant, which might even be less desirable than the original problem.

Staats indicates the need for sophisticated systems of learning in the field of behavior therapy:

> This example indicates the need for relating a sophisticated learning conception of the ARD system to the field of behavior therapy--including knowledge of the relationship of conditioned stimulus, discriminative stimulus, and reinforcer stimulus value. For while behavior therapy changes conditioned stimulus value in the controlled treatment procedure, its results depend upon the change of discriminative stimulus and reinforcing value in the natural and unmonitored conditions of the patient's life circumstances (pp. 61-62).

SUMMARY AND IMPLICATIONS

1. Anxiety theory and research show that there is a relationship established between anxiety and avoidance or other types of instrumental behavior. The implications for relationships between non-disabled and disabled persons are obvious. If friends, counselors, or family members experience anxiety in the presence of disabled persons, the anxiety may be reflected in their behavior and attitudes, thus causing strained interpersonal relationships.

2. Attitudes can be established by principles of classical conditioning. This implies that attitudes are deep rooted, involving emotional components. Furthermore, initial experiences with disabled persons on the part of non-disabled persons may have a powerful influence upon future attitudes and behavior. Further research is needed, however, to substantiate the general findings in the area of attitudes toward disabled persons.

3. There is a strong theoretical base and some research evidence which support the use of systematic desensitization as a strategy to modify attitudes.

4. Studies showing the generalization of behavior resulting from systematic desensitization treatment offer empirical support for a mediational hypothesis involving active rather than passive processes on the part of the client. There is evidence that a general anxiety-reducing skill can be acquired by a client which can be translated into cognitive relabeling. This involves a cognitive process as well as conditioning.

5. There is evidence that attitudinal stimuli follow the context of a three-fold function: classical conditioning, reinforcement, and the discriminative controlling functions which such stimuli acquire. The discriminative function of the stimulus is what is measured on an assessment instrument, such as an attitude scale. This explanation of attitude formation attributes reinforcing properties to social objects and words (such as items on an attitude scale) in their own right. The close relationship between classical and operant functions as explained by Staats' ARD system offers support for a rationale that conditioning of autonomic responses can be generalized to operant behavior.

These observations support the rationale for this paper, in which it is asserted that systematic desensitization of fears of non-disabled persons in social situations with disabled persons can be generalized to responses to stimuli on attitude scales which include disabled persons as attitudinal objects.

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PSYCHOLOGICAL ASPECTS OF LONG CANE ORIENTATION TRAINING

Jennifer C. F. Peel

In the preceding papers of this series (Research Bulletin 27) the progressive development and testing of an experimental technique for training in long cane mobility was described. Up to now, however, all the experiments reported upon were carried out in an artificial setting in which use was made of young, intelligent, sighted, blindfolded subjects. Although the experiments did indicate that it was probably safe to use these methods with blind people, they still needed validating in a real life setting in which the training would have some permanent significance for those involved.

This paper is concerned, therefore, with the evaluation of the experimental training techniques in such a real setting. Other side issues are also covered, namely, the testing of new performance evaluation methods, and a report on the first occasion on which a blind person's performance has been evaluated before, during, and upon completion of training.#

A summary of the five-paper series is appended.

PART V

An Application of Experimental Techniques in Long Cane Mobility Training to a Real Life Situation

SUBJECTS

Practical considerations were necessarily the major factors in deciding what type of subject should take part in this evaluation. A school for the blind provided the most convenient setting because there the stringent requirements of space for the apparatus and time for doing evaluations could be met. The headmaster and staff of Worcester College (the equivalent of a sighted grammar/ public school) agreed to help. At this school the boys were boarded, and long cane training had already been established.

Six boys took part in the experiment (that being the instructor's maximum daily teaching load). The school's mobility master chose the boys and purposely selected a group who showed a wide range of abilities.

The boys were numbered in order of ability before training--a ranking agreed upon by members of the research unit on the basis of evaluation, and independently by the mobility master.

Boy 1 had been totally blind since the age of four. Before training

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*Currently at the University of Ife, Department of Sociology and Anthropology, West Nigeria.

#Many of these techniques had been developed by members of the British Medical Research Council's Blind Mobility Research Unit, Nottingham University, Nottingham, U.K.

his mobility was good in the sense that he traveled regularly even on unfamiliar city routes. However, this was done at the cost of a lot of sighted interference and many collisions and jolts. He was 16 years old and had a good attitude towards the training.

Boy 2 was congenitally totally blind. Before training he sometimes had to venture alone in familiar city areas; he only traveled regularly and alone in familiar quiet residential areas. In doing this he too had to put up with sighted interference, jolts, and bumps. He was 17 years old, had a poor attitude towards the training, and was generally lazy and indifferent.

Boy 3 had had light perception only from birth. Before training he traveled alone, but rarely, on town routes, keeping mainly to familiar, quiet, residential areas. He was 18 years old, was indifferent to the training, and often appeared listless and careless.

Boy 4 was congenitally blind and also had a hearing loss. Consequently he was more cautious than most before training and when alone probably only traveled on familiar, quiet residential routes. He was 17 years old and had willingly agreed to do the training even though he was a reserved and somewhat shy boy.

Boy 5 was congenitally totally blind. He was immature, obsessively anxious, and always expecting failure. For these reasons he rarely traveled outside the school alone. He was 16 years old and reluctant to undergo training.

Boy 6, who was not English, was congenitally totally blind and had poor motor control. Before training he only traveled alone on residential routes where he acted rashly and in a dangerous fashion. He was 18 years old and, on the surface, *appeared* keen to do the training.

Although none of the boys had received formal mobility training, most of them were mobile in the sense of being prepared to travel in difficult areas. However, none of them did this efficiently, that is, without colliding with obstacles, falling off curbs, or needing to accept sighted help; neither were they particularly elegant in terms of style.

The fact that the boys were chosen to do the training rather than being allowed to volunteer marked a departure from the college's previous tradition. This was the first time that boys who were unwilling to be trained were strongly persuaded to do so. Two out of the six showed such a reluctance.

THE TEACHING

The boys were taught for 50 to 60 minutes a day (including travel time to and from the training site), five days a week, for six weeks. For various unavoidable reasons the boys were given an average of only 27 hours of teaching. Boy 1 missed the most (four) lessons, and Boy 5 the fewest (two) lessons.

Teaching Apparatus

This was a modification of the apparatus described in the previous paper (see discussion section and Fig. 1 of Part IV) as having been used by group TKR-1 (....---...---....). The modifications insured that it was better suited to the six boys and fitted unobtrusively into the school. One adjustment was to the size of the rough and smooth strips, to bring them into accord with the boys' mean shoulder width. Thus, with a mean shoulder width of 43 cms (maximum deviation ±2 cms) the floor surfaces were made to the following measurements:

1. Central rough strip--18 cms across
2. Two smooth strips--15 cms across
3. Two outside rough strips began 24 cms from the center of the pathway
4. The joint edges of the central rough strip with each of the two smooth strips were 85 cms from the center of the pathway
5. The pathway measured 15.24 meters long by 1.35 meters wide (50 ft. long by 4 ft. 5 in. wide).

Training Scheme

The description of the training scheme can be kept fairly brief, since much of it has already been discussed in previous papers.

Indoor training--1 week. Lessons 1 and 2 were spent teaching basic cane handling on the apparatus.

Lessons 3 to 5 were spent in the corridors of a local school, though each one began with practice on the apparatus. Orientation was introduced in Lesson 4 and more fully in Lesson 5. Having been fairly mobile to start with, the boys appeared capable of coping with it by then.

Formal teaching of pre-cane skills was avoided because experience had shown that it was invariably humorously dismissed by adolescents. Instead it was slipped in casually as the need to apply particular skills arose.

Outdoor training. During the second and third weeks of training the boys dealt with quiet residential areas, local shopping centers, and main roads. The emphasis in the lessons was evenly divided between cane handling and orientation. The latter included instruction in the use of tactual maps which, from the second week of training, were available for every route (Pickles, 1970; and Leonard, 1967).

Practice on the apparatus was given in over half of the lessons, sometimes before and sometimes at the end of the session. The apparatus was used in this way because an earlier experiment had shown that practice on the apparatus had most beneficial effect if it were used whenever a changeover to a new environment was made. Just before going outdoors, for instance, the boys practiced on the apparatus. Used in this way it seemed to reestablish for the subjects the notion of a "good technique" which they then appeared better able to carry over to the new setting. However, too much practice on the apparatus had been shown to cause this effect to diminish (Peel, 1972, pp. 184-213). Thus, as training continued, the apparatus was only used when the boys seemed to need reminding about cane handling.

During the remaining three weeks of the training the boys dealt with more complicated routes, bus journeys, traffic lights, and city centers. By comparison with the standard training scheme, in which city centers are approached only after about 50 hours' training, these boys went there after only 23 hours of training.

The reason for pushing ahead at this pace were two-fold. First, there were ethical constraints--the target of competence up to quiet residential areas was pre-set (two of the boys were leaving school at the end of term, and the others would not be able to continue their training until after the summer holidays).

Second, past experience had shown that it was quite reasonable to expect relatively mobile young people to progress at this speed (Leonard, 1969; and Campbell, 1971). Further, if the boys benefitted, as expected, from using the apparatus (they acquired good cane handling technique quickly), then a long period such as is usually spent in simple environments would be unnecessary.

Departures from the Standard Training Method

1. Use of apparatus which provided knowledge of results in connection with arc width.

2. Delay in teaching of orientation.

3. Teaching of pre-cane skills slipped in throughout the course rather than forming special lessons.

4. One week only spent indoors.

5. For boys 1 to 4 (see Results and Discussion) involving rapid progress from one topic to the next.

MEASUREMENT OF PERFORMANCE

The most significant events in this experiment were the three major performance evaluations. These occurred before training, after 14 hours of training, and at the end of training. For these evaluations subjects negotiated one or more routes and were observed and scored as they did so. Most of the techniques used were derived from previous experiments (see Part II of this series), and, therefore, only the novel features of this series need to be described here.

The Rater

As before, a qualified long cane instructor scored subjects' performance according to a "flow chart" type of assessment form (Leonard and Wycherley, 1967). The new assessment forms contained more items; for instance they asked for judgments of:

1. The way subjects negotiated bends (mid-pavement being the ideal).

2. Whether or not subjects indented on unfamiliar routes.

3. Whether subjects used their canes dangerously with regard to other pedestrians for Routes 3 and 4 on Evaluation 3.

Finally, both the rater and a second observer tape-recorded a commentary on the subject's cane handling ability and methods of coping with problems, etc.

Measurement of Gait: The Accelerometer

A new method of measuring gait was developed which involved using an electromagnetic device mounted on the subject's back which, when the subject was in motion, transmitted to a receiver and tape recorder in an accompanying car.* This signal, having been decoded, made information available on whether the subject was standing still; or whether he was moving, and when the subject's heel touched the ground.

*This technique was pioneered by the late Dr. J. A. Leonard and Miss S. Miller of the Blind Mobility Research Unit, University of Nottingham.

From the latter it was possible to calculate the subject's step frequency. Again, coupling that information with knowledge of the subject's walking speed allowed the subject's average step length to be calculated. (For a fuller description of the equipment see Peel, 1972, p. 227).

A Third Commentary

This commentary was put onto the second track of the tape recorder carried in the car, and was used in conjunction with the records obtained from the accelerometer. An auditory signal was put on the track to indicate:

1. The start and finish of each subject's route.

2. When the subject passed markers painted on the pavement distinguishing sections of the route from one another.

3. When other events, such as falling off the side curb or bumping the inside shoreline occurred.

4. When the subject came to the end of a block, crossed, and stepped onto the up curb.

From these records the following measurements were obtained:

1. Time taken to negotiate route (journey speed).

2. Time spent standing still (as a percentage of the total travel time).

3. Length of time for which the subject was lost (as a percentage of the total travel time).

4. Estimated walking speed (an average of three samples of 100 yards (91.4 meters) each taken from straight stretches of the pavement).

5. Estimated step interval (an average of the same three samples).

6. Number of times a subject committed various errors.

7. Accumulative times to various points along the route.

The Mobility Master's opinion was sought after training had finished and after the Master had given each boy one lesson. He was asked to compare how they had fared under the experimental conditions and how they might have done under his own tuition.

Comparisons Between the Gait of Sighted and Blind Subjects

It has been suggested (Leonard and Wycherley, 1967) that a blind traveler performs in a more irregular way regarding rate of travel, so that he experiences more interruptions and hesitations than does the sighted person. In this experiment it was possible to record this by measuring the variability of step frequency of a comparable group of sighted and blind subjects. Matching six sighted boys to the six blind boys, the gait of both groups were measured as they negotiated Route 1.

Test Routes

The first in a quiet residential area was similar to those described in Part II of this series. The others were more complex and each time represented the most with which the boys could be expected to cope. Thus, on Evaluation 2, Route 2 took them along main roads, while on Evaluation 3, Route 3 was situated in the city center. Only four boys attempted the latter because by then Boy 6 was only able to cope with busy main roads while Boy 5 (for reasons of stress and anxiety) was excused at the third evaluation.

RESULTS

This study produced not only data from the three evaluations, but also information gathered through the daily measurement of the accuracy of the boys' arc width. The latter results will not be presented here because they showed the same trend as in Part III.

The data collected at the three major evaluations fell into two categories--one, recorded by the rater on his score sheets; the other, the log data collected for use in connection with the measurement of gait (see Table 1).

Changes in Performance--I.

Route 1. The data were tested to see whether there was evidence of change in performance over the six weeks' training. For this a Friedman two-way analysis of variance (Siegel, 1956) was applied to the group's scores ($N = 5$), a particular item for the three evaluations.

On the rater's score sheet significant differences between performances were found for the detection of down curbs, falling off down curbs, squaring up, traveling straight, cornering, and crossing roads straight. On all except the last, the poorest performance was on Test 1 (for the exception, it occurred on Test 3). Generally the best performance was on Test 3, though they squared up best on Test 2. The significance levels lay between 0.039 and 0.0077.

The log data showed only that subjects fall off side curbs more often during Evaluation 1 than during the other two evaluations ($p = 0.024$).

A more detailed analysis involving a Wilcoxon matched-pairs signed-ranks test was possible for Evaluation 1 and 2 (where $N = 6$). This showed improved performances on Evaluation 2, in which subjects detected down curbs more reliably, bumped inside shore lines less, and fell off fewer down curbs ($p = 0.05$).

The difficult routes. For the purposes of testing for changes in performance on the difficult routes, for Evaluation 1, Route 1 was designated a "difficult route" because at that stage the boys were untrained and totally unfamiliar with it.

The Friedman two-way analysis of variance applied to the data from the rater's score sheet showed significant differences on the detection of down curbs, falling off down curbs, squaring up, and crossing straight. For all these items performance was worst on Evaluation 1 and either best on Evaluation 3 or equally good on Evaluations 2 and 3 (significance ranged between 0.05 and 0.00077).

TABLE 1

Subjects' Mean Evaluation Scores (Percent Correct)
Raters' Scores (Percent Correct Responses)

	Bends	Detects down curb	Falls off down curb	Squares up	Listens	Crosses Straight	Detects up curb	Clears on up curb	Stumbles on up curb	Straight travel	Pavement position	Corners
Route 1												
Evaluation 1	40.0	10.0	20.0	0.0	26.7	53.5	40.0	-	93.3	42.0	84.0	28.0
Evaluation 2	80.0	60.0	50.0	46.7	86.7	60.0	73.3	73.3	73.3	76.7	100.0	76.7
Evaluation 3	86.7	90.0	83.3	33.3	93.3	40.0	93.3	100.0	86.7	88.0	84.3	96.7
Difficult Routes												
Route 1	40.0	10.0	20.0	0.0	26.7	53.5	40.0	-	93.3	42.0	84.0	28.0
Route 2	55.0	80.0	80.0	60.0	90.0	78.3	95.0	85.0	85.0	80.0	100.0	75.0
Route 3	-	86.9	87.5	95.0	100.0	85.0	95.0	95.0	90.0	96.9	100.0	100.0

Log Data

	Speed (mph)		Percent time		Step interval (seconds)			
	Average	Over fixed distance	"Lost"	Standing still	Mean	Standard deviation	Coefficient of variation	
Route 1								
Evaluation 1	2.42	2.55	5.05	1.46	0.56	0.034	6.23	N = 5
Evaluation 2	2.08	2.74	1.08	-	0.57	0.032	5.72	N = 5
Evaluation 3	2.26	2.53	2.24	2.74	0.58	0.032	5.6	N = 5
Difficult Routes								
Route 1	2.42	2.55	5.05	1.46	0.56	0.034	6.23	N = 5
Route 2	2.2	2.5	3.6	-	0.59	0.054	9.58	N = 5
Route 3	1.24	2.2	0.52	24.9	-	-	-	N = 4

According to the log data the only difference was in journey speed where subjects were slowest on the third evaluation, quickest on the first ($p = 0.00077$).

The more detailed comparison of Evaluation 1 with Evaluation 2 afforded by the Wilcoxon matched-pairs signed-ranks test showed that subjects negotiated bends better, detected more, and fell off fewer, down curbs on Evaluation 2 ($p = 0.05$).

Changes in Performance--II, (Individual Subjects)

By comparing each boy's performance over Route 1 on the three evaluations it was possible to see whether his performances changed. For this the Wilcoxon matched-pairs signed-ranks test was applied to each boy's successive scores on the ten items of the rater's score sheet, and the seven items of the log data.

According to the rater's data, Boys 2, 4 and 6 performed better on Evaluation 3 than on Evaluation 1, while Boys 2 and 3 also performed better on the second than on the first evaluation. (Here significance ranged between 0.05 and 0.01.) On the log data the only improvement was shown by Boy 2 who improved between Evaluation 1 and 2 ($p = 0.032$).

A similar comparison of the data obtained from the difficult routes only showed that, according to the rater's score sheet, Boy 5 had improved between Evaluations 1 and 2 ($p = 0.01$).

A clearer demonstration of the effect that training had on the way the boys performed in succeeding evaluations is presented in Table 2. Here the number of subjects who showed improvements according to the rater's score sheet, and the number who moved in the same direction as the mean on the log data on Route 1, are shown. From this and the above, it is clear that much of the improvement took place between Evaluations 1 and 2.

COMPARISON OF SIGHTED AND BLIND SUBJECT'S PERFORMANCE

The performance of six sighted boys were compared with those of five blind boys on Route 1 of each evaluation (Table 3). A Mann-Whitney U Test was used for this and revealed:

1. For the three measurements of total travel time, approximate speed in mph and journey speed, the blind were always slower than the sighted.

2. On Evaluations 1 and 3 (no record was available on Evaluation 2 owing to apparatus problems) the blind spent a greater total time standing still than did the sighted.

3. The sighted showed a smaller step interval than the blind on all three evaluations and that the differences became increasingly significant with succeeding evaluations.

4. For the coefficient of variation of the step interval the difference decreased with training with only Evaluation 1 showing a significant difference.

5. Similarly, for the standard deviation from the mean step interval the difference seemed to get less with training, so that significance was only reached on the first two evaluations.

For all these measurements the significance levels lay between 0.03 and 0.002.

SUBJECTIVE DATA—TRAINING RECORD

The first point for comment is the effect that apparatus training had on these boys. In many respects the experiences here coincided with those of previous training experiments (Part IV), but one of the more novel effects was in providing a neutral starting ground for the training. This meant that instead of beginning the training with pre-cane skills (which would inevitably entail some criticism of the boys' existing methods of getting about) the instructor could begin in an entirely new and neutral setting--the pathway--and with a skill that was largely unrelated to the boys' previous experience.

In a similar way the instructor was able to avoid giving the appearance

TABLE 2

The Number of Subjects Who Showed Improvements
Rater's Scores

	Bends	Detects down curb	Falls off down curb	Squares up	Listens	Crosses straight	Detects up curb	Clears up curb	Stumbles up curb	Straight travel	Pavement position	Corners
Route 1												
Evaluations:												
1 and 2	4	5	4	5	4	1	3	-	0	3	3	5
2 and 3	1	4	4	2	1	0	2	2	1	2	0	4
3 and 4	3	5	5	2	4	0	4	-	1	4	1	5

The Number of Subjects Along the Same Trend as the Mean

	Speed (mph)		Percent Time		Step Interval (seconds)		
	Average	Over fixed distance	"Lost"	Standing still	Mean	Standard deviation	Coefficient of variation
Route 1							
Evaluations:							
1 and 2	4	2	4	-	3	2	3
2 and 3	4	3	3	-	2	-	3
3 and 4	4	2	4	4	3	2	3

N = 5

TABLE 3

Mean Scores for the Sighted and Blind Boys on Route 1
Log Data

	Speed (mph)		Percent Time		Step Interval (seconds)			
	Average	Over fixed distance	"Lost"	Standing still	Mean	Standard deviation	Coefficient of variation	
Sighted subjects	3.84	3.83	0.74	0.17	0.50	0.018	3.76	N = 6
Blind subjects								
Evaluation 1	2.42	2.55	5.05	1.46	0.56	0.034	6.23	N = 5
Evaluation 2	2.08	2.74	1.08	-	0.57	0.032	5.72	N = 5
Evaluation 3	2.26	2.53	2.24	2.74	0.58	0.032	5.60	N = 5

of nagging the boys over their cane handling mistakes. Even if for a whole lesson a boy had been making a mistake without correcting it then, with as little as one walk down the pathway, he seemed able to detect the error for himself and was provided with sufficient tactual feedback to correct it himself.

The tactual knowledge of results provided by the apparatus was found to be particularly useful in overcoming some of the conceptual difficulties experienced by congenitally blind boys. For instance, many of them on the basis of verbal instructions alone could not appreciate the difference between an inward and an outward swing of the cane. In this study the problem was easily overcome because the different surfaces of the pathway not only provided concrete unambiguous feedback regarding the correctness or otherwise of the movement, but also discouraged them from making the wrong movement in the first place (Part IV, Discussion).

INTENSIVE TRAINING PROGRAM

In their reaction to the intensiveness of the training program the boys were effectively split into two groups. In the first group were Boys 1 to 4 for whom it seemed to be entirely beneficial. An example from this group is Boy 4 who in many ways had the greatest difficulties and yet made the greatest gains. Due to his hearing loss this boy found it difficult to maintain a straight line. Even so the standard procedure of holding him back in a quiet residential area while he overcame the problem was not followed. Instead he kept up with the other boys and successfully worked on his tendency to veer during the less demanding periods of each lesson. (Boy 4's scores for hitting the side curb and inner shore line dropped from 5 to 0 and 10 to 2, respectively, between the first and last evaluations.) In this way something that was already a social handicap was not made to loom large in this sphere as well.

In the second group the two poorer performers (Boys 5 and 6) could not and did not keep to the original training program. Nevertheless, both benefitted from leaving the indoor environment relatively early. Boy 5 suffered too much embarrassment there and could not bear to look foolish and clumsy in such a confined space. Boy 6 found the indoor setting so safe that he would not use his cane until outdoor conditions forced him to.

However, even the more conventional training program that was adopted for these two boys produced only limited success. By the end of the experiment Boy 5 could not use maps, could not orient himself, and would be left paralyzed with embarrassment by the mildest brush with a pedestrian. Boy 6 gradually lost his exaggerated "lascar sailors walk," was more considerate in the way he used his cane, and was decidedly safer. But his orientation was still so erratic that he could not travel alone reliably.

RATER-OBSERVER— COMMENTS

There was unanimous agreement that five of the boys improved with each evaluation. Boy 5 was also thought to have improved between Evaluation 1 and 2, even though his performance was obviously affected by his fear of being watched.

The boys were ranked in order of merit and some comments about them are given below.

Boy 1, whose pre-experimental level of mobility was high in terms of areas attempted, though low in style and technique, had become an impressive performer by Evaluations 2 and 3, especially on town routes. He could handle sighted interference effectively, feel his way out of trouble with his cane tip, was flexible in the way he used it, and was considerate and careful with other pedestrians. In short, he had learned a great deal in terms of improvements to his technique and style.

Boy 2, by the end of six weeks, was thought to have something of the style and technique of Boy 1, but he gained most in ironing out erratic and dangerous movements. Briefly, his improvements were twofold; he could travel independently, reliably, and safely in familiar and unfamiliar town centers, and he had a well-learned repertoire of techniques for dealing with most situations.

Boy 4 was the most successful trainee because he had improved the most in spite of a hearing defect. His deafness meant that he needed sighted help at road crossings, and in terms of grace and style he was not as impressive as the other two; but in other ways his achievements were largely comparable.

Boy 3, by the end of training, still exhibited an erratic, bumbling performance, but the dangers he faced had obviously been reduced. Style apart, he achieved all that the others had except that he would not always come through without the odd jolt or bump on the shoulder.

Boys 5 and 6 have been discussed above.

MOBILITY MASTER—COMMENTS

The mobility master concluded that four of the six boys were better than the typical college long cane trainee, though all of them were more teacher-dependent and less used to going off on their own. He thought that Boy 5 had suffered from being taught in an experimental setting, but that neither Boy 5 nor Boy 6 were likely to improve under any other teaching method.

DISCUSSION

The results of this study have provided clear evidence that the experimental training techniques brought about changes in the boys' mobility. For example, on Route 1 five out of eleven items scored by the rater indicated that the boys' poorest performances occurred during the first evaluation. A similar trend was also evident in the results of the difficult route.

The evaluation techniques also managed to provide evidence of variability in performance. From the scores on the rater's score sheet it became clear that the boys were varying their performances according to the point they had reached in training. Thus as comparative novices on Evaluation 2 they were indenting, squaring up at down curbs, and crossing straight; but on Evaluation 3, Route 1, they were quite rightly largely ignoring these items. However, where these skills became necessary again (i.e., for city-center travel) the scores show that they reappeared. The boys were, therefore, exhibiting one of the characteristics of skilled performers, namely, sufficient flexibility to choose appropriate skills from a repertoire for use as the occasion demands.

The data also indicated instances in which the training had a detrimental effect on performance. For instance, the boys stumbled on up curbs less before training than at any other time. This is probably a reflection of the difficulty they had in changing from the efficient, but ungainly traditional technique of "goose stepping" in anticipation of an up curb, to the long cane technique of curb detection.

The log data showed this trend also, for whereas the boys gained in terms of being lost for shorter times and hitting the shore lines less often, their walking speed tended to be slower and they spent longer standing still later in the training. However, this probably means that while their previous high speed had been obtained at a cost of a considerable number of bumps and jolts, their comparative slowness gave them greater safety. For instance, they began to wait longer at down curbs, especially on town routes.

A most significant piece of information provided by the log data related to the boys' coefficient of variation and standard deviation from the mean step intervals. Both these values tended to get smaller with each evaluation showing that the training had the effect of enabling the boys to perform more like their sighted peers.

CONCLUSIONS

As in the previous experiment (Part IV) the central feature of this study is the effect that the apparatus had in simplifying the training environment and in providing the trainees with much-needed learning feedback. In addition, this study supplied the information that these benefits assist not only the medium-to-good performers, but the poorer performers as well. Indeed they seem even more necessary for them. Furthermore, by making use of the apparatus the instructor was able to avoid some of the teacher/client conflict which is so often a source of difficulty in the teaching of adolescents.

Regarding the more general features of the training program, there was again support for the notion that the indoor environment is not particularly suitable for the early stages of training. All the boys benefitted from being removed from such a cluttered and confined space. It is also obvious that it requires such a move before the already mobile blind will make use of their canes rather than continue to rely on their old established techniques, and that on the more positive side, it will relieve them of the embarrassment and confusion caused by the close proximity of others. These two factors, in particular, will probably be found to weigh as much with the adult/middle aged trainee as it did with these adolescents.

The intensive, somewhat pressurized, character of the training program appeared to be an efficient and challenging method of training the medium-to-good blind trainee. However, this study made it clear that such a program is not feasible for the poorer performer, and that further work must be done to find one that caters to the multiply handicapped.

ACKNOWLEDGEMENTS

I would like to acknowledge the supervisory help of the late Dr. J. A. Leonard, the financial assistance of the British Medical Research Council, the kindness and help given me by the staff of Worcester College for the Blind, particularly the Headmaster, Mr. Fletcher and the Mobility Master Mr. J. Pickles, and finally, the assistance of my colleagues at the Blind Mobility Research Unit, Nottingham University, Nottingham, U.K.

APPENDIX

Summary and Conclusions

This series of five papers has described the main stages in an experimental study whose purpose was to improve upon the standard training method. It began by looking at ways in which the learner's initial problem of overloading could be eased. At the same time it tested whether the indoor or outdoor environment was most suitable to him at an early stage. The next problem tackled was that of ensuring that the trainee had enough feedback regarding his movements with the cane. This entailed presenting the feedback in a tactual and kinesthetic form rather than a verbal form. Finally, with the addition of the hypothesis that the trainees should work under an intensive rather than a leisurely training scheme, all the new methods were tested in a real life setting.

Here it was shown that for the client of medium-to-good ability, the best training scheme was one which began on a constucted pathway which both simplified the training setting and gave him sufficient augmented feedback to acquire the skill of cane handling quickly. For the first week he was given practice on this apparatus indoors before being placed in the outdoor setting where the teaching of orientation began. From then on, with occasional practice on the apparatus, he was taught to deal with progressively difficult outdoor situations until by Lesson 25 he was proficient and able to cope with even unfamiliar city centers.

On the way to devising this new training scheme, improvements were made to current techniques for measuring performance. At first only a modification of Leonard and Wycherley's flow-chart score sheet was used. Later, not only were further items added to this, but also more sensitive techniques were developed. For instance, the psychological threshold for drop detection was determined, and the means for taking a daily analysis of the way the cane was used and positioned was invented.

Finally, members of the Blind Mobility Research Unit produced a device for measuring various characteristics of a subject's gait. With this it was possible to demonstrate that training had brought about changes in the blind subjects' performances, and it also revealed how their performances differed from, but became more like, those of the sighted.

In conclusion, these papers have shown that it is possible, by combining theoretical psychological knowledge with practical experience, to make it easier for clients to become mobile and well orientated with a long cane. By using the training methods described here, half the time that is usually spent on the training can be saved. This means that both the individual client benefits (by tackling a more motivating and efficient training schedule) and that others benefit from the instructor's general increase in productivity. However, as always, this investigation has raised more questions which need answering. For instance, it has yet to be shown whether some or all of the new methods will be equally helpful for those who only want to reach an intermediate standard of performance. But the most glaring needs are those of the multiply handicapped. Here it was found that even for the mildly multiply handicapped, current training methods were not suitable. The sad conclusion must be that until such suitable training methods are devised then the benefits of long cane mobility cannot be shared by these people.

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THE SOCIAL ADJUSTMENT OF VISUALLY HANDICAPPED CHILDREN IN DIFFERENT EDUCATIONAL SETTINGS

Rudolf Schindele*

Abstract. This investigation is part of a larger comparative study of visually handicapped students in different educational settings.

Three samples of pupils were investigated: 36 visually handicapped students integrated in resource or itinerant programs in regular schools, 36 visually handicapped children from residential schools, and 36 sighted control subjects. Each visually handicapped sample consisted of three disability subgroups; all samples included an equal number of males and females. The samples and subgroups were matched in degree of visual disability, intelligence, sex, age, grade placement, socioeconomic status, and race.

The social adjustment of each subject was measured by application of the Self-Concept Adjustment Score developed by Cowen, Underberg, Verillo, and Benham (1961). Each subject was tested individually by the investigator.

The statistical analysis of our data by analysis of variance, *t* tests and calculation of correlation coefficients revealed the following main results:

1. There is no significant difference between the social adjustment of visually handicapped and sighted students.
2. There is no significant difference between the social adjustment of visually handicapped students integrated in regular schools and visually handicapped students in residential schools.
3. There is no overall significant difference between the social adjustment of partially sighted, severely visually handicapped, and totally blind students.
4. There is no significant difference between the social adjustment of visually handicapped or sighted males and females.
5. There is no significant difference between the social adjustment of integrated visually handicapped students in resource and itinerant programs.
6. No significant correlation, but some trends, were revealed between age and social adjustment.
7. Intelligence and social adjustment correlate significantly for the integrated visually handicapped sample, but not for the other two samples.
8. Significant inverse correlation exists between socioeconomic status and social adjustment for visually handicapped students in residential schools, but none for the other two samples.

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INTRODUCTION

"Adjustment is a complex concept that shares almost as many meanings as there are persons attempting to cope with adjustment." This quotation from Lukoff and Whiteman (1963, p. 58) indicates the perplexing vagueness and complexity of the conception "social adjustment," which is extremely frequently used in literature and research, but for which no generally accepted scientific definition seems to exist. In none of the many publications (see references) we know about "social adjustment," "social adjustment to blindness," or "social adjustment of the visually handicapped" we found clear and exactly delimitating definitions of these central conceptions. An analysis of the literature reveals, however, some dimensions included by most authors, when they speak of social adjustment; it also shows that a number of researchers try to circumvent the dilemma of this concept by replacing it through other conceptions (Chevigny and Braverman, 1950, pp. 11-24), by defining it practically through description of areas of adjustment training (Bauman and Yoder, 1966, pp. 5-35), or by operational descriptions of certain dimensions of the complex area for the purpose of research (Cowen, et al., 1961; Meighan, 1970; Williams, 1971).

According to our understanding the concept social adjustment mainly concerns the following two areas:

1. The structural and qualitative organization of the self (personality of a person) and of the behavior specific to this personality (Chevigny and Braverman, 1950; Bauman and Yoder, 1966; Lowenfeld, 1947; Carroll, 1961).

2. The structure and quality of the relations this self has with his social environment (Lukoff and Whiteman, 1963; Chevigny and Braverman, 1950; Cutsforth, 1950; Carroll, 1961).

In visually handicapped people this organization of the self and of its relationship to the social environment have to take place under the condition of visual disability.

The quality of the organization of the self and its relationships to the environment cannot be determined absolutely and objectively. What good social adjustment means for a certain person is essentially dependent on the opinions and views of this individual himself and on the norms, opinions and attitudes held in the social environment relevant to him. In a pluralistic society like ours a change of the social group relevant to a person may result in a change of what constitutes good social adjustment for this individual.

These considerations indicate that at least in our society "social adjustment" cannot be measured absolutely or objectively. A researcher can only measure what he regards as good social adjustment or what he believes or has tried to evaluate that the majority of the respective society consider as good social adjustment.

The definition of "social adjustment" can therefore only be given operationally through the instruments used to measure this complex variable. In the research studies we know mainly two kinds of measurements have been used:

1. Instruments by which the subject is induced to judge his own personality or some characteristic features of it (personality inventories, self-concept scales, self-ideal discrepancy scales, anxiety scales, etc.).

2. Instruments through which the social adjustment of a person is judged by relevant individuals of his social environment (rating scales given to parents or teachers, self-ideal discrepancy scores given to parents, etc.).

In some recent studies more dynamic instruments like projective tests have been used, too (Cowen, et al., 1961, pp. 52-72). This nature of instruments naturally makes most measurements highly subjective and prone to a diminution of their validity by a lack of honesty in the person investigated or by social desirability.

It has often been assumed that visual disability is a complicating or deleterious factor for the social adjustment of a person (Hathaway, 1959; Lowenfeld, 1947; Scott, 1969; Kurzhals, 1970). At the same time some authors stress that visual disability per se does not necessarily have negative influence on the social adjustment of the individual (Cutsforth, 1950; Chevigny and Braverman, 1950; Barker, Wright, Meyerson, and Gonick, 1953; Norris, Spaulding, and Brodie, 1957).

Assuming that the social adjustment of a person is highly dependent on the social environment in which an individual develops it has often been suggested, too, that the kind of educational setting and surrounding in which a child develops might have a decisive influence on his social adjustment, especially if this adjustment is complicated by visual disability (Cutsforth, 1950; Hathaway, 1959; Abel, 1958; Meyer, 1950; Frampton, 1965).

A great deal of literature has been written and many empirical investigations have been carried through to support or reject these theoretical assumptions. The investigations of the social adjustment of visually handicapped students included in our study have much the same purpose. Specifically we tried to test the following hypotheses.

Hypotheses

1. There is no significant difference between the social adjustment of visually handicapped students in integrated or segregated educational settings and normally sighted students.

2. There is no significant difference between the social adjustment of visually handicapped students integrated in regular schools and visually handicapped students in residential schools.

3. There is no significant difference between the social adjustment of partially sighted, severely visually handicapped, and totally blind students in integrated or segregated educational settings.

4. There is no significant difference between the social adjustment of visually handicapped or normally sighted boys and girls.

5. There is no significant difference between the social adjustment of integrated visually handicapped students in resource programs and integrated visually handicapped students in itinerant programs.

6. There is no significant correlation between the social adjustment and the age of:

   a. integrated visually handicapped students,

   b. visually handicapped students in residential schools, and

   c. sighted students.

7. There is no significant correlation between the social adjustment and the intelligence of:

   a. integrated visually handicapped students,

   b. visually handicapped students in residential schools, and

   c. sighted students.

8. There is no significant correlation between the social adjustment and the socioeconomic status of:

   a. integrated visually handicapped students,

   b. visually handicapped students in residential schools, and

   c. sighted students.

REVIEW OF RESEARCH

A thorough review of the extensive research work done on the social adjustment of the visually handicapped cannot be given in an article such as this. We can, however, refer the reader to two outstanding publications on the subject which both contain extensive reviews of literature and research for certain periods of time:

Research done till 1953 is thoroughly reported and analyzed in Barker, et al. (1953, pp. 269-308). The authors report on 15 empirical investigations in this area mainly carried through by means of personality inventories. The results of their "confusing array of findings" is summed up by the following statements:

> In 6 studies both the subscale test scores and total test scores are in the direction of greater maladjustment for the blind as compared with seeing groups. . .
>
> In the other 9 studies the visually handicapped did not consistently fall significantly below seeing controls on subscale and total test scores. . .
>
> Studies using the same personality inventory produce different results, (p. 282).

Barker, et al. name two main possible reasons for the inconsistencies found in the results of the studies:

> In all studies except one. . . the presence of numerous items of different interpretive significance almost certainly attenuates gross results.
>
> The presence of uncontrolled variables makes it impossible to attribute obtained differences to blindness, or to generalize beyond the specific groups studied.

A review of 17 empirical investigations on social adjustment of the visually handicapped is given by Cowen, et al. (1961, pp. 9-19). This report includes some more recent studies not yet analyzed in Barker's summary. In the summary of their review of research Cowen, et al. stress some points very similar to the summary statements given by Barker:

> We have found no studies in which blind or visually disabled Ss as a group have been reported to be better adjusted than a comparable sighted control group. On the other hand we have reviewed a fair number of studies in which ostensibly better adjustment is reported for sighted groups in comparison to the visually disabled. Too, there have been virtually as many investigations in which no differences between groups were demonstrable. In the great preponderance of all the foregoing studies. . . we have observed problems of methodology, design and instrumentation sufficient to render the actual findings suspect, (p. 72).

A sampling of recent literature on "Social and Psychological Aspects of Blindness" is given by Jastrzembska (1973). A detailed description and analysis of research on the social adjustment of the visually handicapped done later than 1960 can, however, not be found in any recent publication that we know. It cannot be given within this article either. We shall, however, report at least the results of some recent investigations as far as they concern the hypothesis tested in this study:

In a monumental five-year longitudinal study Norris, et al. (1957) investigated the influence of blindness on 295 blind children. Their overall finding was, that "there are no special problems or 'handicaps' which can be directly attributed to blindness, (p. 65)."

Jervis (1960) studied the self-concept of 20 blind students from residential schools and 20 sighted controls by interviews and by the Chicago *Q* Technique Card-sort. He did not find any significant difference between the self-concepts of the blind and sighted adolescents as measured by these instruments.

In a very thorough and extensive investigation which included 71 visually disabled adolescents attending regular public schools, 56 visually handicapped adolescents from residential schools, and a control group of 40 sighted students, Cowen, et al. (1961) investigated the social adjustment of their subjects by seven different adjustment measures. They did not find any significant difference of adjustment among their three samples; nor did they find any overall significant differences between the visual disability subgroups of their two samples of visually handicapped students. Thus their data "strongly contradict the notion of any positive relationship between degree of disability and degree of maladjustment, (p. 123)." Sex differences in adjustment were only found in the residential sample, where males scored significantly better than females (pp. 115, 173, and 174).

Winer (1962) found significant relationship between the intelligence and emotional stability in a sample of 22 totally blind students tested by the WISC verbal part and by the Emotional Factors Inventory.

Karnes and Wollersheim (1963) studied the personality adjustment of 16 partially seeing children. Their data from the California Test of Personality support their hypothesis of partially sighted having no poorer personality adjustment than children with normal vision. Moreover significantly more children (at the 1 percent level) were found in the better adjusted group on the social standards and social skills scales. On the feeling of personal worth, antisocial tendencies, family relations scales as well as for the total social adjustment scale the greater number in the better adjusted group was significant at $\alpha = 0.05$.

The Lipsitt Self-concept scale was administered to 29 visually handicapped and 29 sighted pupils in the fourth grade by Zunich and Ledwith (1965). Their results show very little difference between the self-concept of their visually handicapped and sighted subjects.

Hardy (1966) tested 122 blind residential high school students by an experimental instrument specially developed for this purpose in accordance with Taylor's Manifext Anxiety Scale. He found a significant negative correlation between verbal intelligence and manifest anxiety for those students with some vision. The correlation between verbal IQ and manifest anxiety in the totally blind group was not significant. A significant positive relationship was found between age and manifest anxiety.

The social adjustment of about 1,250 fifth- and sixth-grade partially seeing pupils was investigated by Peabody (1967). The results found by application of the Teachers' Behavior Rating Scale did not support the hypothesis of inverse relation between the visual acuity and the social adjustment of the subjects; nor was any significant relationship found between sex and adjustment of the investigated students. In respect to age a slight tendency of worse social adjustment was found for the younger partially sighted pupils; a very slight tendency for better adjustment appeared to have been adjusted with children in itinerant programs and poorer adjustment with children in resource programs.

McGuinness (1970) investigated 139 blind children from special school settings, resource room settings and itinerant teacher settings. His application of the Internal-External Locus of Control Scale revealed no significant difference between the three samples on this measurement.

The social-emotional adjustment of 20 blind children in regular schools and 20 blind children in a residential school was studied by Rosman (1970) by means of the Teachers' Social Behavior Rating Scale and by projective tests measuring the self-image of the children. The results showed significantly that children raised in families with very low socio-economic status adjust better in residential schools, and that children who are completely blind adjust better in regular schools.

The Tennessee Self-Concept Scale by Meighan (1970) was used to study 120 totally blind and 83 partially seeing students from residential schools. The results from plotting the mean scores of the subjects on the TSCS profiles indicated that they form a very deviant and homogeneous group whose scores on the basic dimensions of self-concept were found to be significantly different from the normative group in the negative direction. No significant relation was found between the academic achievement and self-concept of the subjects.

Williams (1971) studied the manifest anxiety and self-concept of 32 totally blind students of grades 9 to 11 in a residential school and of a control group of 32 sighted students. The areas self-concept, self-acceptance, ideal-self and discrepancy between self-concept and ideal-self were measured by Bills' High School Index of Adjustment and Values;

manifest anxiety was tested by the Taylor Manifest Anxiety Scale. The results show significant higher scores for the totally blind than for sighted subjects in the areas of self-concept and self-acceptance. Females were significantly better in the self-concept area while no difference between males and females could be found in the area of social acceptance. The totally blind students also showed a significantly higher ideal-self than the sighted controls. Females tended to be higher than males on this variable. The discrepancy between ideal-self and self-concept was significantly lower in the blind group than in the sighted subjects. Lower scores for the blind were also found in the area of manifest anxiety. The overall finding then indicates that totally blind subjects exhibit significantly better personality adjustment than sighted subjects.

A very recent study carried through by Mersi and Weinlader investigated 33 partially sighted students attending grades 1 to 4 in regular schools without any special help and all sighted students of the respective classes. The emotional adjustment of these subjects was measured by the Children's Anxiety Test (CAT) and by questionnaires given to children, teachers and parents. In the area of anxiety no significant difference could be found between partially sighted and sighted pupils; the results indicate, however, a tendency for less anxiety in the partially sighted sample. No significant difference was found for the locus of control of the two samples. The evaluation of the questionnaires for teachers revealed no difference of adjustment and behavior in stress situations. The results of the questionnaire for children by which the pupils should give an appraisal of their situation in school did not show any overall differences between the samples.

This survey of more recent research on social adjustment of the visually handicapped also reveals very inconsistent results. It also shows, however, that only in relatively few studies the social adjustment of the visually handicapped was found to be poorer than the social adjustment of sighted subjects. At the same time this report includes some studies in which for the first time the social adjustment of visually handicapped students was shown to be superior to the social adjustment of sighted controls.

PROCEDURE

General Design

This study on the social adjustment of visually handicapped children is part of a larger investigation in which visually handicapped students integrated in regular schools (itinerant or resource programs) were compared with visually handicapped children in residential schools and with a control group of sighted students. The areas of comparison were school achievement, social adjustment, social competency and sociometric status among classmates. The investigation for the whole research project, which could only be realized through the cooperation of many schools in the United States and by the help of a great number of American specialists, above all Dr. Jeanne Kenmore, director of the American Foundation for Overseas Blind, Mr. Fred Sinclair, Consultant, State Department of California, Dr. Mary K. Bauman, and the specialists in the research department of the American Foundation for the Blind, was carried through in spring 1973 by testing for seven weeks in regular schools with integrated programs in a large western American state, and for four weeks in the residential schools for the visually handicapped of nine states scattered all over the USA. All the testing was done by the investigator himself.

Subjects

Three groups of subjects were included in the study:

1. Thirty-six visually handicapped students integrated in resource or itinerant programs in regular schools.

2. Thirty-six sighted students in regular schools, chosen from the regular classes which were attended by the visually handicapped students of group 1.

3. Thirty-six visually handicapped students from residential schools.

All the students were born in 1961 or 1962 and attended grade 5 or 6 (one girl had meanwhile been promoted to the 7th grade). Only pupils whose IQ was 70 or more, who had no functional handicap than the visual one, and whose parents and administrators had given permission, were included in the testing. The visual handicap of the students in groups 1 and 3 had to be either congenital or occurred before the age of 3.

The sample of 36 visually handicapped pupils integrated in regular schools constitutes a random sample chosen from all respective pupils in a large western American state. The sighted control subjects were chosen by the class teachers of the classes attended by the students of Group 1 on the basis of matching the sighted student as closely as possible to the visually handicapped pupil in sex, age, grade, intelligence, socioeconomic status, and race. The sample of visually handicapped residential school pupils was drawn on the ground of closest matching with the other two samples from the total population of 56 students born in 1961 or 1962 from the 5th and 6th grade in 9 different residential schools for the visually handicapped. The schools were selected on the basis that they should represent all geographical areas of the USA and that there should be no or only few integrated programs in the geographical area around them.

Each of the two samples of visually handicapped consisted of three subgroups:

1. Twelve partially sighted students (visual acuity 20/60 or less, to more than 10/200).
2. Twelve severely visually handicapped students (visual acuity 10/200 to 4/200).
3. Twelve totally blind students (less than 4/200).

The group of visually handicapped students integrated in regular schools was subdivided in 14 pupils from itinerant programs and 22 pupils from resource programs.

The three main samples were matched in age (with the exception of one main sample), grade placement, sex, intelligence, socioeconomic status, and (roughly) according to race. The two samples of visually handicapped students were also matched in visual acuity. Matching on all these control variables was also aimed at and nearly always achieved within the three subgroups of each of the main samples, among the corresponding subgroups of these three samples, and between boys and girls of each sample (each group and subgroup having the same number of boys and girls). The two subgroups, itinerant and resource program, within the sample of integrated students were also matched on the above stated variables.

Table 1 illustrates the structure of the whole group of 108 subjects; at the same time it gives the visual acuity of the visually handicapped students as measured by Snellen Chart in the better eye after correction.

The Mann Whitney Test was applied to find out whether the visual acuity distribution was significantly different in the two samples and between the three corresponding subgroups. Table 2 shows that the results of these tests are far from indicating any significant difference.

The quality of the matching of the three samples and their subgroups was tested by the t test for difference between means. Table 3, which gives the means and standard deviations for all samples and subgroups, and Table 4, which gives the t ratios for all possible differences between means, demonstrate that no significant difference could be found between the three samples in the control variables intelligence (measured by WISC verbal part) and socioeconomic status (rated by North-Hatt-Index). As visually handicapped students in residential schools are frequently one year older than pupils in corresponding grades in regular schools, total matching of the three samples on the control variable age was not achieved. We could keep to the criteria that in residential schools, too, all our sighted subjects should be in grade 5 or 6 and born in 1961 or 1962. Nevertheless visually

TABLE 1

Structure of the Whole Group of Subjects and Distribution of Visual Acuity

Sub-groups	Sex	Program (for Int.)	No.	Sighted Controls (NSS)	Integrated Vis. Hand. (IVH)	Segregated Vis. Hand. (SVH)
Subgroup 1: Partially Sighted (ps)	Boys	Resour.	1		20/200	20/200
			2		40/200	20/200
			3		40/200	40/200
		Itiner.	4		20/200	20/200
			5		13/200	20/200
			6	normal	20/200	20/200
	Girls	Resour.	7	sight	20/200	20/200
			8		17/200	14/200
			9		40/200	66/200
		Itiner.	10		20/200	20/200
			11		20/200	20/200
			12		66/200	66/200
Subgroup 2: Severely Vis. Hand. (svh)	Boys	Resour.	13		10/200	10/200
			14		4/200	5/200
			15		10/200	10/200
		Itiner.	16		10/200	10/200
			17		10/200	10/200
			18	normal	10/200	10/200
	Girls	Resour.	19	sight	10/200	10/200
			20		10/200	7/200
			21		10/200	10/200
		Itiner.	22		7/200	4/200
			23		8/200	10/200
			24		10/200	10/200
Subgroup 3: Blind (bl)	Boys	Resource	25		L P	L P
			26		NIL	CF1'
			27		L P	NIL
			28		NIL	H M
			29		L P	CF1'
		It.	30	normal	NIL	L P
	Girls	Resource	31	sight	NIL	L P
			32		CF3'	NIL
			33		H M	L P
			34		NIL	NIL
			35		NIL	CF3'
		It.	36		CF1'	H M

handicapped pupils in residential schools are on an average 4.5 months older than integrated visually handicapped students, which constitutes a difference significant at $\alpha = 0.01$, and they are on an average 3.5 months older than the sighted controls, a difference significant at $\alpha = 0.05$.

The difference between samples and subgroups in grade placement was tested by χ^2 test. Table 5 shows that no significant difference in grade placement could be found.

TABLE 2

Mann-Whitney Order Test for Visual Acuity Between Samples and Subgroups

	IVH - SVH	IVH/ps SVH/ps	IVH/svp SVH/svp	IVH/bl SVH/bl
R	1297.50	148.50	148.50	134.50
Z	0.1890	0.0248	0.0755	0.7685

TABLE 3

Means and Standard Deviations of Intelligence, Age and Socio-economic Status for Main Samples and Subgroups

			Sighted Controls	Integrated Vis. Hand.	Segregated Vis. Hand.
Intelligence	sample	M	108.1388	107.2500	106.0277
		SD	12.6136	12.8525	10.9541
	subgr.1 ps	M	104.0833	106.8333	104.4166
		SD	13.7959	13.9096	8.4659
	subgr.2 svh	M	107.6666	106.0000	105.1666
		SD	12.7257	11.3898	11.2669
	subgr.3 bl	M	112.6666	108.9166	108.0000
		SD	11.1892	13.1283	12.7028
Age (in months)	sample	M	135.2777	134.4166	138.7222
		SD	6.2964	6.7365	6.4062
	subgr.1 ps	M	134.6666	132.0833	136.3333
		SD	6.5364	7.5206	4.0532
	subgr.2 svh	M	135.5000	134.1666	139.7500
		SD	4.8955	6.6889	6.7206
	subgr.3 bl	M	135.2777	137.0000	140.0833
		SD	7.2279	6.7263	7.8388
Socioecon. Status	sample	M	66.7222	68.6388	67.0833
		SD	17.7843	14.5108	14.3292
	subgr.1 ps	M	65.8333	68.5000	66.3333
		SD	9.6508	9.8615	15.3097
	subgr.2 svh	M	66.0833	65.9166	66.9166
		SD	8.5091	12.3319	10.0370
	subgr.3 bl	M	68.2500	71.5000	68.0000
		SD	9.5229	12.7562	9.0277

TABLE 4

t-Ratios for Differences in Intelligence, Age and Socioeconomic Status Between Samples and Between Subgroups of Samples

	NSS - IVH	IVH - SVH	NSS - SVH	
Int.	0.2921	0.4284	0.7479	N=36, df=70, $t_{\alpha=0.05}$=1.99
Age	0.8732	2.7441*	2.2697^{+}	
Soc.St.	0.3851[1]	0.0732[1]	0.0561	
	NSS/1-NSS/2	NSS/1-NSS/3	NSS/2-NSS/3	N = 12, df = 22, $t_{sign, \alpha=0.05}$ = 2.074
Int.	0.6333	1.6033	0.9790	
Age	0.3385	0.2080	0.0971	
Soc.St.	0.0644	0.5912	0.5628	
	IVH/ps-IVH/svh	IVH/ps-IVH/bl	IVH/svh-IVH/bl	
Int.	0.1573	0.3613	0.5566	
Age	0.6866	1.6165	0.9908	
Soc.St.	0.5427	0.6121	1.0457	
	SVH/ps-SVH/svh	SVH/ps-SVH/bl	SVH/svh-SVH/bl	
Int.	1.7711	2.2514^{+}	1.2711	
Age	1.4442	1.4096	0.1071	
Soc.St.	0.1056	0.3110	0.2662	

$^{+}$significant at α = 0,05, not significant at α = 0,01

*significant at α = 0,05 and at α = 0,01

[1] significance tested by t-test for heterogenous variances, df ≈ 35

The differences between boys and girls of the three samples and between pupils in resource and itinerant programs of the integrated visually handicapped sample were also tested for significance on the variables intelligence, age, socioeconomic status, grade placement, and visual acuity.

TABLE 5

χ^2 Ratios for the Differences in Grade Placement Between Samples and Subgroups

	main samples	subgroups of NSS	subgroups of IVH	subgroups of SVH
χ^2	1.6539	2.9760	2.9760	0.9628
$\chi^2_{sign, \alpha=0.05}$, df = 4(2) = 9.488 (5.991)				

Table 6 demonstrates that no significant difference at the α = 0.01 level could be found between any at these subgroups in intelligence and age. The control variable socioeconomic status shows, however, significant difference between boys and girls in all three samples, not however, between resource and itinerant pupils.

TABLE 6

t-Ratios for Differences of Intelligence, Age, and Socioeconomic Status Between Boys and Girls in the Three Samples, and Between Pupils in Itinerant and Resource Programs in the Integrated Visually Handicapped Sample

	NSS/ Boys - NSS/ Girls	IVH/ Boys - IVH/ Girls	SVH/ Boys - SVH/ Girls	
Int.	1.9013	1.4845	2.3082°	N=18, df=34, $t_{sign, \alpha=0.05}$ =2.032
Age	1.1139	2.0579°	1.0918	
Socio.	2.9423*	3.7396*	3.2959*	
	IVH/Resource – IVH/Itinerant			N=14, df=26, t_{sign} = 2.145
Int.	1.7059			
Age	0.3474			
Socio	1.0965			

°significant at α = 0.05, not sign. at α = 0.01

*significant at α = 0.01

The application of the Mann-Whitney Test to test the differences of visual acuity between the boys and girls of the two visually handicapped samples and between resource and itinerant pupils did not show any significance (highest z-value = 0.4289); nor did we find any significant difference of grade level between the boys and girls of the three samples, and between resource and itinerant pupils, when the χ^2 test was applied (highest χ^2 value = 1.260).

Instrument

The selection of an instrument which measures at least some essential dimensions of social adjustment, and which can be applied both to sighted and visually handicapped students was indeed one of the most difficult tasks in the course of our study.

We felt that our measurement of adjustment should meet the following criteria:

1. The instrument should cover as many areas as possible of the complex phenomenon "social adjustment."

2. There should at least be some empirical cues to the reliability and validity of the instrument.

3. The instrument should not contain any items which are not valid when applied to the visually handicapped.

4. The length and testing procedure of the instrument had to be of a kind that the measurement could be applied in the course of our study.

We hope to have found such an instrument in the Self-Concept Adjustment Score developed by Cowen, et al. in their study *Adjustment to Visual Disability in Adolescence*. They regarded the development of adequate instruments for measuring social adjustment of sighted and visually handicapped children as the main objective of their study, and developed three major instruments: the Self-Ideal Sort (Self-Ideal Discrepancy Score and Self-Concept Adjustment Score), the Teachers' Behavior Rating Scale, and the Situations Projective Test B. The results of their testing show so significant correlations between the scores of the Self-Concept Adjustment Score and the results of the other adjustment measurements used (compare coefficients of correlations given below) that the Self-Concept Adjustment Score can with reason be regarded as a good instrument for measuring social adjustment.

On the theoretical assumption that good adjustment of a person is "characterized by a self-concept which is not substantially removed from one's concept of the way he would like to be" (p. 53), and that "the *Q* technique pioneered by Stephenson (1953), and utilized extensively and effectively in the Chicago studies on the effects of psychotherapy (Rogers and Dymond, 1954)," (p. 54), is more effective than a simple rating technique for self-ideal discrepancy, Cowen, et al. developed an instrument "which a) reflected self-ideal congruence, b) was functionally manageable and practical in time requirements for the visually disabled and c) yielded true differences in estimate rather than differential response sets," (p. 56). Their items were culled primarily from instruments used by Rogers and Dymond (1954) and by Jervis (1960). Their final pool of 60 items consisted of 30 items which had been judged to reflect good adjustment by a 100-percent agreement of five clinically trained judges, and of 30 items judged as reflecting poor adjustment. A pilot study was undertaken to determine an optimal form of the instrument.

The final form of this instrument consists of ten groups of six (three "well adjusted" and three "poorly adjusted") statements. To get the Self-Concept Adjustment Score these items have to be rated by the subject by the following procedure: while repeatedly reading or hearing the six statements, the subject first selects the statement "most like me," than the "least like me," than the "most like me" and "least like me" of the remaining four statements; and than the "more like me" of the remaining two. This procedure is repeated for all ten blocks. In each instant the "most like me" statement gets the lowest number available out of rank 1 to 6, the statement "least like me" always gets the highest number available. For evaluation the numbers of all statements judged as reflecting good adjustment are added. As the lowest number possible for three statements is 6 (1 + 2 + 3) and the highest number possible 15 (4 + 5 + 6) the total self-concept adjustment score value must lie between 60 and 150, lower value indicating better adjustment.

Cowen, et al. report that "separate reliability estimates for this instrument were not obtained; however the comparable *Q*-Sort Adjustment Score reported by Rogers and Dymond (1954) had a test-retest reliability of 0.86. Their instrument. . . was developed in the same general fashion," (p. 58).

Some cues about the validity of this adjustment measure may be drawn from the fact that when applied to 127 visually handicapped and 40 sighted students in the Cowen, et al. study, substantial correlations between this measurement and the other reliable measurements of adjustment were found. An average correlation of 0.94 was found for the results of the Self-Concept Adjustment Scores and the Self-Ideal Discrepancy Scores of the three groups tested by Cowen, et al. Between Self-Adjustment Scores and the results of the Teachers' Behavior Rating Scale an average correlation of 0.40 existed for the integrated visually handicapped sample and a correlation of 0.37 for the sighted control group. An average correlation of 0.38 could be found between the Self-Concept Adjustment Score and the subjects of the Situations Projective Test B, regarded as reliable by the authors (Cowen, et al., pp. 85-87).

Method

The Self-Concept Adjustment Score was given to all subjects individually by the investigator in a place where nobody could hear the answers of the students. The sighted students and those visually handicapped students who could make use of it were given the test paper as shown in the following pages in clear 11-point type. Visually handicapped students who could not read the test paper were given the set of items orally as often as they wanted to have them read to them, at least twice at the beginning of each of the ten sets of 6 items and once more before further choice between a set of items was made.

The actual procedure of testing was as follows:

1. In a period of about 3 minutes to set up some personal contact the subject was told a) that this is not a real test, but a paper by which we want to find out his personal opinion about himself and his relationship to others, b) that nobody but the investigator will ever know the answers the subject gives, c) that no names or individual data will be given in the publication of results, d) that it is extremely important for the investigator and his study that the subject is really honest in making his choices of items.

2. After giving the subject the paper or reading the first set of items to him, it was explained what he was expected to do. An example of choice was gone through in which the subject showed that he had really understood the procedure, by explaining the choice in his own words.

3. All ten sets of items were worked through by the subjects and choices were recorded on the investigator's paper. The subject was told repeatedly that he should take his time and have a short break whenever he wants. If the subject asked the meaning of a word, the investigator gave a simple explanation for this expression; the same explanations were used for all subjects.

Analysis of Results

All test papers were evaluated by the investigator after the whole investigation had been finished. Test scores of all 108 subjects were determined by the procedure described earlier.

An analysis of variance was applied to find out whether there were any significant differences in the Self-Concept Adjustment Scores between and among the different samples and subgroups. The t test for dependent variables was applied additionally to check the difference of means where such a difference was supposed to be near significance among subgroups. Differences of social adjustment between boys and girls in all samples and between integrated visually handicapped students in itinerant and resource programs were also tested for significance by the t test for dependent variables. The correlation between some of the independent variables age, intelligence, socioeconomic status, and the data of the self-adjustment measure were calculated by Pearson's product moment correlation. All calculations were made by hand on an automatic calculator.

Self-Concept Adjustment Score
by Cowen et al.

First Name	*Surname*	*No.*

Block	No.	Item	Dir.	Score
I	1	I enjoy being with the opposite sex.	G	
	2	I feel people are unfriendly.	P	
	3	I stand up for what I think is right.	G	
	4	I usually like people.	G	
	5	I am afraid of a full-fledged disagreement with a person.	P	
	6	I avoid facing problems.	P	
II	1	I feel that I can't do anything as well as others can.	P	
	2	I feel unsure of myself.	P	
	3	I am considerate.	G	
	4	I am easy to get along with.	G	
	5	I find myself belittling others in conversation.	P	
	6	I am able to accept criticism.	G	
III	1	I get along well with the people around me.	G	
	2	The way I feel depends on the mood of those around me.	P	
	3	I value independence.	G	
	4	I have a fear of failing in everything I want to accomplish.	P	
	5	My relationships with others are satisfactory.	G	
	6	I am sarcastic.	P	
IV	1	I tend to be on my guard with people.	P	
	2	I am a frank person.	G	
	3	I am able to accept responsibility.	G	
	4	I hide my true feelings.	P	
	5	I like to plan and carry things out for myself.	G	
	6	I don't trust my own feelings.	P	
V	1	I envy the happiness that others seem to enjoy.	P	
	2	I am liked by most people who know me.	G	
	3	I am sincere.	G	
	4	I am easily upset.	P	
	5	I always keep to myself.	P	
	6	I am usually in good spirits.	G	

Block	No.	Item	Dir.	Score
VI	1	I am able to be self-reliant.	G	
	2	Self control is a problem to me.	P	
	3	I feel that I am not getting enough done.	P	
	4	I am emotionally grown up.	G	
	5	I feel relaxed.	G	
	6	I am usually shy.	P	
VII	1	I can usually make up my mind and stick to it.	G	
	2	I feel that the things I do are worthwhile.	G	
	3	I usually seek the advice of others.	P	
	4	It is difficult for me to control my anger.	P	
	5	I often feel resentful.	P	
	6	I feel I am intelligent.	G	
VIII	1	I am a stubborn person.	P	
	2	I have little respect for myself.	P	
	3	I am optimistic.	G	
	4	I am guided by values and standards of my own.	G	
	5	I often make excuses for myself.	P	
	6	I am a cheerful person.	G	
IX	1	I have a feeling of hopelessness.	P	
	2	My feelings are easily hurt.	P	
	3	I put up a false front.	P	
	4	I feel confident.	G	
	5	I am able to express my feelings to others.	G	
	6	I understand myself.	G	
X	1	I am tactful.	G	
	2	I am likeable.	G	
	3	I am able to assert myself.	G	
	4	I am a nervous person.	P	
	5	No matter what I do, I can't satisfy my friends.	P	
	6	I can't seem to make up my mind one way or another.	P	

Survey of Data

The self-concept adjustment scores of all our subjects are given in Table 7 together with the means and standard deviations of all the three main samples and twelve subgroups.

Analysis of Group Differences by Analysis of Variance

The two-way analysis of variance applied to the three samples: sighted controls, integrated visually handicapped, and segregated visually handicapped (column effect: kind of educational setting), and to the three visual acuity groups: partially sighted, severely visually handicapped, and blind (row effects: degree of visual acuity) was to test the following hypotheses:

1. There is no effect of the kind of educational setting on social adjustment (corresponding to the hypothesis of no column effects).

2. There is no effect of the degree of visual acuity on social adjustment (corresponding to the hypothesis of no row effects).

3. The visual disability-group-kind of educational setting combination has no unique effect on social adjustment (corresponding to the hypothesis of no row-column interaction.

The summary table for this analysis of variance (Table 8) demonstrates that none of the above stated hypothesis can be rejected. The *F* values of row effects and of column effects are far below the value of *F* = 3.09 required for rejection at the 5-percent level; the *F* value for interaction falls below required *F* value of 2.46 required for rejection; our *F* value here, however, approximates significance much more than in the other two cases.

TABLE 7

Self-Adjustment Scores of All Subjects and Means and Standard Deviations of Samples and Subgroups

Subgr.	Sex	Progr.	Sighted Controls	Integrated Vis. Hand.	Segregated Vis. Hand.
Partially Sighted	Boys	Res.	76	65	83
			86	89	86
			71	66	86
		It.	68	81	85
			91	94	84
			66	75	82
	Girls	Res.	79	110	98
			69	67	73
			86	73	101
		It.	68	69	83
			71	75	81
			94	106	79
	M		77.0833	80.8333	85.0333
	SD		9.4468	14.8763	7.3085
Severely Visually Handicapped	Boys	Res.	113	89	112
			70	80	67
			88	90	86
		It.	119	71	68
			67	82	98
			85	88	67
	Girls	Res.	101	90	72
			63	89	78
			86	91	71
		It.	76	72	61
			79	87	72
			64	65	79
	M		82.2500	82.8333	77.5833
	SD		17.7722	8.5326	14.0561
Blind	Boys	Res.	72	71	64
			80	67	91
			70	61	70
			81	71	97
			92	64	64
		It.	74	77	65
	Girls	Res.	80	71	97
			93	94	75
			65	63	86
			63	102	114
			90	87	70
		It.	97	74	75
	M		79.7500	75.1666	80.6666
	SD		10.8737	12.2870	15.4721
M (total)			80.3611	79.6111	81.1111
SD (total)			13.5321	12.6057	13.1503

TABLE 8

Summary Table for the Analysis of Variance (Rows: Degree of Visual Disability Groups; Columns: Kind of Educational Setting)

Source	SS	df	MS	F	
Rows	187.0555	2	93.5277	0.5290	$F_{sign} = 3.09$
Columns	40.5000	2	20.2500	0.1145	
Interaction	848.4450	4	212.1112	1.1997	
Error (w.c.)	17502.9167	99	176.7971		
Totals	18578.9167	98			

Testing of Differences Between Subgroups

The fact that in this analysis of variance the *F* value for interaction was so much higher than the other two *F* values induced us to look more carefully at the means and standard deviations of our subgroups in order to find more explanation for this fact.

We found that our group of partially sighted students in residential schools shows a social adjustment mean which seems strikingly higher than that of any other subgroup. For more careful statistical analysis we, therefore, applied a series of *t* tests for dependent variables to examine whether on the basis of this significance test any significant difference could be found between the social adjustment of partially sighted students in residential schools and severely visually handicapped or blind students in residential schools, and between the social adjustment of partially sighted students in residential schools, partially sighted students in integrated programs and corresponding sighted controls. The results of these tests of significance are shown in Table 9.

These *t* ratios indicate that the relatively high *F* value for interaction in our analysis of variance is mainly caused by the strikingly lower mean of self-concept adjustment scores of partially sighted students in residential schools. As now *t* ratio shows significance at the $\alpha = 0.05$ level we cannot exclude the possibility that

TABLE 9

t Ratios for Difference of Means of Social Adjustment Between Segregated Subgroups and Partially Sighted Subgroups

	SVH/ps _ SVH/svh	SVH/ps _ SVH/bl	SVH/svh _ SVH/bl	
t	1,4180	0,7833	0,3795	N = 12; df = 11
	NSS/1 _ IVH/ps	NSS/1 _ SVH/ps	IVH/ps _ SVH/ps	$t_{sign, \alpha = 0,05} = 2,201$
t	1,1051	2,0455	1,1498	

the low mean of social adjustment has only occurred by chance. Thus we must refrain from making any interpretive speculations on this phenomenon.

The *t* test for dependent variables was also applied to examine the difference of means of social adjustment between the boys and girls in our three samples. Table 10 shows the results of these tests.

TABLE 10

t Ratios for Differences of Social Adjustment Between Boys and Girls in the Main Samples

	Sight. Contr. Boys – Girls	Int. Vis. Hand. Boys – Girls	Seg. Vis. Hand. Boys – Girls	df = 17
t	0,5913	1,2740	0,0747	$t_{s, \alpha = 0,05} = 2,110$

These results indicate that no significant differences between boys and girls in the three samples exist at the $\alpha = 0.01$ or $\alpha = 0.05$ level.

The test of significance applied to the two subgroups of the integrated sample: 14 pupils from resource programs, and 14 corresponding pupils from itinerant programs resulted at a *t* value of 0.0992. This indicates that no difference in social adjustment consists between these two subgroups (t_{sign} at $\alpha = 0.05 = 2.160$).

Correlations Between
Control Variables and
Social Adjustment Scores

To find out if any significant correlations exist between the three main control variables and social adjustment scores a series of product moment correlation coefficients were calculated for the respective variables of the three samples. The results of these calculations are given in Table 11:

TABLE 11

Pearson's Product Moment Coefficient for the Relationship of the Three Control Variables; Age, Intelligence, and Socioeconomic Status with the Social Adjustment Scores in the Three Samples

	Normal. Sighted	Integr. Vis. Hand.	Segreg. Vis. Hand.	
Age – Social Adjustm.	–0.0008	–0.1937	+0.2088	r_p,sign, $\alpha=0.05$, df=34 ≈ 0.325
Intell. – Social Adj.	–0.0236	–0.5472*	– 0.0946	
Socioec. Status – Soc. Adj.	–0.1671	–0.0236	+0.3678	

*sign at $\alpha = 0.05$

These coefficients of correlation show that no significant correlation between social adjustment and age could be found for any of our three samples. The correlation of r_p = -0.1937 in our integrated sample indicates, however, that social adjustment of integrated, visually handicapped children seems to improve with age; vice versa the positive correlation coefficient (r_p = +0.2088) of our segregated sample indicates a trend of lower social adjustment of visually handicapped children in residential schools with increasing age.

The coefficients of correlation between social adjustment and intelligence do not indicate any relationship of these two variables for the normally sighted or for the segregated visually handicapped. A very significant correlation between social adjustment and intelligence exists, however, for the integrated visually handicapped sample. As lower scoring means better adjustment on our social adjustment measurement the coefficient of r_p = -0.5472 indicates higher intelligence has a positive influence on the social adjustment of visually handicapped students integrated in regular school, while no such influence seems to exist in normally sighted students or in visually handicapped children in residential schools.

The variables social adjustment and socioeconomic status do not have any significant correlation for our sample of integrated visually handicapped. For the normally sighted the correlation is not significant either, the coefficient of r_p = -0.1671 may however indicate a trend for higher social adjustment with higher socioeconomic status. A significant positive correlation of the two variables could be found for our sample of segregated visually handicapped (r_p = +0.3678). This indicates that higher socioeconomic status of parents means less social adjustment for visually handicapped children living in residential schools.

SUMMARY AND DISCUSSION OF RESULTS

In reference to our hypotheses stated earlier, our study revealed the following results:

1. No significant difference could be found between the social adjustment of visually handicapped and sighted students. Hypothesis 1 can therefore not be rejected.

   These findings are in opposition to many theoretical argumentations and to the results of many early empirical studies. They are, however, in accordance with theoretical assumptions recently expressed in literature and with the results of a number of recent empirical studies, above all with the findings of Cowen, et al. (1961), Jervis (1960), Peabody (1967), McGuinness (1970), and Williams (1971).

2. No significant difference could be revealed between social adjustment of visually handicapped students integrated in regular schools and visually handicapped students in residential schools. Rejection of Hypothesis 2 is therefore not possible.

These results are also in perfect accordance with the findings by Cowen, et al. (1961), and McGuinness (1970). These results do, however, not necessarily indicate that the social environment in regular schools and in residential schools have the same kind of influence on the social adjustment of visually handicapped children. It may well be speculated that while the social adjustment of visually handicapped students in regular schools has developed in a realistic surrounding the social adjustment of the visually handicapped in a residential school is mainly the result of being brought up in a sheltered and unrealistic environment. In this case the good social adjustment of these children might be seriously affected as they grow older and especially when they have to leave the residential school. These speculations are somehow supported by the tendency of less social adjustment with increasing age in our residential school sample, while the tendency shows directly in the opposite direction in our sample of integrated visually handicapped.

3. Our study did not show any significant overall differences between partially sighted, severely visually handicapped, and totally blind students; they also do not indicate any tendency of better adjustment with increasing visual disability or vice versa. This means that Hypothesis 3 cannot be rejected.

The first part of these results support the findings by Cowen, et al., though they believe to see a slight tendency for better adjustment with increasing visual disability in their data.

4. No significant difference could be found between boys and girls in the three samples. Hypothesis 4 cannot be rejected. A slight tendency for better adjustment of boys could, however, be revealed in the sample of visually handicapped students integrated in regular schools.

These results are somewhat divergent to the Cowen, et al. findings who revealed that boys are better adjusted in residential schools; in any of their other samples they did, however, not find any significant sex differences either. Our findings in this area are in accordance with the respective findings by Peabody (1967) and partially with the results obtained by Williams (1971).

5. The comparison of integrated visually handicapped students from resource programs and itinerant programs did not show any significant difference in the area of social adjustment. Rejection of Hypothesis 5 is therefore not possible.

These findings are in accordance with respective results revealed by McGuinness (1970). The slight tendency for better adjustment of pupils in itinerant programs as derived from Peabody's findings cannot be deduced from our data.

6. In reference to Hypothesis 6, no significant correlation between age and social adjustment could be found in our study. This hypothesis must therefore be maintained. As already stated above our data in this area indicate however better social adjustment with increasing age for visually handicapped pupils in regular schools and less social adjustment with increasing age for visually handicapped children in residential school.

These data are partially in accordance with the findings by Peabody (1967), who found a slight tendency for better adjustment of older partially sighted students in regular schools. In respect to residential school pupils, our data are in full accordance with the findings reported by Hardy (1966) who found a significant positive relationship between age and manifest anxiety in blind residential school pupils.

7. Hypothesis 7 can be maintained for our sample of visually handicapped children in residential schools and for the sighted control, as no significant relation between social adjustment and intelligence could be

found in any of these samples. The hypothesis must, however, be rejected for our sample of visually handicapped children integrated in regular school. A very significant correlation between intelligence and social adjustment was found for these children.

> Together with the findings that this group of visually handicapped children in regular schools was the only one where a difference of social adjustment between boys and girls was revealed, these results may lead to the speculation that integrated visually handicapped students have to make special efforts to achieve a high level of social adjustment. Boys and more intelligent children are more likely to be successful in these efforts. The fact that the social adjustment of this group of subjects is not significantly lower than that of the other two groups demonstrates, however, that though it seems to be harder for visually handicapped children to achieve good social adjustment in the realistic surrounding of the regular school these children can, and normally do, achieve the same level of social adjustment as visually handicapped children raised in the sheltered area of residential schools, and as sighted control students.

8. Testing of Hypothesis 8 did not show any significant correlation between social adjustment and socioeconomic status in the integrated visually handicapped sample. A slight but not significant tendency for better social adjustment with higher socioeconomic status was found for the sample of sighted control. Our sample of visually handicapped students in residential schools shows the very opposite tendency: the significant positive correlation shows that for these students higher socioeconomic status is likely to result in less social adjustment.

> This result, however striking at the first glance, shows some accordance with Rosman's finding (1970) that children with low socioeconomic status adjust better in residential schools. It may lead to the speculation that in reference to Sommers' (1944) theoretical considerations on "The Influence of Parental Attitudes and Social Environment on the Personality of the Adolescent Blind" high socioeconomic status together with residential school attendance increases negative attitudes of the parents especially in the direction of "denial" and "overprotection," which then might result in more adjustment problems of their children. It can, however, be speculated as well that children from families with high socioeconomic status are likely to be sent to a residential school mainly if their parents hold such attitudes, or if beside the visual disability they show abnormal problems of social adjustment.

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EVALUATING THE OPTACON: GENERAL REFLECTIONS ON READING MACHINES FOR THE BLIND

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It is now more than ten years since the American Foundation for the Blind published the Proceedings of the 1962 International Congress on Technology and Blindness (Clark, 1963). Volume 1 of those Proceedings contained a lengthy section on reading machines for the blind, in which there were numerous references to yet earlier symposia and published collections of expert papers outlining the major design features of actual or projected reading devices. The alternation of confidence and scepticism about the nearness of a "breakthrough" is one of the features of these publications most likely to impress the reader. There is, on the one hand, a conviction that a machine giving a satisfactory synthetic or spelled speech output is within easy reach and, on the other, the kind of low-pitched judgment of, for example, Selfridge (1963, p. 287) who, while "very optimistic about the long-range usefulness of technology," was nevertheless "not very hopeful of substantial successes soon." Since then we have seen the design and development of the Optacon by Telesensory Systems, Inc. (T.S.I.), (Linvill and Bliss [1966], Bliss [1969], and Bliss, Katcher, Rogers, and Shepard [1970]). It is this device that now leads the way. No other can really be said to be much beyond the design or prototype stage, and certainly no other has undergone the kinds of prolonged "bench-testing" and subsequent field-testing that have been logged up by the Optacon. In this paper, an account will be given of an independent evaluation of the Optacon in the United Kingdom, and this will be followed by a discussion of some of the factors that have a bearing on the whole rationale of reading machines for the blind. The first part is based on a report presented to St. Dunstan's and the Royal National Institute for the Blind (*vide* Tobin, James, McVeigh, and Irving, 1973).

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EVALUATION OF THE OPTICON

The Optacon, with its array of vibrating pins which give a tactile facsimile of the letterpress symbol being "looked at" by its camera, had aroused a great deal of interest in Great Britain, particularly an account of its compactness, portability, and its potential as a study aid and tool for blind people in the professions. It was against this background that at the request of St. Dunstan's and the Royal National Institute for the Blind, the Research Centre for the Education of the Visually Handicapped at the University of Birmingham, England mounted an investigation, the primary aims of which were:

1. To obtain some information on the usefulness of the Optacon to blind people.
2. To pinpoint characteristics and skills that seem to be associated with successful learning.

3. To prepare teaching materials and procedures.

4. To examine some of the difficulties besetting the learner once the basic teaching program has been completed.

The time made available for the evaluation was one year, and during that time two sets of data were obtained. The first set was from a series of initial training programs involving 30 blind adults and adolescents. The second was based upon extended training and practice sessions with 17 of the original trainees.

Subjects

A total of 36 registered blind subjects, from 16 to 54 years, received training with the Optacon but of these only 30 completed the whole battery of tests and basic training. Of this group of 30, 13 were women and 17 were men. Random selection of subjects was not possible. Of the experimental group of 30, 6 were adults working or living in the London area and known to St. Dunstan's or the RNIB as their own employees, as civil servants, or as working in some other profession; 16 were adults or older teenagers working, or attending a vocational training and assessment unit, in Birmingham; 8 were girls, aged 16 to 18, at a residential grammar school for girls registered as blind. As may be seen, none of the subjects was drawn from that section of the population containing the greatest numbers of blind people--those over 65, and the mean age of the group was, in fact, 32.1 years, S.D. = 13.1 years. It is difficult to arrive at any "index of representativeness" for the group. It is probable, however, that the London and Chorleywood subjects were atypical, in that they were drawn from professional or semiprofessional occupations or would be expected to enter such occupations. The Birmingham group were possibly somewhat more typical of those under 65, since they contained a rather higher proportion of people who had worked in manual or unskilled occupations. However, even this group was quite heavily biased with members who were computer-programmers, teachers, social welfare workers, and students.

Variables

The dependent variable was Optacon reading speed, as measured by means of a ten-minute oral reading test taken on completion of the training with the upper- and lower-case letters. Other reading tests, including letter recognition and prose reading with the aid of the tracking device, were also administered, but the decision to use the test of unaided prose reading as the measure of the dependent variable was made on the grounds that this procedure approximated most closely to the eventual aim of the Optacon designers, i.e. the use of the device to permit easy, unaided access to print material. Its special feature was that the typeface was IBM Dual Gothic printed at a spacing of 10 letters-per-inch.

For correlational purposes, measures were taken on a number of variables that were thought likely to be related to success. Among these were: age, sex, degree of residual vision, age of learning braille, visual experience of letterpress symbols, braille reading speed, short-term memory (letter span), tactual discrimination, and sixteen personality factors (Cattell 16 Personality Factor Inventory).

The T.S.I. Teaching Manual (Weihl, 1971) gives extensive practice in the reading of upper-case letters before the introduction of the corresponding lower-case typeface. An alternative teaching Manual was prepared, in which greater emphasis was placed in the initial stages on lower case letters (described in greater detail in Tobin, James, McVeigh, and Irving [1973]), and this system was used with some of the subjects while others followed the original T.S.I. Manual. No formal, experimental comparison between the two teaching methods was planned since random assignment of subjects was precluded by the rather tight timing schedule of the evaluation.

Teaching Procedure

1. The 30 subjects were taught on a one-to-one basis.

2. The 16 Birmingham subjects attended for four one-hour sessions

per week, and continued until all upper and lower case letters had been covered. Their total teaching sessions occupied approximately 12 hours.

3. The eight girls from Chorleywood gave up their autumn half-term holiday and spent ten successive days on teaching and practice with the Optacon. However, the scores used in the first analysis are those obtained after a total of approximately ten hours teaching/learning.

4. The six London subjects attended for ten days, each daily session lasting about three hours, during which time supervised training and some private practice were provided. The Optacon scores for these subjects were those obtained on completion of the upper and lower case letters, and the amount of time spent on learning before administration of the test ranged from 10 hours to 30 hours.

Results

As may be seen from Table 1, the mean oral-reading speed at the end of the initial training period was 6.6 wpm. The superior attainment of the adolescent girls at Chorleywood College for Girls (a grammar school for girls registered as blind) should also be evaluated in the light of their greater efficiency, since all eight of them were tested after approximately ten hours of training spread over about five days.

Table 2 shows the correlations between Optacon reading scores and the battery of predictor tests. Of course, a sample of 30 is small for correlational purposes but the validity of the results is in part authenticated by previous findings on braille reading (Tobin, 1971). The significant negative correlations with age and age of learning braille accord well with much previous research in the general educational field on the importance of age and previous relevant experience; the significant positive correlations with braille reading speed, short-term memory capacity, and tactual discrimination ability may also be seen as confirmation of what might have been expected by experienced teachers of the blind. The finding of no significant correlation between Optacon reading and intelligence (as measured by Factor B of the 16 P.F. Inventory) is probably to be accounted for by the homogeneity of the subjects on this variable (they were nearly all of above average intelligence, the mean for Factor B being 9.1 which corresponds to a Sten Score of 8 for the general population on whom the Inventory was standardized.

In order to obtain some idea of the combined predictive power of the independent variables, the multiple correlation coefficient (R) was calculated, with Optacon score as the criterion. Using all 25 independent variables, the obtained R was 0.99

TABLE 1

Reading Speeds at End of Initial Training

Group	Number	Mean Age (in years)	Mean Speeds (wpm)
Total Group	30	32.1	6.6
Subgroup 1, excluding Chorleywood subjects	22	37.8	4.9
Subgroup 2, Chorleywood subjects	8	16.6	11.1

TABLE 2

Correlations between Optacon Reading Scores and the Battery of Predictor Tests. Number of Subjects = 30

Predictor Tests		Correlation Coefficients (with Optacon scores)
1. Sex (male = 1, female = 2)		+0.2178
2. Age		-0.5158**
3. Degree of residual vision		+0.1606
4. Age of learning braille		-0.3794*
5. Visual experience of letters		-0.1674
6. Braille reading speed		+0.4325*
7. Short-term memory (letter span)		+0.4174*
8. Tactual discrimination (two-point threshold)		+0.4743**
9. Method of teaching (T.S.I. Manual = 1, New Manual = 2)		+0.3552
	Factor A	+0.0179
	Factor B	+0.0245
	Factor C	+0.1155
16	Factor E	-0.0514
	Factor F	+0.1744
P.F.	Factor G	+0.2293
	Factor H	+0.2572
(Personality	Factor I	+0.1783
	Factor L	-0.1938
Variables)	Factor M	+0.3046
	Factor N	-0.1751
	Factor O	+0.0539
	Factor Q_1	+0.3245
	Factor Q_2	-0.0289
	Factor Q_3	+0.1388
	Factor Q_4	+0.0144

*Significant at 5 percent level.

**Significant at 1 percent level.

which is significant beyond the 5 percent level. Perhaps of more practical value are the regression equations based upon 1) age, braille speed, memory, and tactual discrimination, and 2) these four plus sex, degree of residual vision, age of learning braille, visual experience of letters, and method of teaching. The obtained multiple *R* with the smaller number of predictors is 0.73 (percentage variance = 53 percent). With nine independent variables, one of them being method of teaching, the multiple *R* is 0.77 (percentage variance = 59 percent). The beta weights for the latter may be cautiously interpreted as perhaps showing some evidence for the value of the specially prepared teaching program (as opposed to the T.S.I. Manual), but, again for practical purposes, the important point is that the second multiple *R* is not significantly different from the first. That is, there is little difference in predictive power between the battery of four tests and the battery of nine.

An alternative way of looking at the results is in terms of the profiles of the most and the least successful Optacon learners. The ten most successful and the ten least successful of the total group of 30 were compared therefore, and the results are shown graphically in Fig. 1. The variables chosen for the basis of the comparison were those suggested by inspection of the correlation matrix and the regression equations. Figure 1 brings out the differences; with the more able learners being above average on tactual discrimination, memory, and braille reading speed but below average in age and age of learning braille. Since the Chorleywood subgroup had performed better, on average, than the rest of the total group, and had contributed six subjects to the "10 best," a further comparison was made. This was done by excluding all eight Chorleywood subjects, together with two others. The Optacon scores of these two were those immediately above and below the median. Based on the new group of 20, Fig. 2 has a pattern very similar to that shown in Fig. 1; the more successful Optacon readers are younger, learned braille at an earlier age, and obtained superior scores on the touch, memory, and braille reading tests.

The results of *t* tests to test the significance of the differences between the groups are given in Table 3. It will be seen that in the comparisons on the group of 20, no statistically significant difference was found in terms of age as between the good and poor Optacon readers, although the observed apparent divergence was similar to that found for the group of 30. The exclusion

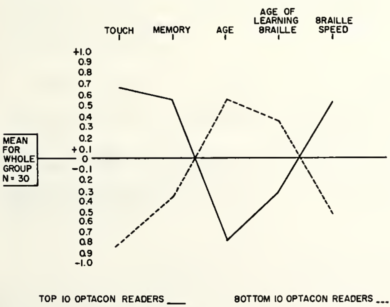

Figure 1. Profiles of Top Ten and Bottom Ten Optacon Readers (Means Based on 30 Subjects). Standard Scores (*Z*).

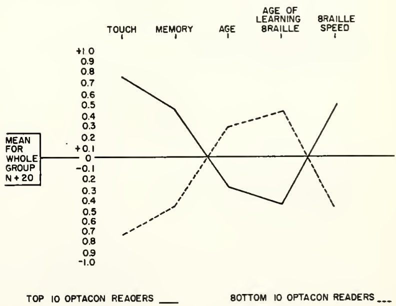

Figure 2. Profiles of Top Ten and Bottom Ten Optacon Readers (Means Based on 20 Subjects, Chorleywood Girls Being Excluded). Standard Scores (*Z*).

TABLE 3

Comparisons on Selected Independent Variables between High and Low Optacon Scorers

Baseline (shown in Fig. 1) derived from means of all 30 subjects		Tactual Discrimination	S.T.M. (letter span)	Age	Braille Reading
High scorers (N = 10)					
	Mean	17.8	14.3	21.7	628.8
	S.D.	1.78	2.45	7.86	199.99
Low scorers (N = 10)					
	Mean	14.6	11.5	39.5	371.3
	S.D.	1.49	3.14	12.58	254.96
	t	4.13	2.11	3.60	2.38
	P	<0.01	<0.05	<0.01	<0.05
Baseline (shown in Fig. 2) derived from means of all 20 subjects					
High scorers (N = 10)					
	Mean	18.1	14.5	33.8	601.0
	S.D.	1.51	2.77	8.11	218.39
Low scorers (N = 10)					
	Mean	14.7	11.5	39.8	341.7
	S.D.	1.55	3.14	12.04	258.25
	t	4.70	2.15	1.24	2.30
	P	<0.01	<0.05	N.S.	<0.05

of the Chorleywood subjects had had the effect, of course, of curtailing the distribution of this variable since the eight youngest had been discarded.

FOLLOWUP INVESTIGATIONS

Upon completion of the initial training, 17 subjects participated in a series of more prolonged training and practice sessions. The purpose was to provide experience with differing type styles and formats and to develop Optacon reading skills in relation to books, letters, journals, personal correspondence, etc. Selection of subjects was based upon availability and willingness to continue, performance during initial training, and ease of access for the investigators. Among the 17 subjects were seven of the eight girls from Chorleywood College. Some sharing of Optacons was arranged, mainly at Chorleywood but also by a married couple who had an Optacon in their household.

Three subjects were based in Birmingham and took possession of their Optacons for periods of 9 to 12 weeks after finishing their initial training. One was a male university student, aged 20; the second was a male computer programmer, aged 22; and the third was a male administrator, aged 49. Table 4 shows their oral reading rates on tests of prose printed in sans-serif type, together with the speeds reached on newspaper print.

Fig. 3 shows the speeds of the teenage girls during the course of their 20 weeks of additional training and practice. The test materials were continuous prose passages in books of the kind being used in the practice sessions.

Fig. 4 provides similar information for six of the seven London-based adults who participated in this follow-up investigation, while Fig. 5 gives the details for the seventh London-based adult, a subject who entered the training system past the half-way stage of the project.

TABLE 4

Subject No. 1. Male, Aged 20, University Student

Practice Time (hours)	15	20	24	48	60	
Optacon Reading Rate (words-per-minute)	13	14	18	24	27	("The Times" newspaper-11)

Subject No. 2. Male, Aged 22, Computer Programmer

Practice Time (hours)	14	20	25	30	
Optacon Reading Rate (words-per-minute)	10	10	8	11	("The Times" newspaper-4)

Subject No. 3. Male, Aged 49, Administrator

Practice Time (hours)	18	24	30	35	
Optacon Reading Rate (words-per-minute)	5	7	10	13	("The Times" newspaper-3)

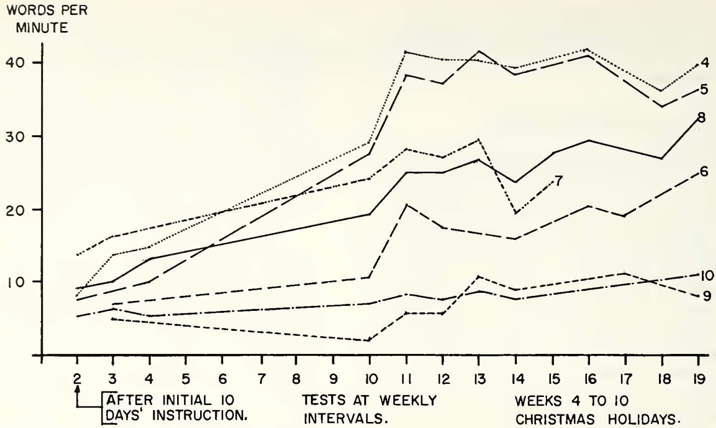

Figure 3. Book Reading Extended Practice Beginning 2 Weeks After Initial 10 Days Instruction (Chorleywood Girls)

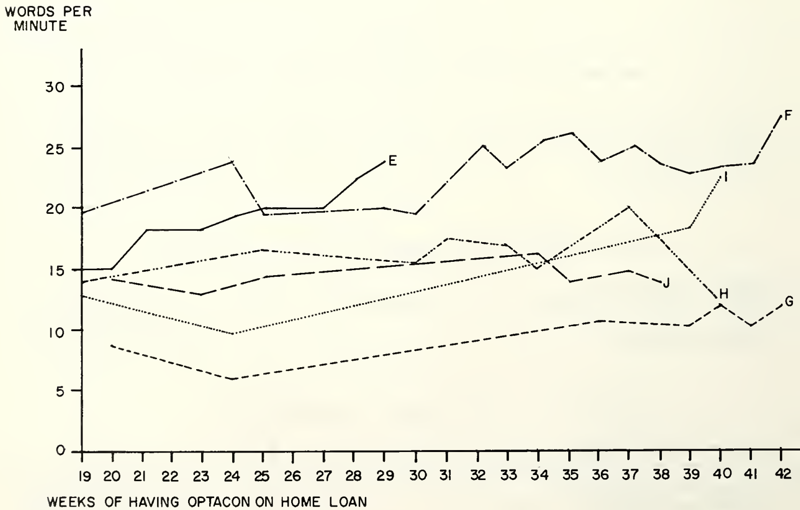

Figure 4. Book Reading Based on Extended Practice from Week 19-42 on Home Possessed Optacons (London Adults)

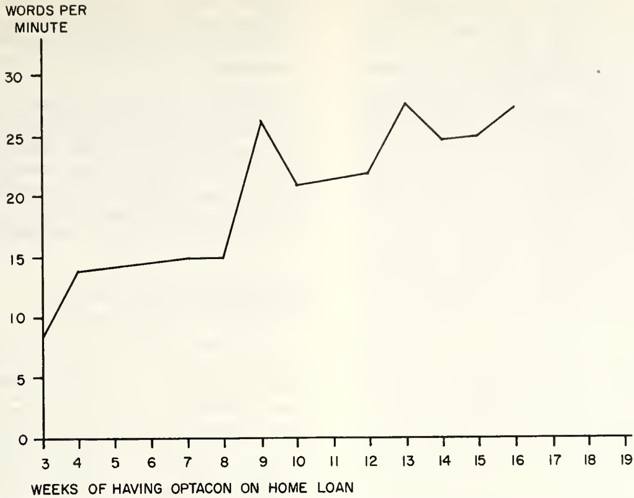

Figure 5. Book Reading Based on Extended Practice Recorded from Third Week of Home Possession of Optacon (One London-Based Adult)

SUMMARY AND COMMENTS

It must be emphasized that the two sets of data obtained in this evaluation should be seen first of all for what they are, summaries of the performance of 30 subjects who had not been selected on a random basis. The representativeness of the sample is difficult to assess. All that can be said about them with any safety is that as a group they were probably above average in intelligence and were highly motivated to succeed (most of them were in professional posts and all were volunteers eager to participate in evaluating this new, widely-praised aid).

The initial training showed that the most successful Optacon learners were, on average, above the norm in terms of tactual discrimination ability, short-term memory capacity (letter span), and braille reading speed; they were, in general, below the average of the whole group in age and in age at which braille was learned. Wide divergences quickly appeared among the learners even during this relatively short initial training period, some achieving speeds on specially prepared test materials of the order of 15 words-per-minute while others could not reach even one word per minute. The mean reading speed was 6.6 wpm for the whole group of 30; 4.9 wpm for the subgroup of 22 "older" subjects; and 11.1 wpm for the subgroup of 8 "younger" subjects, the adolescent girls from Chorleywood College.

The extended period of supervised and unsupervised practice did not bring about any clustering or "regression to the mean." That is, wide disparity in performance was still very evident, even after subjects had had prolonged use of Optacons in their own homes, jobs, or school. Some readers were managing only some 10/12 wpm, while others were able, for short periods, to read from books of their own choice at speeds of about 40 wpm. (It is of interest to note that, when the subjects were "force-paced" by having to read from a moving paper-tape, reading rates could be doubled for some of the slower readers and increased by 30 or 50 percent for the faster ones. It is suggested that problems of camera control and the reader's own set, style, and level of expectation serve to produce reading rates below those at which he/she could, in fact, operate.) Even the most successful learners felt that their reading speeds were not good enough for occupational purposes or, indeed, any purpose which entailed lengthy periods of reading. Nevertheless, the group as a whole retained very positive attitudes towards this method of reading, feeling that it gave them access to reading matter not otherwise accessible, or accessible only through the mediation of sighted helpers.

These findings suggest that training to some useful criterion is going to be a lengthy process. For adults and adolescents who already possess a high level of reading skill in some other medium, the investigators consider that nothing shorter than three months of supervised, daily practice with carefully structured and graded materials would be sufficient. Once the novelty effect has worn off, motivation has to be sought from the learner's own needs and aspirations and from the setting of suitable and varied goals by the teacher. It would seem that many blind adults would not be able to cope with the demands made on them by the Optacon if a target of the order of 40/50 wpm were to be set. No doubt a less rigorous criterion would be acceptable in relation to many nonvocational reading needs, but the attainment of a lower level of proficiency such as 10 wpm, would seem, on the evidence of this investigation, to be by no means easily or quickly accomplished. Experienced teachers of braille are well aware, and objective investigations such as that undertaken on the mobility and reading habits of the blind by Gray and Todd (1967) bear them out, that most newly-blind adults find it extremely difficult to learn braille. Optacon reading would seem to be of the same order of difficulty, *even when the learner has a good combination of the characteristics associated with success.* Training courses for adults are likely to have, therefore, a very high failure or dropout rate unless entry to training is made on a selective basis. Even in these circumstances, continuation of training may need to be made contingent on attainment of prescribed levels of proficiency at intermediate stages of the course.

Perhaps a true assessment of the value of the device for study and occupational purposes can only be made when much younger pupils, starting at the age of six or twelve years of age, have had the opportunity to obtain training on a daily basis over a period of five to ten years; a period comparable to that made available for the teaching of braille.

READING MACHINES OUTPUTS: POINTS FOR CONSIDERATION

For the user, one of the most important aspects of a reading machine is the nature and quality of the output. His ideal device would no doubt have either a high quality, Grade 2 braille embossed on a page (as opposed to a paper tape) or a high-fidelity, "natural speech" output presented through headphones. Much of the discussion recorded in works such as the proceedings on technology and blindness (Clark, 1963) has, however, dealt with the technicalities of spelled and synthetic speech, acoustic codes (as in the Optophone), and speechlike sounds. Until the work of Linvill and Bliss, very little attention was given to any form of tactile output, but it is in this area that the most significant advance has been made, no other device, despite Cooper's prediction (1963, p. 392), having been brought to the level of development of the Optacon. It is, nevertheless, the very fact that the Optacon is in production and in use on a routine basis by some readers that enables us to see more clearly what is still needed. Our experience with the Optacon (and it must be emphasized that our findings are not completely on all fours with those of other evaluators) has brought out that success is heavily dependent upon the existing skills, background, and motivation of the learner. It is this experience that pinpoints for us the drawbacks of all devices other than the ideal ones and yet, at the same time, points forward to the next generation of intermediate devices.

The complex of problems facing the would-be designer of a reading machine is not only to do, then, with the harnessing of our current technology--although that, as the technologists would hasten to add, is not easy in itself. Given that adequate financial resources and the know-how of modern engineering are to be made available, there remains the question, "What is the target population?" In other words, "What kind of people will use the device?" If it is all, or nearly all, of the blind, then the output must be "natural speech." The spoken language is the one means of communication shared by the whole group, and the only code that requires no new learning on the part of the users; there is the advantage, too, that with the aid of modern technology it should be possible to vary the speed of presentation, within limits, to allow for individual differences. If the goal of a natural speech output is too far off (and it may be very far away if additional constraints are to be imposed on the designer, constraints such as portability and immediate access to a wide range of type styles and sizes), then we must recognize that the users are going to be not the whole blind population but some subgroup of it. One such group consists of those still at work or in school. In England and Wales, some 70 percent of all blind people, and some 80 percent of all those newly registered as blind each year, are above the normal retiring age of 65. The results of our Optacon trials, and the subjective judgments of most experienced teachers of braille, would suggest, however, that even the remaining 30 percent or so cannot be seem as homogeneous.

Apart from the varied purposes which reading has to serve for them and the differing proportions it takes up of each day's work or recreation, there is the inescapable fact that the facility for picking up information by tactual means is not shared out equally. People vary in their tactual sensitivity, and the mere restatement of the long-established findings that practice can bring about a significant lowering of sensory thresholds (e.g., Volkmann, 1858, and Dresslar, 1894) does not mean that we can all eventually reach the same high level of tactual sensitivity. Even within our small group of Optacon volunteers, there was a sufficiently wide variation in tactual ability for this to be associated with a parallel variation in Optacon reading; or, put another way, the task confronting them required the exercise at the highest level of their capacity to process information reaching them through their sense of touch. It follows that all tactile devices, even if not intended for use by the elderly, must have outputs of optimum clarity, stability, and size. To make these demands more than the trivial restatement of the obvious, we must add some such criterion as that 90 percent of the target group should, after x hours of training and practice, reach a reading rate on material of a specified kind of y words per minute. Building these conditions into the design will make it clear that a good deal of empirical testing is going to be necessary before the device is marketed; that the target group will be known before, and not after, the hopes of the whole blind population have been raised; and that educationists, psychologists, and blind users are involved in the design alongside the engineers right from the beginning.

Although in danger of seeming to labor this last point unduly, we would argue that the processing of tactile stimuli brings into operation factors such as short-term memory capacity, letter and word synthesis skills, the use of contextual cues related to syntax and meaning, previous learning, and current motivation. The importance of these variables probably changes as the readability of the output changes, with greater demands being made upon these capacities as the clarity of the stimuli falls away from some optimum level. Our finding of a significant correlation between Optacon reading rate and short-term memory span suggests that with letter-by-letter presentation of an unstable image (unstable because of the vibrating nature of the stimulus and the distortions produced by fluctuations in the reader's fine-motor coordination), the reader is having to hold information in store while locating, identifying, and integrating the additional information needed to bring about correct labeling of the whole word or phrase. If this is to be the general nature of tactile reading machines, we shall have to be prepared to define the target population with greater specificity so that hopes are not raised unduly high, and so that realistic estimates of the required training periods can be made. The learning of braille--indeed of ink-print reading--is a very lengthy process and it seems likely that expertise with devices like the Optacon will take just as long to develop. The design teams working on such machines will be anxious to take account of these human factors, and it will be incumbent on financial sponsors to ensure that applications for support are backed by evidence that the team has its complement of engineers, psychologists, and educationists, together with assured access to blind volunteers from the specified target group.

In taking it for granted that no one device is going to be the panacea for all the reading needs of the blind, and on the assumption that both tactile and acoustic outputs are to be made available in what we would conceive of as an array or battery of alternative instruments, the desirability of a braille output should need little urging. Braille has the great advantage that it is a reading and a writing code. Those already expert in it have good grounds for asking that attention be devoted to the production of a braille machine, at least for use in schools, libraries, and offices, that would give them immediate access to printed materials. While a Grade 2 output should be the long-term aim, there is some evidence (Tobin and Lorimer, in preparation) that even Grade 1 braille would permit reading speeds at rates useful for many purposes, with the added advantage that no extended period of learning would be required. A device of this kind, particularly using page embossing rather than paper tape, could also form the basis of a small-scale, braille printing unit, either by being used to produce multiple copies or by being placed alongside the standard Thermoform Braille Duplicator. Work on the Transicon, which incorporates some of these features, is now in hand in Israel, in Great Britain, and elsewhere. There are also teams working on braille outputs, input generally being indirect, from typewriter keyboards and magnetic tape, rather than directly and immediately from an optical character recognition system as is the case with the Transicon. Again, however, one asks whether there is sufficient awareness that some of the problems to be faced by the user could be anticipated by recognizing from the beginning that the task is only partly within the province of the engineer.

If these points are not borne in mind, we shall have to admit that reading machines are going to be peripheral aids, useful where speed is of no great consequence (as when identifying incoming mail from the tax-collector); valuable where no other help is available (as in scanning the contents list of a book when no sighted helper is at hand); pleasant when the aim is recreation (a few pages of a novel each day). However, when the gathering of information is more regular, more urgent, and more extensive, then the problem and its mode of solution is of a different kind. The users' needs and situation will dictate the appropriate output. Optimal efficiency will require that attention be paid to their differing cognitive and perceptual skills. In insisting on this more precise definition of the target groups, with the concomitant that this can be done only by a multidisciplinary team, we would argue that this is the surest way of obtaining products that can meet their specifications in human terms as well as in engineering terms.

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COMMENTS ON THE TOBIN AND JAMES PAPER, "EVALUATING THE OPTACON: GENERAL REFLECTIONS ON READING MACHINES FOR THE BLIND"

James C. Bliss*

The St. Dunstan's/RNIB subcommittee deserves considerable praise for their leadership in undertaking an evaluation of the Optacon at an early stage in its distribution. They are also to be commended for conducting this evaluation in an expeditious manner, making the results available within a year after delivery of the first Optacons to the UK. These results have added considerably to our store of Optacon-related knowledge.

During the year in which the evaluation was in progress, several additional evaluations were initiated in other countries. There are over 500 Optacons in the field, and results are now becoming available from these evaluations and field experiences. The comments below on various aspects of the Tobin and James paper are intended to place their evaluation in the context of the much greater experience throughout Europe and America. Tobin's evaluation project had at its disposal 12 Optacons which had to be time-shared among more than 30 blind people. This constraint seriously limits the firmness of conclusions that can be drawn from the results. It is necessary, therefore, to complement the findings of the British evaluation with experience elsewhere to obtain a truer picture.

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LIMITATIONS IMPOSED BY CONDITIONS OF THE STUDY

To understand why several conclusions reached by Tobin and James are in contradiction with experiences from other parts of the world, the procedures used in the evaluation should be examined. A crucial ingredient in any Optacon program is the training, and Tobin and James' training procedures were unusual in several respects. Two training manuals were used: an early version of the TSI Stage I Manual, and an alternative teaching manual prepared by Tobin's group. However, the TSI teaching method was *not* used, especially in the length of time instruction was provided. A TSI training course is composed of approximately 50 hours of private instruction. Tobin and James' subjects received only 10 hours of training before the dependent variables, which are the major results of the study, were measured. This very short training period compromises the validity of their results.

The choice of dependent variables is also open to question. As determined by a survey conducted by the American Foundation for the Blind[1] of over 100 Optacon users, a majority of users do not feel that reading speed is the most important factor in use of the Optacon. Factors such as accessibility of printed information, accuracy, independence, and privacy are often more highly valued. However, the dependent variable used by Tobin and James was reading speed alone, without taking into account these other factors. Fortunately, the much larger study done in the United States by the American Institutes for Research[2] (AIR) did measure reading accuracy.

Another important characteristic of the British evaluation was the degree to which the conditions of the study motivated the subjects to succeed with the Optacon. It has been long recognized that learning the use of the Optacon, like learning a foreign language or other language code, requires a great deal of motivation and personal commitment on the part of the student. Motivation and commitment are more easily obtained if the subject can see some value to him as a consequence. In the case of the Optacon, we have observed significant attitudinal differences, with concomitant performance differences, when blind people were assured of access to an Optacon after training. Whether a blind person enters an Optacon training program believing that he is a guinea pig in an experiment or believing that he is learning a lifetime skill, useful in his educational and vocational development, has a large effect on performance. This point is clearly illustrated by a remark made to me by one of Tobin's subjects: "I don't want to become dependent on the Optacon because it might be taken away from me."

Thus, the British evaluation of the Optacon was severely limited in terms of duration, amount of available equipment, number of subjects, choice of dependent variables, and motivation of the subjects. The results should be viewed in this light.

RESULTS

While the reading rates obtained at the end of the initial training period may appear to many readers of this paper to be very low, one must keep in mind that the measurements were made after only ten hours of training. There is every reason to expect that, given a training of longer duration and subsequent practice, reading rates comparable to those found elsewhere would be achieved.

The correlations and profiles obtained may be very useful in identifying and assessing how prospective Optacon candidates will perform in the first ten hours of training. However, these results should be viewed only as tentative, especially since larger studies of longer duration are not in full agreement. For example, in the first year of the AIR study no significant correlation was found between braille reading speed and Optacon reading speed--one of Tobin's major findings.

FOLLOW-UP INVESTIGATIONS

The follow-up investigations demonstrated that some subjects could achieve speeds of 40 wpm even within the constraints of the study. These investigations were conducted at a time in which materials, techniques, and equipment for this stage of the learning process were not nearly as well developed as they are today. It is reasonable to expect that these new instructional techniques could especially help the slower readers in the group. This would tend to reduce the wide disparity in performance which Tobin and James report.

SUMMARY AND COMMENTS

Even though not based on the same type of scientific study as the rest of the paper, the summary and comments section of the Tobin and James paper will undoubtedly have a major impact on potential Optacon distribution plans in Great Britain. Indeed, whether or not the Optacon is made available to blind people in Great Britain may depend more on Tobin and James than on the desires, needs, and accomplishments of the blind people themselves. Therefore, it is important to examine the background and basis for their comments before accepting the major conclusions.

To decision makers within agencies for the blind the most important statement in the Tobin and James paper is: "Even the most successful learners felt that their reading speeds were not good enough for occupational purposes or, indeed, any purpose which entailed lengthy periods of reading." This statement is in contradiction with the evidence from studies and experience in other situations. For example, in an unsolicited letter reporting results from a field trial of the Optacon in Germany involving four times as many Optacons as were available to Tobin and James, observation No. 3 illustrates that the above comment by Tobin and James is not true in general. Other evidence indicates that it is not even the most common response.

ERUFSFORDERUNGSWERK HEIDELBERG

Trager: Stiftung Rehabilitation Heidelberg

June 21, 1973

Dr. M. J. Tobin
University of Birmingham
Birmingham, England

Dear Dr. Tobin:

We wish to thank you very much for your transmittal of your excellent report entitled "Print Reading for the Blind." At the same time we are sorry that we are not able to carry on our training and its evaluation on such a scientific basis, our conclusions are necessarily mainly of empirical nature, it would have been interesting to make exact comparisons with our groups of young adult trainees.

I would, however, like to make a few observations, which might interest you.

1. Our trainees feel that the recognition of upper-case letters is definitely easier. Our earlier groups have meanwhile read mainly computer print-out, i.e. capital letters, but I hope to find the time soon to make a test with the newest group, which, as yet, has not read much computer output.

2. We also found a wide divergence in performance, when reading speed is the criterion. Contrary to our expectations we found in our first group that among the slowest Optacon readers was the best (by far) braille reader; the best Optacon reader was the second slowest braille reader (the slowest had only learned braille a short time before). Explanation: the first student was a highly intelligent individualist who could not be convinced that he would need the Optacon in his vocational or private life, the motivation, which we consider to be extremely important, was missing; the other had been taught an inefficient braille reading method. In our second group the best braille reader also does best with the Optacon, well over 30 words within half a year, with possibility to practice limited due to our strenuous course of study.

3. Contrary to your findings the great majority of our people do not consider their Optacon reading too slow for use in work. Our trainees continually use their devices for their programs, we have heard the same thing from several of our graduates. Computer print-out is always the same type style, the layout, size and format are familiar to the programmer and the quality of print is relatively good if care is taken in the installation that the ribbon is changed before it is worn out. In addition, extreme reading speed is not the most important factor in "debugging," the program, if it is his own, is more or less familiar to the reader, the vocabulary is limited. All these factors apply to our field, certainly not to many other vocations or to students in school.

4. We were surprised by the short periods of time your subjects were able to read without tiring--our current best reader has told me that he has read four hours at a time without fatigue, though the average is probably around one hour at a time.

5. All of our students wanted to read without the tracking aid after the first trial.

Again many thanks for your report, we hope you will keep us on your mailing list for further results on your research.

Sincerely yours

s/s Michael Gottschalk

Michael Gottschalk

The AFB survey of over 100 Optacon users gives evidence of the utility of the Optacon for occupational purposes, and purposes which entail lengthy periods of reading. Again, the constraints of inadequate training, small sample, short duration, and lack of incentives for their subjects seem to have led Tobin and James to an erroneous conclusion of major importance. This conclusion seems to be based on the comments of a few individuals rather than any scientific data.

Tobin and James go from one extreme of an inadequate ten hours of training to the other extreme of considering "that nothing shorter than three months of supervised, daily practice with carefully structured and graded materials would be sufficient." This comment appears to be based on the concept of "training to some 'useful' criterion," a concept which assumes that a "useful" criteria can be specified in general, and that supervised, daily practice is required until the criterion is reached. The first of these assumptions is an oversimplification. There is no absolute criterion of "useful" reading performance. What is useful to one person is inadequate for another, depending on the desires, needs, and alternative methods of information access that are available. The second assumption is incorrect, because Optacon readers continue to increase their reading rates for more than a year after leaving a training course. This increase is accomplished without "supervised, daily practice." Not only is this three months of supervised training unnecessary, it would be an inefficient allocation of manpower. Three months appears to be an untested and arbitrary period specified by Tobin and James, and other "educationists and psychologists" are certain to disagree on the appropriateness of this training duration.

Tobin and James seem to advocate additional control over the blind by their proposal to make entry to training "on a selective basis" and continuation of training "contingent on attainment of prescribed levels of proficiency at intermediate stages of the course." This suggestion implies that achieving these arbitrary proficiency levels has a value to society more important than the individual's needs. Tobin and James' proposal would be a blow to the cause of freedom of choice and independence for the blind. Their approach also assumes that blind people themselves, when given full information, are not able to decide whether or not a given performance level is "useful." Tobin and James would substitute the dictates of the "educationist and psychologist" for consumerism and market evaluation.

COMMENTS ON PART 2

In this section of the paper, Tobin and James espouse their philosophy of how research on reading machines should be managed and how services to the blind should be delivered. In their view, the approach should be: 1) to define the target population, 2) to define the "useful" criterion and 3) to harness current technology to obtain a design which permits the target population to achieve the "useful" criterion. There are many pitfalls in this approach, as we have already seen in the above discussion on the concept of "useful" criterion. This approach also fails to take into account the limitations of current technology, the cost/benefit relations, interactions with societal and technological changes affecting the situation, the urgency of the need, the costs associated with delay, and the advantages of pursuing alternative solutions in parallel.

A good example of how far afield this approach can lead is implied in Tobin and James' own arguments. They seem to urge that, instead of making Optacons available for adults, a multidisciplinary team should be formed to develop a spoken word or braille output reading machine which permits a target population of over 65 years of age to read at rates over 100 words-per-minute. While such goals are commendable, this approach will run aground as soon as realistic budgets are made for expenditures and development time, taking into account the performance specifications desired by the "psychologists and educationists." In addition, distribution and service costs will be enormous for such complex equipment. While this project is being pursued, many blind people will be deprived of a useful tool, such as the Optacon, during the most productive years of their lives.

Moreover, Tobin and James assume that the optimum path of scientific development toward "products that can meet their specifications in human as well as engineering terms" can be determined in advance (presumably by psychologists and educationists) instead of by the consumers after working models are available.

In defense of the process by which the Optacon was developed, a careful reading of the Optacon-related bibliography will clearly illustrate that the Optacon team was truly multidisciplinary. There are many more published papers related to the Optacon in referred psychological journals than for any other sensory aid for the blind. Many more blind users were directly involved in the development of the Optacon than for any other sensory aid for the blind. These factors greatly influenced the form and function of the current model, which helps to explain why it has met such widespread acceptance among blind people. Fortunately, these blind people were not influenced by the tactics of a few psychologists and educationists who seem to be trying to establish their authority over research funding in the field and to limit the freedom and independence of blind people. This point has been best stated by a blind person who wrote the following letter after reading the report on which the Tobin and James paper was based:

THE OPTACON

> Sir: I was appalled by certain aspects of your June editorial on the Optacon. It shows a patronising attitude, regarding publicity for the Optacon as undesirable except to the extent that it can be controlled by those who regard the blind as incapable of judging such matters for themselves if they are presented with all the facts. The first Optacon news letter was published in America in November 1970, the second in November 1971 and the third in November 1972. I now have copies of all these, which show clearly the extent to which the matter has been hushed up in this country. Even over the last few months, too little publicity has been given, particularly to its use abroad, and there has been too great a tendency to damn the Optacon with faint praise.
>
> In other countries, emphasis tends to be on the practical business of trying to get Optacons into the hands of those who can best make use of them. This country has had trials which seem to lack any sense of purpose, much less the urgency that such an undertaking should demand. At university I was not impressed by trendy sociological jargon when applied to my subjects: much less am I impressed when it is applied to the Optacon, which should be a matter of plain common sense and practical action.
>
> In one area in particular, which is of special interest to me, the case in favour of the Optacon is overwhelming: I refer to computer programming. There is a great deal of evidence for this from America and Germany. I have on my desk before me at this moment a letter from a blind programmer in America who has replied to my request for a personal assessment of the Optacon in his work: no one could be more enthusiastic.
>
> The most disturbing part of your editorial is the news that these endless trials are to continue for another year. We should long be past the stage of asking whether the Optacon is of use, and into the stage of seeing that those who can use them get them. It is nonsense to suggest that we must forget this till the cost comes down. If it can be done in other countries, it can be done here. It should be financed by the Government and organisations of and for the blind should be pressing for this to be done at once. I am very much encouraged that the British Computer Association of the Blind has now adopted such a policy. It is also urgently necessary that the best possible training should be immediately available to anyone who is able to get an Optacon through his own resources or from an employer.
>
> If matters are allowed to drag on as at present for much longer it will be regarded in years to come as one of the worst examples of the paralysing lack of imagination that has been such an obstacle to the progress of the blind in this country.
>
> Balerno, Midlothian****John Newing

Published in *The New Beacon*, Journal of Blind Welfare, July 1973, by the Royal National Institute for the Blind, London, England.

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AN EXPERIMENTAL ONE-HAND OPTACON

Harry Garland*

BACKGROUND

Ten years ago research began at Stanford University on the development of a reading aid for the blind. This research, under the direction of Dr. John Linvill, was aimed at developing a machine capable of converting ordinary printed material into a readable tactile image. While machines built early in the course of the research demonstrated the feasibility of this idea, these early machines were very clumsy and would have been impractical to produce in quantity. As research continued, however, the reading machine became increasingly more refined until, in 1971, a portable machine was built that was suitable for production. This reading machine, known as the Optacon, is currently being used by blind people in over a dozen countries throughout the world.

Research in the disciplines of psychophysics and solid-state engineering was crucial to the development of the Optacon. Research in psychophysics generated new knowledge of the mechanisms of tactual reading and pointed toward improved designs for the Optacon. Research in solid-state engineering, on the other hand, made possible the realization of these designs in a compact, producible form. Even as the Optacon is now being produced, research in these areas is continuing at Stanford in order to find ways of making the Optacon an even more effective aid for the blind. As a result of this continuing research, a new design for the Optacon has been proposed (Linvill, 1973).

The most striking difference between the current Optacon and the proposed Optacon is that the new machine will require just one hand for operation. In using the current machine, a small sensor is moved over a printed line with one hand while a tactile display is felt with the index finger of the opposite hand. The proposed "one-hand" Optacon, however, will contain the sensor and tactile display in a single, hand-held unit. As this unit is moved along a printed line with one hand, the index finger of the very same hand will receive the tactile impressions.

PSYCHOPHYSICAL CONSIDERATIONS

The idea for the one-hand Optacon was motivated, in part, by psychophysical considerations. Several experiments have shown that information about movement of a receptor surface can be very important in perception. For example, information available to the brain about movement of the eyes is known to play an important role in visual perception (Merton, 1964). (If the brain is deprived of this information, movement of the eyes results in the illusion of movement of the visual field.) An experiment has been carried out that suggests that information about movement of the Optacon sensor plays a similarly important role in Optacon reading (Garland, 1973). It is known that the two hemispheres of the brain can act quite independently, and that information is often transferred more effectively

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within a given hemisphere than it is between hemispheres. If information about movement is indeed important in Optacon reading, a one-hand Optacon might be more effective than the current Optacon, since with this new machine both tactual information and motor information would project to the same hemisphere of the brain.

In order to establish whether or not the proposed one-hand machine would in fact be more effective than the current Optacon, an experimental version of the one-hand machine was built and evaluated. The experimental one-hand machine was built by mounting a special tactile array, with the same 144-pin configuration as the current array, on top of a current model R1B Optacon camera. This assembly, shown in Fig. 1, weighed 250 grams and stood 7.5 cm high. The electronic circuitry for the one-hand unit was housed separately, and connected to the one-hand assembly by means of flexible cables.

EVALUATION

Three college-age blind students, all experienced in the use of the current "two-hand" Optacon, participated in the evaluation of the experimental one-hand Optacon. All three subjects rapidly adapted to the one-hand

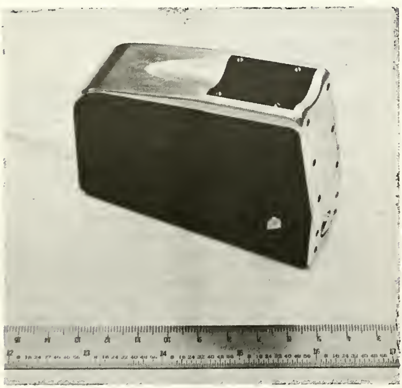

Figure 1. The Experimental One-Hand Optacon

machine, each reaching his two-hand Optacon reading speed after an average of less than four hours of practice. It is interesting that all three subjects strongly preferred using the machine with the left hand, finding it much more difficult to read using the right hand. When a subject attempted to read with the right hand, he had the impression that the letters were going "backwards" across the fingertip. A similar result has been reported for braille readers who rely exclusively upon one hand (Critchley, 1953). These readers may explain their difficulty in reading braille with the other hand by saying that all the characters seem to be reversed. All three of our subjects had a great deal of experience in reading with the current Optacon in which each used his left hand to feel the tactile array. Whether this prior experience fully explains the superiority of the left hand with the new Optacon or whether the left hand is inherently superior at this task, we do not yet know.

Only one of the three subjects was able to spend an extended amount of time practicing with the experimental one-hand machine. Her progress was measured regularly by testing her reading speed on short passages taken from *Reader's Digest.* The subject was asked to read three such passages for each test, and her median reading rate was taken as her score. Prior to her introduction to the one-hand machine, the reading speed of this subject was measured in this same way with the conventional two-hand Optacon and found to average 54.3 wpm (standard deviation = 5.7 wpm). The results of the one-hand reading tests are shown in a graph in Fig. 2. After just 15 hours of practice, this subject could read consistently between 70 and 80 wpm with the simulated one-hand machine.

In order to assure that the superior performance with the one-hand machine was not unduly influenced by recency of practice, after the subject had completed 35 hours of practice with the one-hand machine three weeks were allowed to elapse during which the subject did not use the one-hand machine at all. During this time the subject used her two-hand Optacon extensively in preparing a written report. During the week following this three-week period the subject used

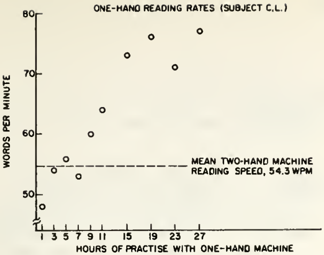

Figure 2. Reading Rates with the Experimental One-Hand Optacon

her two-hand Optacon and the one-hand Optacon for approximately equal amounts of time. At the end of this week a test was run to compare one-hand and two-hand reading speeds. At this point the subject had used the one-hand machine for a total of 40 hours over a period of 3 months. By removing the R1B Optacon camera from the one-hand assembly, the same camera, electronics, and tactile array were used for the two-hand reading speed measurements as for the one-hand measurements. By using the equipment in this way, any performance differences under the two experimental conditions could not be attributed to subtle differences in the operation of the hardware. Fourteen short passages from *Reader's Digest* were read for this test, alternating at random between the one-hand and two-hand Optacon configuration. The median reading speed for the two-hand configuration was 55 wpm. The median reading speed for the one-hand configuration was 81 wpm. The difference in results between the two experimental conditions was statistically significant (Rank-Sum Test $p < 0.005$).

RESULTS

The results of this evaluation of the experimental one-hand Optacon are very encouraging. We have seen that people experienced in the use of the two-hand Optacon readily adapt to the one-hand configuration, and we have seen one reader significantly exceed her two-hand reading speed with the one-hand machine. A further advantage of the one-hand machine is that it frees one hand for other tasks during reading. In fact, a recent independent evaluation of the Optacon has recommended that research proceed on a one-hand Optacon in order to free one hand for holding reading material (De Benedictis, 1973).

In view of the encouraging results with the experimental one-hand Optacon, plans have now been formulated for a completely self-contained one-hand Optacon (Melen, 1973). A substantial amount of research will be required, however, before such a machine can be built. Over 500 cubic centimeters are required for the electronics of the current Optacon, yet only a few cubic centimeters will be available for the electronics of the self-contained one-hand Optacon. The electronics can be reduced to this size only through the use of the most advanced integrated-circuit technology. Once funding is received, several years will be required to develop the necessary integrated circuits. The final one-hand Optacon built with these integrated circuits could easily fit into a shirt pocket or a purse and will, we believe, provide the blind with a new convenience in reading ordinary printed material.

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THE AUTOMATIC TRANSCRIPTION OF FRENCH INK PRINT INTO BRAILLE

Monique Truquet*

INTRODUCTION

In France at the moment ink print to braille transcription is done either with stylus and slate or by a semiautomatic process, by linking a braillewriter to an embossing device. Very often the text is transcribed first and then recopied on an embosser, allowing the creation of a zinc plate master.

A few schools for the handicapped use another method which consists in hardening braille pages embossed on cardboard and using these as matrices, in the Espinasse method, in a duplicator press for copies on paper of 150 to 180 gram- (5.3- to 8.3-ounce) weight. This allows braille texts to be obtained at a reasonable price. The technique does not allow many copies to be made, therefore a zinc matrix method is preferred but at greater cost. There are, therefore, few books transcribed.

These are among the reasons why M. Mendels (President of the Association for the Protection of Handicapped Children) and M. Espitallier (Professor of Braille) asked the Information Laboratory at Toulouse to devise a transcription program; I was charged with the task.

THE FRENCH BRAILLE SYSTEM

The French braille system is comprised of two forms: letter-by-letter (or uncontracted), and contracted.

Uncontracted Braille

When this work was undertaken, the Faculty of Sciences at Toulouse had at its disposal only an IBM 7044, for which the card input was generated on a Model 026. The card punch keyboard had only letters from A to Z, numbers from 0 to 9, and some punctuation marks (point, comma, dash, slash). It was thus necessary to code letters with accent marks and the following punctuation marks: semicolon; exclamation point; question mark; colon; quotation marks; etc.

It is no hardship for a sighted person to read a text in capital letters, without accents, since he recognizes words in the context of phrases. The nonsighted read sentences word by word. Words are read in an analytical way, and comprehension occurs through integration. For example, suppose a nonsighted reader encounters the word GENERATION written without an accent. The syllables encountered are GE and NE, and since no word starts in this way, reading becomes impossible. In contrast, if accents are marked, it is the group of syllables GÉNÉ which is read--and many words begin like that: GÉNÉTIQUE, GÉNÉRER, GÉNÉRATION, etc. The selection of the right word depends on encountering the letter R, and the contraction ATION allows for recognition of the word.

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Letters with accent marks facilitate reading, but in addition they are necessary to distinguish one word from another. Such is the case with MAÏS (maize); if the dieresis is omitted, the meaning is changed, and one confuses the word with MAIS (but).

Our objective, the programming of uncontracted braille text free of error was achieved by following the rules described below.

The letters missing on both the IBM 026 or the IBM 029 were encoded indirectly, using a number after the letter:

1 = accent grave

2 = accent acute

3 = circumflex

4 = dieresis.

Thus,

Ù is coded as U1

é is coded as E2

ë is coded as E4

Â is coded as A3

ï is coded as I4

The same coding method was used for the following punctuation:

; is coded as P1

? is coded as P2

! is coded as P3.

The semicolon is the most frequently used punctuation (as compared with the question mark or exclamation mark), so we followed the letter P (for Punctuation) with the number 1.

The signs specific to braille had to be coded; that is, signs for capitals, beginning of italics, beginning of a title, etc. Admittedly this system of coding interfered with the transcription of numbers; we had to impose a minor constraint on the typist, that of preceding the beginning of a number by a space. These rules should be followed in order to prepare a high-quality uncontracted braille text:

1. A title or number of a chapter should be centered on the line, and followed by a blank line.

2. The text should begin with a capital in the third space of the line.

3. Pagination begins with the second page and is preceded by at least two blank spaces.

4. If a word cannot be contained on a line, it must be begun on the following line, and replaced by blank spaces, unless it contains a double consonant, in which case the first consonant is followed by a hyphen, and the second consonant is then followed by the characters which are set on the following line. In addition, this splitting of words cannot be done if the first part is on the last line of a page; that is, on the 23rd line, because we have chosen the standard format of 23 lines and 31 characters per line.

5. Several blank cells in the middle of a braille line are prohibited, so their correction has to be anticipated.

6. The program suppresses also a blank space preceding a puncutation (since that is an error in braille), and adds it after a puncutation if a typist forgot it.

7. A blank space at the beginning of the line is suppressed and the hyphen changing a speaker is placed in the third space. In addition, the program permits the insertion or erasure of words or phrases without having to retype the cards which follow it.

These automatic corrections permit the typist to enter the text without major constraints.

The sentence, C'est l'été; évidemment il fait chaud. (It is Summer; naturally the weather is warm.), can be written according to four codes:

First coding: C'EST L'E2TE2P1E2VIDEMMENT IL FAIT CHAUD

Second coding: C'EST L'E2TE2 P1E2VIDEMMENT IL FAIT CHAUD

Third coding: C'EST L'E2TE2 P1 E2VIDEMMENT IL FAIT CHAUD

Fourth coding: C'EST L'E2TE2P1 E2VIDEMMENT IL FAIT CHAUD

As we shall see later, in the case of contracted braille, only the first and fourth codings are allowed.

The formatting of braille text is facilitated by using certain codings which permit the executive program to call up subprograms. The code designation L1 calls up the subprogram to skip a line when the author does so in the text. The code L2 calls up the subprogram to change a page when a new chapter appears. The code L3 calls up the subprogram which allows the chapter heading or the chapter number to be centered. All these codes permit the typist to enter characters one after the other without being preoccupied with the presentation of the braille text.

Contracted Braille

This is more complex than uncontracted braille. It comprises 46 expressions or phrases, 2000 words already contracted because they follow no rule, and 120 contractions or groups of letters obeying precise rules.

Expressions. These are presented in the following form: "La plupart" (For the most part), "pour ainsi dire" (so to speak), "c'est-à-dire" (that is to say), and "par conseqúent (consequently), etc. It is the grouping "la plupart" which is transcribed, and not "la" (the), then "plupart" (most). The recognition of these phrases causes the running of a branch, starting with the heading "L" up to the terminator, unless in the course of the test the conditions are not met for fulfilling the recognition, in which case the article "la" (the) is retained by itself, and searching is begun in the table of 2000 words.

The 2000 words. These are placed in a table, with the aid of a method developed by Hashing. One makes a sum of modulo N of the internal codes of all the letters of the word. The configuration obtained gives access to a subtable which contains the addresses beginning the different synonyms in the table of 2000 words. It is a table of half words and half characters and occupies 10K machine words. We have opted for this configuration because we found that the majority of ordinary words contracted in this table are formed of 12 characters, and it is not possible to replace each character by a machine word; the volume of the table would be too large.

To distinguish the expressions from the words we have utilized a syntax analyzer, in the form of a list. This permits, in addition, the recognition of punctuation, numbers, and special signs. If a word is neither recognized among the expressions, nor in the Hashing table, the program looks to see whether the word does not possess groups of letters called contractions.

Contractions. There are 86 contractions, but considering all the special cases, there are actually 120. Certain of these contractions cannot be utilized in the beginning of words, like ER or ION, but must appear before consonants or in terminations. Others are to be found in the beginning of words, as in RECOM, REDIS, COM, DIS, TRANS, INES, and in addition these must be placed before a consonant; the latter is also the case for EM, EX, UI; before a consonant or terminator like EN or IEN. IEN has, in addition, the following exception: it can be contracted at the end of a word only when it is not followed by a period. IENT is contracted as IEN-T in "client," and I-ENT in verbs in the first group in IER. Some contractions appear before a vowel, as in BL, CONCR, CR, GL, GR, PL. . . BL cannot be followed by EU, but can be followed by EUE, or EUS, or EUES. There are those contained between two vowels, as *ss*, *ll*, or *tt*. In addition, *tt* cannot be before "-ement," and *ss* before "è." There are 58 at the end of words, counting plurals, such as: ABLE, ABLEMENT, BILITÉ, ITION, LOGIE, etc. There are, however, eight contractions which are transcribed under all circumstances, these are IEU, OI, AI, AU, CH, EU, GN, and OU.

Some of these "contractions," as we have seen, contain some exceptions.

That is also the case for BR, which is not transcribed when it is found before UI; CON when it is found before CR; and DR when it is found before Ô, or before ANT. Consequently we have considered BRUI, CONCR, DRÔ, DRANT, etc., as contractions; these are, therefore, already transcribed in the table of contractions, thus avoiding many errors.

Let us take the example of BRUI: the contraction BR and the contraction UI are represented by the same braille character (dots 2 and 3). Since two braille signs of the same value cannot be next to each other, the rule requires that the contraction can be done only as it occurs the second time. That is to say, BRUIRE, instead of writing it as BR UI R E would be written B R UI RE.

It should not be forgotten that the permutation of six dots gives only 64 combinations, counting the blank cell, and the same braille character can represent at the same time several contractions, as well as a word or a character. This is the case for the following braille character: dots 1, 4 and 6 represents AIT if it terminates a word, CL if it is before a vowel, and CET if it is a word.

Program Operation

The syntactic analyzer has the responsibility of recognizing the expressions, words, punctuations, special signs, and numbers. If an expression or a word is recognized, the equivalent braille will be then placed in a braille line, up to the total of 31 characters. At this time, the braille is tested, any consecutive blank spaces are corrected, and when the braille is justified, the three lines of embossing which will constitute the braille line are prepared, then embossed. When neither an expression nor a word are recognized, the program sees whether they are formed of contractions, and whether they respond to the proposed rules.

I described the method permitting the isolation of contractions at a symposium at Münster (GDR) in March, 1973. This method has the aim of referring in the first instance to the longest contractions. These are comprised usually of contractions containing exceptions, and it is important to recognize these in the beginning of a test sequence. When a word is formed with no contraction, it is transcribed character by character. In reality, one tests characters two by two, because of accented letters and special signs. As "pénurie" (poverty) has as a coded form PE2NURIE, it contains no contraction. It is therefore transcribed character by character, and is recognized as group E2, and presented in braille accordingly:

●●	●●	●●	●○	●○	○●	●○
●○	●●	○●	○○	●●	●○	○●
●○	●●	●○	●●	●○	○○	○○
P	É	N	U	R	I	E

or

E2

TABLE 1

Codes

Codes	Ink Print
A1	à
A3	â
A4	ä
A6	ae
C5	ç
E1	è
E2	é
E3	ê
E4	ë
I3	î
I4	ï
O3	ô
P3	!
P4	period placed after the initial of a forename

TABLE 1 (Continued)

Codes	Ink Print
P7	%
D1	beginning of a title
D2	beginning of a subtitle
D3	beginning of a hyphen for an expression between hyphens
D4	beginning of italics
F1	end of title
F2	end of subtitle
F3	end of hyphen for an expression between hyphens
O6	oe
U1	ù
U3	û
U4	ü
D5	:
D6	d°
G1	<<
G2	>>
P1	;
P2	?
F4	end of italics
M1	capital
T1	hyphen changing the speaker
V1	end of verse
X1] X2]	all the characters contained between these two codes are ignored
*(	beginning of uncontracted text
)*	end of uncontracted text
L1	change of line
L2	change of page
L3	centering

Of all the codes, only :, ;, and % are found on all IBM 029 machines; but it will be enough to create a keyboard to eliminate the need for all but a very few codes.

The program of transcription in contracted braille also permits the formatting of a page. The presentation of the text in contracted braille differs from a text in uncontracted braille. A contracted text too begins in the third space, but is not preceded by a capital character. A title is always in letter-by-letter braille, and a break in words is handled differently. A word which is letter by letter in a contracted text is always preceded by a braille sign for letter by letter, unless that word is a proper name, in which case it is preceded by a capital sign. In uncontracted braille, we have seen that the program corrects blank spaces that are found before punctuation. In the case of contracted braille, this is impossible because many words or articles have the same braille value as certain punctuations. Thus, ? and EN have the same braille value (dots 2 and 6). The apostrophe and LA have the same braille value (dot 3). Therefore, a text which is to be transcribed into contracted braille requires more attention on the part of the typist than when it is to be transcribed into uncontracted braille.

The texts that we have obtained in contracted braille have brought us face to face with ambiguities that we had not anticipated, and which are often difficult to program. Take for instance the following verbal form: CONVIENT. This could be a form of the verb "convier" (invite), or the verb "convenir" (to agree), and the braille transcription is not the same in the two cases.

We are confronted with homonyms. French musical notes are such a case. Thus, one does not transcribe in braille the note re and the Isle of Ré; the note mi and the invariant MI meaning "half"; the note sol and the word SOL (ground); the note la and the article LA (the); and the note si and the conjunction or adverb SI (if).

In French there are also other peculiarities: the same verb put in the infinitive, for example, is rendered differently according to whether it is isolated or preceded by an apostrophe.

Such is the case for the verb entrer (to enter), for in the phrase il faut entrer (entry is required) it would be written EN T R ER; whereas in another phrase, defense d'entrer (entry prohibited), it would be written D ' EN TR ER. It is, therefore, very difficult to obtain a text in contracted braille without error.

CONCLUSION

The programming was done on an IBM 7044 in FORTRAN AND MAP language. This program allowed us to obtain texts for students in sociology. At the moment, the program has been rewritten in basic FORTRAN for the IBM 360, which allows the possibility of utilizing IRIS 80, of the University of Paul Sabatier, or an IBM 360.

The results obtained by other countries--USA, Germany, England--with these methods give us hope for the future.

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A GRAPHIC ANALYSIS OF TOUCH TECHNIQUE SAFETY

Mark M. Uslan*
Paul Manning**

Within the field of orientation and mobility there exists the view that the inherent limitations of the cane and the inherent deficiencies of the scanning method of using the cane can only be minimized by the resourceful application of the blind user's ingenuity (Suterko, 1967). Thus, overcoming deficiencies of the "touch technique" is an art which only the resourceful blind person can master. Those who hold to this view would say that since there are degrees of resourcefulness, there are degrees of mastery of the touch technique. Yet one must not lose track of the role of the peripatologist. It is his job to create impetus in learning touch technique; and it is also his job to reduce the limitations of the cane as a tool, and the deficiencies of the scanning method. The user is the dependent variable, but neither the cane nor the method are unvarying constants.

The touch technique is a systematic procedure for using the long cane in safe and efficient travel for blind persons. Its proper use involves the mastery of some basic technique. The dominant hand must be in the center of the body with the index finger pointing straight down along the cane. The wrist is pivoted so that the tip of the cane describes an arc in front of the user, touching the ground lightly on each side. As it describes the arc, the tip should just clear the ground so that low protruding objects may be detected. The arc must be equidistant from the center on both sides, to allow for proper coverage of the entire body. The cane tip is moved in a rhythmic motion across the body in step with the feet so that when the left foot steps forward, the cane makes its arc to the right, and when the right foot steps forward, the cane makes its arc to the left.

When this technique is mastered, many travelers still continue to collide with objects. Few mobility instructors will dispute that even when executed properly, basic touch technique is not 100 percent safe. Yet most will say that the margin of safety in basic cane technique is still acceptable. But the question of safety cannot be resolved until the touch technique is rigorously analyzed. Should not the instructor strive for 100 percent safety for as large a proportion of the blind population as possible?

The vicious cycle that keeps the poor mobility student from achieving his optimum potential is caused too often by the fear of traveling unsafely. To halt the cycle the instructor strives to instill confidence. The most reassuring way of doing so is to ensure safety-enhancing technique and combine it with adequate execution, good judgment, and short reaction latencies. The instructor must know what safe technique consists of; and he must be able to teach the technique without causing frustration and resentment. Fast reaction and

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the exercise of good judgment are most often learned with practice.

It is our purpose to scrutinize aspects of safety in touch technique and execution of the touch technique by defining crucial variables and proposing modifications in existing technique. Once an optimally safe technique is established, it is possible to improve training in its practice by using monitoring devices to give the traveler and his instructor appropriate information on deviations from an individual's optimum cane technique.

ANALYSIS OF EXISTING TECHNIQUE

A safety analysis of touch technique is composed of two parts: analyzing existing technique, and analyzing the execution of that technique. A complete analysis of existing technique entails the determination of relevant variables present, analyzing the variables, and suggesting corrective procedures.

Our analysis was aided by charting the path of the cane projected on the ground. Prior work has shown that the velocity of normal walking patterns closely approximates a constant (Murray, Drought, Bernard, and Kory, 1964). Hence, no effort was made to monitor an irregular walking speed. An irregular cane velocity was also ignored because an average of the path arcs created by an irregular cane velocity caused minimal distortion.

The crucial variables in touch technique, assuming perfect execution, are cane length, the height of cane hand off the ground while the cane is in operation, and step length or stride. The length of the projection of the cane on the ground (R) is controlled by the length of the cane (CL) and the height of the hand off the ground (H). Therefore $R^2 = (CL)^2 - H^2$. Stride governs the size of unprotected areas of vulnerability if cane length and height of hand remain constant. Areas of no protection increase in size as stride increases. In this analysis the distance from the cane hand to the body is not a variable affecting the size of unprotected areas because the graphs are designed to treat the cane hand as a plane the same width as the body and parallel to it. If this plane is fully protected then the body behind this plane is protected. Lastly, the speed of the traveler is irrelevant as long as optimal touch technique is maintained at high speeds.

MODIFICATION OF EXISTING TECHNIQUE

Experimenting with different graph methods revealed the fact that touch technique can be modified to produce much better protection. The conventional technique of pivoting just the wrist, with the arm stationary, was found to be much less safe than swinging the forearm with minimal wrist action and pivoting from the elbow. When mapping conventional touch technique, we found that there are vast unprotected areas, equal on each side of the traveler, which cannot be eliminated. No mapping of results from canes of differing specifications resulted in significant reduction in areas of vulnerability. The advantages of the forearm swing are illustrated when graphs of identical specifications of step-size, height-of-hand-off-ground, and cane-length used with the conventional technique and a modified technique (using forearm swing) are compared (Figs. 1 and 2).* The drawback of a stationary forearm can be clearly illustrated: the unprotected area juts dangerously into the path of travel. Such comparisons were constructed for a wide range of different specifications of step-size, height-of-hand-off-ground, and cane-length. Our results showed consistently that swinging the arm significantly reduces areas of no protection. It should be remembered that these graphs assume perfect execution and hence, show the best possible coverage for the given cane specification.

A logical outgrowth of touch technique analysis is the compilation of a set of optimum values of the

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*In all graphs:
. = cane hand position, and
/ or \ = cane tip position.

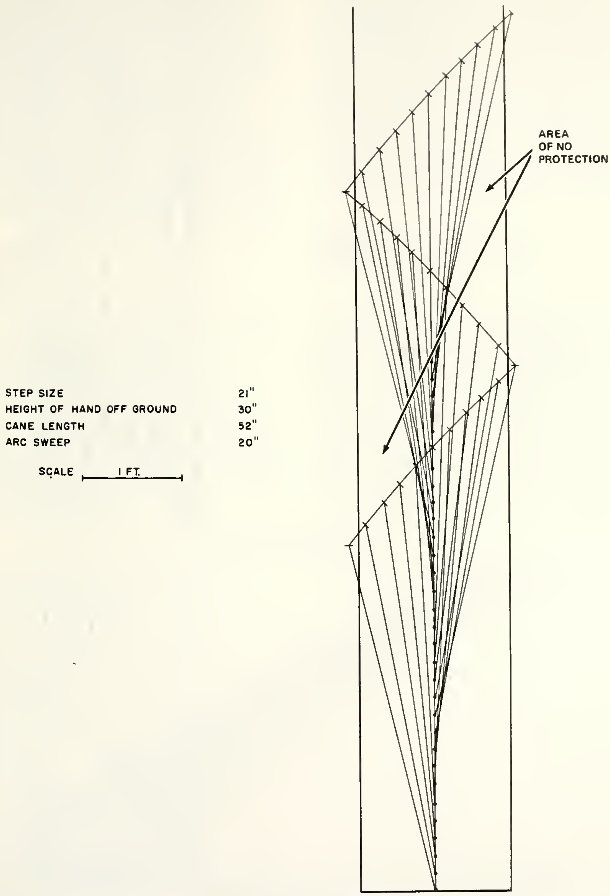

Figure 1. The Conventional Touch Technique (Wrist Pivot)

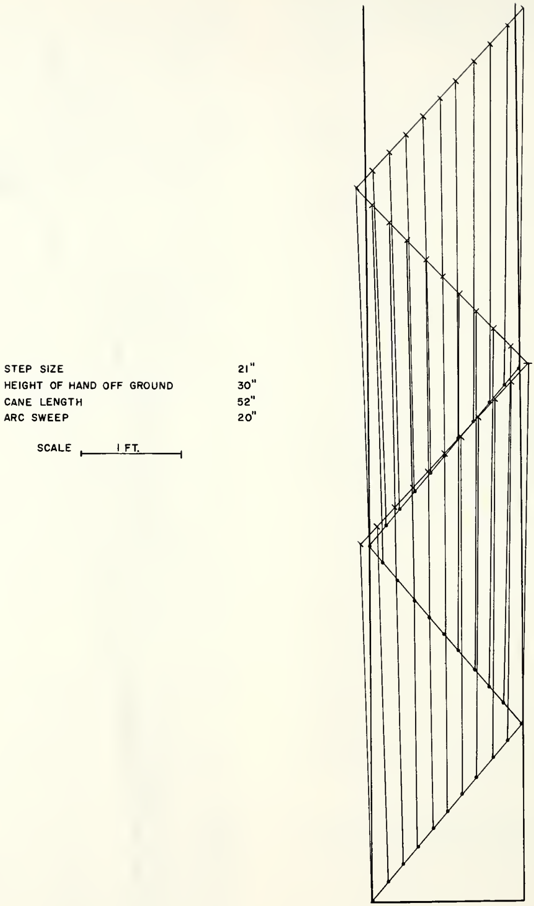

Figure 2. The Modified Technique (Forearm Swing)

variables for all individuals. A chart of such values was derived from numerous maps of several cane specifications; and an index was made from it (Fig. 3). The chart enhances the attainment of maximum safety and assumes perfect execution of cane technique. Thus, for an individual with a given height of cane hand from the ground and a given stride we are able to determine the proper cane length for safest travel. For example, a traveler with a 21-inch stride and a 30-inch height of hand from ground would travel most safely using a cane no shorter than 52 inches. Any body width is covered by the index as long as the cane tip hits the ground at least one inch outside shoulder width.

TOUCH TECHNIQUE EXECUTION AND MONITORING

The problem of poor execution of the touch technique begins when basic techniques are being learned. The importance placed on basic cane technique is underscored by the large blocks of time that are set aside by instructors for teaching it. When a student has difficulty learning basic techniques, the instruction time involved increases very rapidly. Under the pressures of reducing instruction time, some bad habits are often established, as basic techniques are learned. Actually the instructor can expect only a reasonable approximation of perfect touch technique execution. Moreover, perfection in learning basic methods is also compromised by the instructor's internal standard of what is acceptable, based on his perception of the student's ability. Typically the learning of basic technique is considered complete when a given time unit spent on instruction no longer results in improvement comparable to earlier stages. In other words, the law of diminishing returns affects the instructor's evaluation of an acceptable standard of basic technique execution.

SUGGESTIONS FOR IMPROVING EXECUTION OF BASIC TECHNIQUE

Perhaps the optimum aid to swift and accurate learning of basic technique is to monitor mobility behavior and attempt to shape it using simultaneous feedback. A practical and self-contained electronic monitor in synchrony of step and cane tip arcuate motion is now possible. Arc width monitoring and stride monitoring are more complex, but are certainly possible. Monitoring might allow large variances at the outset of training, and gradually narrow the range of

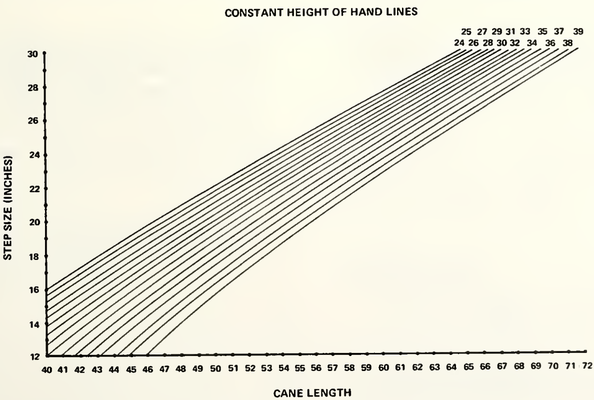

Figure 3. Safety Index

acceptable performance as instruction proceeds. The use of variable control monitoring devices to shape behavior implies a minimum of instructor interference. The level of student frustration directed toward the instructor would be reduced since perception of proper execution is left to the monitor-user system. Basic technique would be learned in a context of safety-oriented behavior, not on what seems acceptable according to the instructor's perception of individual ability. Spot checking basic cane technique safety during the latter stages of mobility training could then concentrate on extinguishing poor habits acquired after the learning of basic technique. In sum, future work might be directed with profit toward the feasibility of using electronic monitors to enhance the learning of optimally "safe" cane technique.

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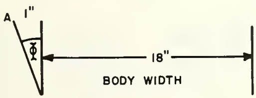
A Graphic Analysis of Touch Technique Safety

The following is a discussion of the method used to chart the path of the cane. All numbers are in reference to Fig. 5.

Let R be the length of the cane projected on the ground. Let (CL) be the cane length and let H be the height of the cane hand off the ground. Therefore, $R^2 = (CL)^2 - H^2$ which is $R^2 = 45^2 - 30^2 = 1125$ so $R = 33.5"$.

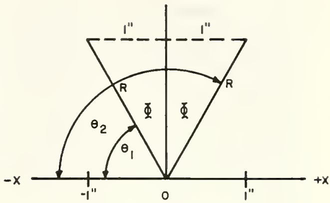
In the modified technique, the motion of the cane is composed of two parts. One type of motion is caused by wrist action (contributing a small arc) and the other type is caused by forearm motion. The motion from the wrist action is discussed below.

In Fig. 5, the body width is assumed to be 18" so there is a 20"-arc swing (one inch of extra coverage on each side). Let ϕ be the angle that the wrist turns in its motion to give a 20"-arc swing for a shoulder width of 18".



Note that Point A is the position of the cane tip when the cane is at the extreme left.

Just considering wrist motion, i.e. body width 0", the following diagram can be made.



$\sin \phi = 1"/R = 1"/33.5 = 0.0316$ so

$\phi = 1.8$

θ values range from θ_1 to θ_2 as the cane moves from the far left to the far right where $\theta_1 = 90° - 1.8° = 88.2°$ and $\theta_2 = 90° + 1.8° = 91.8°$. The graph is made in ten intervals for one traverse across the body. They are labeled 1 to 11 in the data tables. The total range of θ is $91.8° - 88.2° = 3.6°$ so the change in θ for each interval is $3.6/10 = 0.36$. Therefore, for position 1, $\theta = 88.2°$; for position 2, $\theta = 88.2° + 0.36° = 88.56°$; for position 3, $\theta = 88.2° + 0.36° + 0.36° = 88.92°$; etc. Position 1 occurs when the cane is at the far left and position 11 occurs when it is at the far right. Wrist motion is taken into account in the data table in columns x' and y'. The forearm motion is taken into account in the data table in columns P and H.

<u>Columns on the Data Table for Each Graph</u>

x' is the component of the wrist arc in the x direction (arm stationary). $x' = R \cos \theta$.

y' is the component of the wrist arc in the y direction (arm stationary). $y' = R \sin \theta$.

P is the component of the position of the hand in the y direction. Assuming constant velocity, it is simply the step size (1/2 the stride; heel to heel) divided by the number of intervals, i.e., 10. P for position 1 is 0; P for position 2 is 0 + 21/10 = 2.1; P for position 3 is 0 + 2.1 + 2.1 = 4.2; etc. P for position 11 is 21.

H is the component of the position of the hand in the x direction, due to the forearm motion. The forearm swings 18" (the assumed body width) in the x direction through positions 1 to 11. The length in the forearm travels is an interval (18/10 = 1.8). H at position 1 is -9" since position 1 is where the cane and the hand are at the extreme left. H at position 2 is -9 + 1.8 = -7.2; H at position 3 is -9 + 1.8 + 1.8 = -5.4; etc. At position 11, H is 9. (H, P) gives the location of the hand for points on the graph.

The columns x and y are the x and y coordinates of the cane position. $x = (H + x')$ is the sum of x components of the two types of motion that make up the forearm swing mentioned previously. $y = (P + y')$ is the sum of the y components. The (x, y) coordinates of hand position are simply (H, P). The points (H, P) on the graphs are represented by dots while the $[(H + x'), (P + y')]$ points are represented by slashes. The connected points represent a projection of the cane position on the ground for each of the points. Positions 1 to 11 on the data table comprise only one step. The other steps are symmetrical.

Four walking steps are necessary for a complete graphic representation. The first and the last steps are not indicative of cane travel because they are the starting and stopping steps.

SAFETY INDEX

Figure 5 does not have complete cane coverage and cannot be used in the safety index. It serves as a starting point to "guess" the proper cane length for complete protection. In order to arrive at the proper cane length, one must get point 1' to have a y coordinate of 42 (R = 42). Using $R^2 = (CL)^2 - H^2$, the cane length is 51.6". Total protection is attained in Fig. 2 with a cane length of 52".

The step size in Fig. 2 is 21". The R value needed for complete protection is twice the step size (42"). Figures 6 and 8 show the formula working for a 33" step and Fig. 7 shows it working for a 24" step. The preceding three graphs have R values slightly greater than twice the step size. The cane becomes an integral value length. The extra tenths of an inch on the R values show up on the graphs as overprotection.

DATA FOR THE SAFETY INDEX

Cane length deduced from patterns such as the case of the constant height of hand line of 30". Figures 2 and 6 were both deduced using an R of two times the step size and then finding the length of the cane to the nearest inch. Figures 2 and 6 had two extreme sizes of 21" and 33" respectively. The cane lengths of the step sizes in between these two step sizes can be calculated in the same way.

* Since relationships are linear (20" arc sweep), results of 30" and 39" constant height of hand lines can be carried through the remainder of the table.

	Height of Hand (inches)	Step Size (inches)	Cane Length (inches)
*	24	21	48.4
*	24	24	53.6
*	24	27	59.1
*	24	30	64.6
*	24	33	70.2
*	25	21	48.9
*	25	24	54.0
*	25	27	59.5
*	25	30	65.0
*	25	33	70.6
*	26	21	49.4
*	26	24	54.5
*	26	27	60.0
*	26	30	65.4
*	26	33	71.0
*	27	21	50.0
*	27	24	55.1
*	27	27	60.4
*	27	30	65.8
*	27	33	71.4
*	28	21	50.5

	Height of Hand (inches)	Step Size (inches)	Cane Length (inches)		Height of Hand (inches)	Step Size (inches)	Cane Length (inches)
*	28	24	55.6	*	35	27	64.4
*	28	27	60.9	*	35	30	69.4
*	28	30	66.2	*	35	33	74.7
*	28	33	71.8	*	36	21	55.3
*	29	21	51.0	*	36	24	60.0
*	29	24	56.1	*	36	27	65.0
*	29	27	61.3	*	36	30	70.0
*	29	30	66.6	*	36	33	75.2
*	29	33	72.2	*	37	21	56.0
	30	21	51.6	*	37	24	60.6
#	30	24	56.6	*	37	27	65.5
#	30	27	61.8	*	37	30	70.5
#	30	30	67.0	*	37	33	75.6
	30	33	72.5	*	38	21	56.6
*	31	21	52.2	*	38	24	61.2
*	31	24	57.0	*	38	27	66.0
*	31	27	62.3	*	38	30	71.0
*	31	30	67.5	*	38	33	76.2
*	31	33	72.9	#	39	21	57.3
*	32	21	52.8	#	39	24	61.8
*	32	24	57.6	#	39	27	66.6
*	32	27	62.8	#	39	30	71.6
*	32	30	68.0	#	39	33	76.6
*	32	33	73.4	#	24	16	40.0
*	33	21	53.4	#	26	16	41.0
*	33	24	58.2	#	28	16	42.4
*	33	27	63.3	#	30	16	43.9
*	33	30	68.4	#	30	14	41.0
*	33	33	73.8	#	32	16	45.3
*	34	21	54.0	#	32	12	40.0
*	34	24	58.8	#	34	16	46.8
*	34	27	63.8	#	34	12	41.7
*	34	30	69.0	#	36	16	48.1
*	34	33	74.2	#	36	12	43.2
*	35	21	54.6	#	38	16	49.7
*	35	24	59.4	#	38	12	44.9

Data Figure 1

Step Size 21"
Cane Length 52"
Height of Hand 30"
Arc Width 20"

Position	θ	y'	x'	P	H	y	x
1	76.40	41.3	-10.0	0	0	41.3	-10
2	79.12	41.7	-8.0	2.1	0	43.8	-8
3	81.84	42.1	-6.0	4.2	0	46.3	-6
4	84.56	42.3	-4.0	6.3	0	48.6	-4
5	87.28	42.4	-2.0	8.4	0	50.8	-2
6	90.00	42.5	0	10.5	0	53.0	0
7	92.72	42.4	2.0	12.6	0	55.0	2
8	95.44	42.3	4.0	14.7	0	57.0	4
9	98.16	42.1	6.0	16.8	0	58.9	6
10	100.88	41.7	8.0	18.9	0	60.6	8
11	103.60	41.3	10.0	21.0	0	62.3	10

Data Figure 2

Step Size	21"
Cane Length	52"
Height of Hand	30"
Arc Width	20"

For the values of θ, x', sin θ, refer to Fig. 5.

Position	y'	H	P	x	y
1	42.4	-9.0	0	-10	42.4
2	42.4	-7.2	2.1	-8	44.5
3	42.4	-5.4	4.2	-6	46.6
4	42.4	-3.6	6.3	-4	48.7
5	42.4	-1.8	8.4	-2	50.8
6	42.4	0	10.5	0	52.9
7	42.4	1.8	12.6	2	55.0
8	42.4	3.6	14.7	4	57.1
9	42.4	5.4	16.8	6	59.2
10	42.4	7.2	18.9	8	61.3
11	42.4	9.0	21.0	10	63.4

Data Figure 4

Step Size	24"
Cane Length	54"
Height of Hand	39"
Arc Width	25"

Position	θ	cos θ	sin θ	x'	y'	P	H	x	y
1	85	.087	.996	-3.22	36.85	0	-9.0	-12.22	36.85
2	86	.070	.998	-2.6	36.95	2.4	-7.2	-9.8	39.35
3	87	.052	.999	-1.9	≈37.0	4.8	-5.4	-7.3	41.8
4	88	.035	.999	-1.3	≈37.0	7.2	-3.6	-4.9	44.2
5	89	.017	1.	-0.6	≈37.0	9.6	-1.8	-2.4	46.6
6	90	0	1.	0	37.0	12.0	0	0	49.0
7	91	.017	1.	+0.6	≈37.0	14.4	1.8	2.4	51.4
8	92	.035	.999	+1.3	≈37.0	16.8	3.6	4.9	53.8
9	93	.052	.999	+1.9	≈37.0	19.2	5.4	7.3	56.2
10	94	.070	.998	+2.6	36.95	21.6	7.2	9.8	58.55
11	95	.087	.996	+3.22	36.85	24.0	9.0	12.22	60.85

Data Figure 5

Step Size	21"
Cane Length	45"
Height of Hand	30"
Arc Width	20"

Position	θ	cos θ	sin θ	*x'*	*y'*	*P*	*H*	*x*	*y*
1	88.20	-.031	≈1	-1.0	33.5	0	-9.0	-10.0	33.5
2	88.56	-.025	≈1	-0.8	33.5	2.1	-7.2	-8.0	35.6
3	88.92	-.019	≈1	-0.6	33.5	4.2	-5.4	-6.0	37.7
4	89.28	-.012	≈1	-0.4	33.5	6.3	-3.6	-4.0	39.8
5	89.64	-.006	≈1	-0.2	33.5	8.4	-1.8	-2.0	41.9
6	90.00	.000	1	0	33.5	10.5	0	0	44.0
7	90.36	.006	≈1	0.2	33.5	12.6	1.8	2.0	46.1
8	90.72	.012	≈1	0.4	33.5	14.7	3.6	4.0	48.2
9	91.08	.019	≈1	0.6	33.5	16.8	5.4	6.0	50.3
10	91.44	.025	≈1	0.8	33.5	18.9	7.2	8.0	52.4
11	91.80	.031	≈1	1.0	33.5	21.0	9.0	10.0	54.5

Data Figure 6

Step Size	33"
Cane Length	73"
Height of Hand	30"
Arc Width	20"

Position	θ	cos θ	sin θ	*x'*	*y'*	*H*	*P*	*x*	*y*
1	89.10	-.0157	1	-1.0	66.5	-9.0	0	-10	66.5
2	89.28	-.0126	1	-0.8	66.5	-7.2	3.3	-8	69.8
3	89.46	-.0095	1	-0.6	66.5	-5.4	6.6	-6	73.1
4	89.64	-.0062	1	-0.4	66.5	-3.6	9.9	-4	76.4
5	89.82	-.0033	1	-0.2	66.5	-1.8	13.2	-2	79.7
6	90.00	0	1	0	66.5	0	16.5	0	83.0
7	90.18	.0033	1	0.2	66.5	1.8	19.8	2	86.3
8	90.36	.0062	1	0.4	66.5	3.6	23.1	4	89.6
9	90.54	.0095	1	0.6	66.5	5.4	26.4	6	92.9
10	90.72	.0126	1	0.8	66.5	7.2	29.7	8	96.2
11	90.90	.0157	1	1.0	66.5	9.0	33.0	10	99.5

Data Figure 7

Step Size	33"
Cane Length	77"
Height of Hand	39"
Arc Width	20"

For the values of *x*', *H*, and *x*, refer to Fig. 6.

Position	*y*'	*P*	*y*
1	66.4	0	66.4
2	66.4	3.3	69.7
3	66.4	6.6	73.0
4	66.4	9.9	76.3
5	66.4	13.2	79.6
6	66.4	16.5	82.9
7	66.4	19.8	86.2
8	66.4	23.1	89.5
9	66.4	26.4	92.8
10	66.4	29.7	96.1
11	66.4	33.0	99.4

Data Figure 8

Step Size	24"
Cane Length	62"
Height of Hand	39"
Arc Width	20"

For values of *H*, *x*', and *x*, refer to Fig. 6.

Position	*y*'	*P*	*y*
1	48.2	0	48.2
2	48.2	2.4	50.6
3	48.2	4.8	53.0
4	48.2	7.2	55.4
5	48.2	9.6	57.8
6	48.2	12.0	60.2
7	48.2	14.4	62.6
8	48.2	16.8	65.0
9	48.2	19.2	67.4
10	48.2	21.6	69.8
11	48.2	24.0	72.2

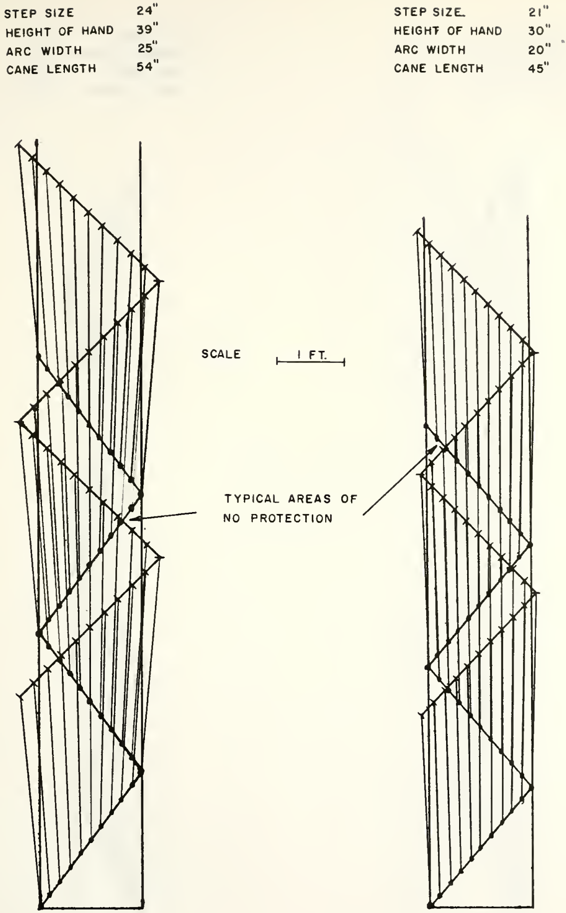


Figure 4.

Figure 5.

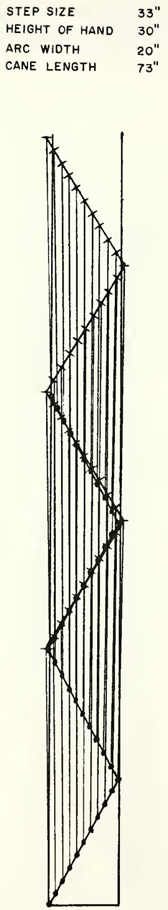


Figure 6.

SCALE 1 FT.

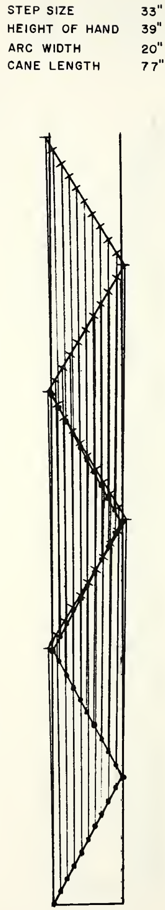


Figure 7.

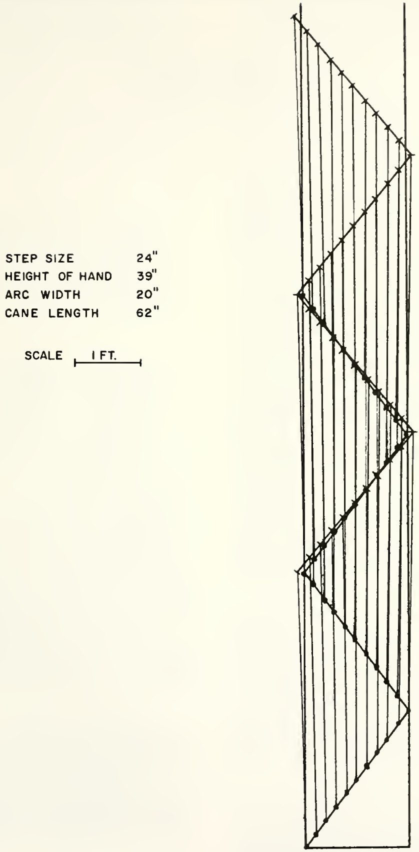

STEP SIZE 24"
HEIGHT OF HAND 39"
ARC WIDTH 20"
CANE LENGTH 62"
SCALE 1 FT.

Figure 8.

FACTORS IN THE SUCCESSFUL MOBILITY OF THE BLIND: A REVIEW

David H. Warren*

Joe A. Kocon*

INTRODUCTION

"The ability to travel safely, comfortably, gracefully, and independently, referred to hereafter by the single term *mobility*, is a factor of primary importance in the life of a blind individual (Foulke, 1971, p. 1)."

Of all the abilities that the blind can have or acquire, effective mobility is certainly one of the most important. Mobility is a vital key to personal independence, to independent travel, and to vocational success. At the same time, truly effective mobility is a complexly determined ability. A whole set of factors is involved in making a person mobile. Two people may both become effectively mobile and yet have quite different patterns of characteristics. One may succeed primarily because he has well-established concepts of spatial relations, while another may have poor spatial relations concepts but may succeed because of his sheer determination to memorize the vast store of information that he must have about his surroundings.

Recognition of this complexity occurs routinely in the literature on mobility training--one is impressed by the frequency of statements of the need to tailor mobility programs to the individual trainee's characteristics. For example, Whitstock (1960) states that children "are individuals, and efforts to guide their behavioral development should be tailored to fit their individual needs, capacities, interests, and circumstances (p. 90)." Similarly, Thomas (1970) states that "each child is different in ability, knowledge, personality, motivation, and readiness, as well as in his need for travel independence. Therefore, rigid standards for independent travel are not set, but each child is evaluated by the mobility specialist individually to determine his need (p. 183)." At the same time, one is struck by the absence of statements about just how to accomplish this individual tailoring. As late as 1969, Cratty wrote that "a review of the literature relating to data upon which these mobility training programs [for children] were established led me to the conclusion that in most cases they employed techniques which were unsupported by objective evidence (p. 157)."

One major purpose of this paper is to provide an organization and review of much of the literature relating mobility[1] success to personal factors. What are the characteristics of the effectively mobile individual? Are there certain characteristics that all mobile people have? Are there ways in which a blind person may "compensate" for a relative lack in one

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[1]By *mobility* we mean the relatively general ability described by Foulke in the opening quote. Occasionally we will refer more specifically to mobility training, by which we mean the formal training program.

important area by relative strength in another? A second major purpose is to provide a preliminary analysis of those factors in the young child's environment that may produce characteristics that will provide a firm basis for effective mobility. Thus, for example, if personal independence is a vital factor in mobility, how may the parent or professional increase the likelihood that the child will develop a personal independence? It is a truism that parents shape many of their child's characteristics; it is our position that with a knowledge of the factors important to mobility and something of the dynamics behind the production of those factors, parents and professionals can provide experience that will allow children to become effectively mobile in spite of a visual handicap. To accomplish this goal, however, we need to make use of the research that is available. We hope that this review will serve as a step in that direction, as well as in complementary direction of pointing out areas in which the research literature on mobility factors is weak or lacking.

The major part of the review consists of three sections; one on perceptual factors in mobility, with sections on body image and spatial relations; a second on IQ and cognitive factors; and the third on personality, social, and emotional factors.

PERCEPTUAL FACTORS—VISUAL

Residual Vision

There is relatively little research, and therefore some disagreement, on the importance of the role that residual vision should play in mobility training. One author may detail the types of residual visual characteristics, while another states that "the reaction and adjustment of each blind person to his residual vision is something that cannot be predicted (Richterman, 1966, p. 236)." There is agreement that there are both negative and positive effects of residual vision, however, and it is the purpose of this section to discuss and document some of the issues.

It is necessary to state at the outset that the term "residual vision" is used quite globally and probably should be replaced by a set of more specific terms that cover more limited categories of visual disability. Residual vision is used to refer to two quite different types of loss, and for mobility purposes, it is probably important to distinguish even within these two types. The two are 1) the residual ability for some visual experience, such as perceiving degrees of diffuse brightness or counting fingers, and 2) the selective dysfunction of some part(s) of the visual system, such as macular loss with peripheral adequacy. Many writers use a set of commonly accepted distinctions within the first category. Within the second category, however, there is often a neglect of differences that are probably quite important for mobility. A person with only macular vision and peripheral loss is quite different from one with only peripheral vision and no macular function, or one with only right hemifield function, and it would not be surprising to find that these types of people respond quite differently to mobility training. Some writers do recognize these distinctions as important. Silver (1965), for example, provides a useful breakdown of various types of loss, along with some discussion of how this variable might interact with mobility training. Hughes (1967) also discusses some distinctions, and he provides the observation that "students with good central vision, but a poor visual field, have the most difficulty in traveling (p. 120)."

There is little question that the person with some residual vision, of whatever type, is at least potentially better off than the person with none. Residual vision allows the intake of a source of information about the world that is lacking in the totally blind. Some writers hold that mobility is positively aided by this information. For example, Bauman and Yoder (1966) state that "freedom of travel is greatly facilitated by even a small amount of remaining vision (p. 72)." Other authors are less optimistic. For instance, Norris (1956) found no relationship between amount of remaining vision and the orientation skills of children.

Norris' *S*s did not have a great deal of residual vision, and it is possible that the sample was too homogeneous on this characteristic for any relationship to appear. It is also interesting to note, however, that Knowles (1969), in his retrospective study of the characteristics of the vocationally successful blind, found that the degree of visual loss had very little relation to vocational success.

In a retrospective investigation of the characteristics of high and low activity groups of adults, Graham (1965) found that even though the high activity group showed a higher incidence of total blindness, those high activity people who did have some sight used it more regularly than did those with some vision in the low activity group. Clearly the issue is not only whether some vision is present, but whether and how it is used. Lord (1969) reports that children with light perception were significantly superior to the totally blind on several measures of locomotion, including pointing the toes in the direction of travel, walking with a relaxed gait, walking up and down steps alternating feet, and running freely. The totally blind group, by contrast, were better at pointing at cardinal directions and traveling routes using cardinal direction.

It is clear that there are differences in mobility performance attributable to the perceptual aspects of residual vision. These effects are complex, however, as evidenced by Lord's (1969) finding that the totally blind were better than the partially sighted in some aspects of mobility and orientation performance. Before the relationship of residual vision to mobility can be successfully exploited in mobility training, much more research and evaluation needs to be done. Furthermore, it will not be helpful in this work to deal with residual vision or with mobility performance as categorical factors. The specifics of visual deficit and of mobility performance will have to be dealt with in detail.

Even if the detailed relationships between the perceptual aspects of residual vision and mobility are adequately known, there is another important dimension involved. Many writers on residual vision note that the partially sighted person often has greater attitudinal problems with mobility than the totally blind person. It is important to recognize that the mobility task is quite different in some respects for the partially sighted. Their residual vision is often quite adequate for some aspects of travel, such as avoiding large stationary or moving obstacles or discriminating the color of traffic lights. At the same time, the partially sighted traveler often needs help in reading street signs and performing other tasks where good acuity is required. This ambiguity may place the partially sighted traveler in an awkward situation: as Stone (1965) points out, he is neither fish nor fowl. At the same time that they wish to deemphasize their handicap, they need to obtain certain information, and they may be hesitant to ask because of a feeling that "the sighted public will brand them as charlatans or fakers because they appear as seeing persons, when in reality they are unable to distinguish necessary landmarks. . . (Hughes, 1967, p. 120.)" In view of the ambiguity of his circumstances, it is perhaps not surprising that the partially sighted person often shows more resistance to some aspects of mobility training than the totally blind. The long cane, for example, may be rejected as being "an admission of blindness (Lord and Blaha, 1968)."

Clearly attitudinal and personality factors are more at issue here than strictly perceptual factors. Bauman (1964) provides some information about personality differences between partially sighted and totally blind adolescents and adults. The partially sighted gave more unfavorable responses on such items as "blind people should not have to meet the same standards that other people meet," "I go to dances and other social affairs whenever I have the chance," and "almost all blind people have many unusual abilities." Bauman found that the partially sighted show less adequate adjustment to visual loss and a greater incidence of tension and pressure. Thus attitudinal factors represent a potentially negative influence which may lead the partially sighted person to resist mobility training, to the extent that the possible advantages of the available vision are completely lost. It is unfortunate that although many people recognize this possibility, there is little work reported on methods of dealing with the attitudinal problems. It will not be sufficient to recognize the problem--effective solutions must be sought.

There is some disagreement about whether and how residual vision should be used in formal mobility training. One issue is whether blindfolds should be used to encourage the person to make use of nonvisual information. Richterman (1966) notes that occluders may not be useful, since the partially sighted person may really not try to use the other senses, thinking that he need only to remove the occluders in order to see. Richterman argues that occluders should be used "only with extreme caution and with extensive preparation of the blind person, and under no circumstances for a lengthy period (p. 237)." Like others, though, he points out that training with occluders may be necessary in cases where vision is known to be deteriorating. Cohen (1966), on the other hand, argues that occluders may be used effectively to require concentration on information from the other senses. The disagreement seems more apparent than real: there is no disagreement on whether the partially sighted individual should develop his remaining senses, only about the relative difficulty in getting him to do so.

There also seems to be little disagreement about whether use of any residual vision should be encouraged for mobility. Although it has in the past been thought that the use of residual vision may cause it to deteriorate more rapidly, this fear seems to be groundless on several counts. First, even if the residual vision did decrease more rapidly, if the person does not use it while it remains, it is of no value to him anyway. Second, as Barraga (1964) has concluded, using residual vision probably does not lead to its faster deterioration and may in fact lead to its improvement. Finally, there is evidence that the person who has had some use of early vision can make more effective use of many types of nonvisual spatial information than the congenitally blind (Warren, Anooshian, and Bollinger, 1973). Warren et al., argue that the later blind retain a visual frame of reference that provides an organizational function for auditory and tactual spatial information. The ongoing use of residual vision may serve to establish and strengthen this visual organizational framework. Thus for several reasons, it seems important to make the maximal use of residual vision in mobility training.

Residual vision is potentially one of the very important factors in mobility. Yet it must be concluded that we know little that enables us to structure mobility training effectively to the residual vision characteristics of the individual. At least two areas of research need to be developed much more extensively. The first has to do with the perceptual aspects per se. There is no question that residual vision can provide useful functions for the individual, both in providing direct visual information and in organizing the nonvisual abilities. But these functions and the ways they may relate to mobility are not simple, as evidenced by the pattern of results reported by Lord (1969).

The perceptual aspects of residual vision are only potential advantages. The second area needing intensive attention deals with the personality and attitudinal factors that may limit the use of the potential provided by residual vision. The difficulties of being "neither fish nor fowl" may be severe enough that any perceptual advantage is lost. Research needs to be done on the factors that may intensify or decrease these attitudinal difficulties, and effective methods of dealing with the factors need to be developed and implemented. Furthermore, these efforts need not be restricted to dealing with the individual: group therapy would seem potentially valuable.

In sum, it is not surprising that there is disagreement about the role that residual vision should play in mobility and orientation training. What little research has been done tends to be so nonspecific as to be of little use. This is an area where well designed and executed research can provide information that can be put to immediate and effective use in aiding mobility.

AGE AT ONSET OF BLINDNESS

Another visual characteristic that may have a bearing on mobility is the age at which blindness occurred. Of course, it is sometimes difficult to determine this age, either because the loss was gradual or simply because the visual history is unknown. Also making the early vision factor a difficult one to assess is the relation of the age of onset to the amount of time since onset of blindness. In a sample of homogeneous age, these two factors are perfectly negatively correlated. In a heterogeneous age sample, there is room for independent variation of the two factors, and the time since blindness factor should not be neglected.

An extensive recent review of the effects of early vision on aspects of spatial behavior is available (Warren, Anooshian, and Bollinger, 1973). The early vision factor was not assessed specifically with respect to mobility, but some points emerge from Warren et al. that are relevant. As in the case of residual vision, it is possible to distinguish two aspects of the potential effects of early vision. And as in the case of residual vision, one of those aspects is potentially positive and the other potentially negative. The positive factor is the perceptual advantages conferred by early vision. In many types of spatial performance, the later blind are significantly better. Warren et al., argue that this advantage is due to the fact that early vision provides an organizational frame of reference that serves an integrative function for spatial information received via audition and touch. Even after the onset of blindness, the frame of reference remains, and auditory and tactual information can be more effectively interpreted and integrated than if vision had never been present. Warren (1973) goes on to argue that there may be significant developmental stages in the organizational role that vision plays. One such stage is the period of establishment of visual control over manual activity, another the establishment of visual control over locomotor activity. Still another significant era may be the acquisition of verbal spatial terms--these terms may become more effectively useful if they are acquired in the presence of the visually perceived spatial relations. Thus early vision confers certain perceptual advantages that remain even after the onset of blindness. Warren et al., (1973) point out that this advantage is stronger for more complex spatial tasks--mobility in the environment would certainly qualify in this category.

The factor related to early vision that may be negative, as in the case of residual vision, is one of adjustment, or attitude. Several writers (e.g., Cohen, 1966) have observed that the later blind child is at a disadvantage in that he knows what it is like to have seen and may become depressed by the contrast, while the congenitally blind child has no contrast to become depressed about. Another way of saying this is that the congenitally blind child makes his initial adjustment to the world without vision, thus his permanent mode of adjustment is the one that he acquired initially. In contrast, the later blind child has initially adjusted to the world with the use of vision, and then his adjustment to the world without vision is a readjustment, and more difficult to acquire. The same general argument can be extended to varying durations of early vision. The child who loses his sight early still has much of his development to accomplish--the earlier he becomes blind, the less accomplished development has to be redone. The later the onset of blindness, the greater the relearning task. This same relationship seems to hold for adults. For example, Leonard and Newman (1970) observe that newly blind young adults are more flexible in their response to new mobility techniques than are older adults.

In the case of early vision, then, the potential effects on mobility are again complex. While it is clear that there are lasting perceptual advantages conferred by early vision, it is also apparent that the adjustment to blindness required is greater for the older child or adult. Research needs to be done on both aspects. We need to know just what types of advantage do occur as a result of early vision in order to trade optimally on them in training the child. At the same time, we need good information about the characteristics of the readjustment process, so that the potential drawbacks may be avoided, or dealt with as effectively as possible.

PERCEPTUAL FACTORS—NONVISUAL

It is perhaps a truism that effective mobility for the blind depends on the "other" spatial senses, the nonvisual ones. It is valid, though, to ask just how mobility does depend on the other senses. Foulke (1971) points out that the sighted person may obtain quick and precise information about the nature of the environment through which he moves, including the nature of the path (curves, surface characteristics, irregularities) and the nature of obstacles and landmarks. Further, "as he progresses along his course this picture is continually updated and reviewed (p. 1)." Ongoing and up-to-date information about the path and the potential obstacles is also vital to the blind traveler, but he is forced to rely primarily on auditory and tactile cues for this information.

It is the primary purpose of this section to review the highlights of ways in which the other senses are involved in mobility, and to investigate, in a preliminary way, the question of whether these modes can be trained to provide a more effective basis for mobility. Studies that deal with auditory and locomotor functioning will be reviewed first, followed by sections on the more conceptual aspects of perceptual functioning, such as spatial relations and body image.

Auditory Factors

Hapeman (1967) states clearly the importance of sound localization for mobility, "For a blind traveler, being able to face directly the source of a sound or to maintain the sound on one side is important in determining direction and traveling in a straight line to his objective (p. 46)." Facial vision, or the so-called "obstacle sense" of the blind, has received some very good experimental attention. Hayes (1941) provides a review of the pre-1940 work on the issue. Supa, Cotzin, and Dallenback (1944) carried out a series of studies in which they determined that the primary cues involved in facial vision are auditory ones. The blind *S*s could quite effectively stop just short of an obstacle or a wall. Subsequent research has shown that relatively high frequencies (10,000 Hz and up) are involved in this performance, which is in important respects similar to the echodetection of bats (Cotzin and Dallenback, 1950). Supa et al., also tested blindfolded sighted *S*s and found their performance to be inferior to that of the blind. However, the performance of the sighted *S*s improved markedly over the course of relatively few trials. Evidently facial vision was not dependent on a mode of functioning that the sighted *S*s lacked, but rather on the use of cues which are not normally attended to by sighted *S*s and which can readily become useful.

Curtis and Winer (1969) corroborate the heavy use of auditory cues by blind travelers and report data comparing blind travelers with non-travelers. The only highly significant difference in basic auditory discriminative skills was that the travelers made finer intensity discriminations. The authors suggested that the greater sensitivity of the travelers was a *result* of their mobility, not a cause of it. This suggestion seems especially reasonable in view of Supa et al., (1944) showing the rapid improvement in facial vision capabilities for blindfolded sighted *S*s. Thus the implication is that auditory intensity discrimination is trainable.

Rice (1967, 1969, 1970) reports some interesting research designed to evaluate the echodetection and echolocalization abilities of blind *S*s. Further, Rice, Feinstein, and Schusterman (1965) demonstrated that echodetection ability improves with training, a conclusion similar to that of Juurmaa (1970). While the work of Rice and his colleagues has been done primarily in the laboratory, there is corroboration from field studies that the use of echoes improves with training. Kohler (1964) found marked improvement produced by practice with a sound-emitting device fastened to *S*'s chest.

Unfortunately, with the exception of Rice's investigations of differences between early and later blind *S*s, there has been little attempt to study individual differences in echodetection abilities, either in laboratory studies or in relation to actual mobility. Auditory abilities are important enough to mobility that research attention should be devoted to investigating individual characteristics.

Riley, Luterman, and Cohen (1964), in a step in this direction, report correlations between hearing ability and mobility in blind adults. Most of the *S*s, who ranged in age from 17 to 58 years, had some degree of residual vision which was occluded during testing. Mobility scores were assigned by mobility instructors on the basis of a total of 15 weeks of instruction. Significant correlations between pure tone threshold and mobility score were found over a frequency range of 250 to 14,000 Hz. The trend of the findings was toward higher correlations for the higher frequency levels, thus supporting previous findings by Cotzin and Dallenbach (1950). Riley et al., did not find correlations of mobility socres with interaural pure tone thresholds, but they point out that in most cases the interaural threshold differences were not large. Further investigation of this possible individual difference characteristic is needed. Riley et al., conclude, quite appropriately, that "in the planning of a rehabilitation program for a blinded individual, consideration should perhaps be given to the status of the individual's high-frequency hearing ability. It may ultimately be necessary to modify existing mobility training techniques in accordance with the trainee's ultra-speech frequency hearing ability (p. 141)." A training study by Simpkins (1971) also deserves brief mention in this section. Simpkins administered a six-week auditory training program with speech and environmental sounds. Significant improvement was found only for the latter category, which is relevant to mobility in that it involved both identifying sounds and discriminating sounds against a distracting background. Unfortunately, this research was weak in several respects. Pre- and post-test samples of 14 each were compared to assess improvement. The 14 children in each group were randomly selected from across four grade levels, thus creating quite heterogeneous (and possibly unequal) groups with respect to CA. Additionally, the reader has only the information that "the children were visually handicapped," with no indication of the specific visual deficits or whether they were reasonably equivalent for the two samples.

A group of studies from the psychoanalytic literature is relevant to this section. These reports tend to be oriented to the infant and younger child and are thus especially relevant to the question of the preparation of the child for later mobility. Burlingham (1964) writes generally about the role of audition in the young blind child's orientation to the world. Reviewing several intensive case studies, Burlingham notes that while blind infants show quite adequate early responses to auditory stimuli and in fact delight in creating them, they sometimes have difficulty in coming to integrate the auditory aspects of events with their tactual and kinesthetic aspects. She observes, for example, that in three- to six-year old children, auditory "experimenting" does not seem to "awaken further curiosity; on the contrary, it often leads to what appears like boredom or regression to autoerotic manifestations (p. 100)." Here clearly is an area needing further study. What is it that produces this regression, and what structuring of the child's experience might lead him to continue and develop useful contact with his auditory experience?

Fraiberg and her associates provide contributions along similar lines. Fraiberg and Freedman (1964) report the case study of a child who, although she showed normal responsiveness to sounds in the first few months, at 10 months showed no evidence that sound contributed to the successful reach for an object. In a further study of this phenomenon, Fraiberg, Siegel, and Gibson (1966) note that "sound alone does not confer substantiality to the object (p. 329)." In normal infants, vision apparently serves to facilitate the coordination of auditory and tactile experience. In the absence of vision, the use of auditory information appears retarded even in some cases where overall development is quite good. The implication from this work, like that of Burlingham, is that a search should be made for events and experiences that will lead to an effective coordination of the nonvisual modalities even in the absence of vision. Fraiberg (1968) develops some notions along these lines that will be discussed in the section on motor behavior. Wills (1970) describes a similarly oriented program of investigation, developed parallel to the work of Fraiberg et al.

Locomotor Factors

The second category includes aspects of locomotor abilities. As in the case of auditory abilities, several subcategories may be distinguished. Some studies with adults and older children are directly related to mobility, and some training studies have been reported. There are also, again primarily in the psychoanalytic literature, some studies of locomotion in infants and preschool children.

The relationship between posture and mobility in the blind is straightforward enough: while the sighted person has vision to mediate his perception of the vertical, the blind person must rely on proprioceptive and vestibular cues to perceive the vertical. Without vision, good posture is important in keeping a stable correspondence between body and environment. To the extent that the blind person has postural difficulties, his perception of the vertical (and other spatial directions, to the extent that they depend on the vertical) may be inadequate. Poor posture effectively removes the stable correspondence between body and environment and thus should make mobility more difficult.

Turner and Siegel (1969) points out the necessity of good posture and balance for effective mobility. They provide an evaluation form for the assessment of physical characteristics and abilities, gait, and concepts of body image and orientation (consideration of this latter category will be deferred to the section on body image), in addition to the ability to execute turns. Physical therapeutic procedures are described that are geared to correction of the individual's pattern of difficulty, whether it is primarily based on faulty foot placement, posture, or balance. Siegel and Murphy (1970) provide a much more detailed analysis of the role that posture plays in orientation and mobility, as well as specification of training procedures for correcting postural difficulties. Their sample consisted of 45 students, ranging in age from 17 to 58, who showed both postural defects and mobility deficiencies. After the diagnostic phase, both mobility and medical (postural) treatment phases were initiated and continued for 12 weeks. The major results can be summarized as follows: about two-thirds of the students showed postural improvements, and about two-thirds showed mobility improvements. More importantly, there was a good correlation between improvements in posture and improvements in mobility. No relationships were found between age, sex, or IQ and either postural or mobility improvement. Although it is undeniably risky to conclude a causal relationship from correlational research, the elimination of age, sex, and IQ as relevant variables in the mobility improvements lends strength to the argument that correction of postural difficulties leads to more effective mobility.

Mills and Adamshick (1969) report a broad-range training study that was directed specifically to the question whether formal mobility training would be more effective after a program of sensory training. The goals of the training program dealt with such things as body image, auditory identification and localization, comprehension of mobility terms, and tactical-kinesthetic development. After receiving the training program, which is described in some detail in the article, a group of high school students participated in a five-week orientation and mobility program. Their progress in the program was compared to that of a comparable group of students who did not receive the sensory training. The mobility instructors rated their trainees on orientation and mobility subskills. The sensory training group was able to be instructed on more skills than the control group, and while the average performance on the skills was similar for the two groups, the training group was markedly superior in overall proficiency rating.

Mills and Adamshick provide a list of uncontrollable variables, not related to the sensory training per se, that might have helped to produce the group differences. These variables are primarily related to the motivation and attitude of the students. To the extent that motivation and attitude differed as a result of the sensory training program, of course, these factors may be considered a legitimate, although nonsensory, aspect of the training program. Whatever the reasons, it is clear that the sensory trained group responded better to formal orientation and mobility training. It would be beneficial to pursue this type of training study further, evaluating in particular the source of the improvement in individual *S*s. It may be that attitude was the only improved factor in some *S*s, and it may be possible to produce adequate changes for these *S*s more effectively in other ways than sensory pretraining. The training itself may have been the important factor, but again, it may be possible to diagnose more precisely the exact needs of the individual, so that sensory training specific to those needs can be provided.

Lord (1969) provides an impressive step in the direction of such individual diagnosis with children. Lord's project was designed "(a) to define or identify the behavioral components in orientation and mobility which are relevant for young blind children and (b) to develop scales for the measurements relating the implied performances (p. 77)." Through a process of selecting a large pool of motor performance tasks, having professionals rate the developmental course and significance of the tasks, and testing the resulting sequence on a population of blind children, Lord produced a refined set of scalable abilities that are important in orientation and mobility. To the extent that these abilities are vital to orientation and mobility, Lord's scales should be usable in a diagnostic manner, to select those candidates that are best prepared, in terms of having certain basic skills, for formal orientation and mobility training. At the same time, the use of such scales may allow identification of specific areas of weakness in other candidates, and these weaknesses may then be given special attention.

Cratty has produced a great deal of research, and training procedures based on that research, on the role of locomotor skills in mobility success. Cratty has studied extensively the veering tendency of the blind (the ability to walk in a straight line), as well as their ability to execute various turns. Cratty (1967) studied the veering tendency in an open-field situation in which the *S* was asked to walk in a straight line. There was apparently not a significant difference between *S*s who had participated in formal mobility training programs and *S*s who had not. Interestingly, however, *S*s who reported traveling with guide dog were markedly worse in straight line locomotion than *S*s who traveled either with cane or with a sighted guide. Cratty argues that since physical characteristics such as head torsion, leg length, and hand and leg dominance did not contribute to prediction of veer, training in postural factors may prove to be less successful than training in "perceptual organization (i.e., what a person thinks is a straight pathway) (p. 34)." In this respect, Cratty's position is at issue with that of Siegel, and only further research will clarify the matter.

Cratty (1969) describes a subsequent study in which blind children, aged 7 to 14 years, participated in an eight-week training program involving straight-line walking and facing movements (turning 90°, 180°, 360°). Pre- and posttests on the position relocation (returning to the starting point along the hypotenuse of an isosceles triangle) measures were taken on the training group and on a control group which received no training. The experimental group showed significant improvement from pre- to posttest on the veering task and the turning task, as well as the position relocation task. Other aspects of mobility, orientation, and spatial relations were also reported to show improvement in the trained group, although formal measures were not reported.

While this type of training procedure seems to hold great promise for the preparation of blind children for formal mobility training, the usefulness of the research as reported is diminished by the failure to report any results for the non-trained control group. The control group may also have improved significantly.

If so, at least part of the improvement of the training group would have to be attributed to the pretest exposure or to other variables not related to the training itself. The price of an eight-week training program is a small one to pay if it prepares children better for formal orientation and mobility training. At the same time, it does represent a substantial investment, and it is important to determine just how much of the improvement is attributable to the training program itself.

Cratty (1967) has also studied blind *S*s' sensitivity to the incline and decline of paths. A larger percentage (92 percent) of persons who reported using dog guides for travel were able to perceive a slight gradient than persons who used the cane (63 percent) or who use sighted guides (42 percent). This pattern of results provides an interesting contrast to the veering results from the same groups of *S*s. In the veering task, travelers who used dog guides were much worse than those who used cane or sighted guides. This discrepancy serves to underline the complexity of the set of skills involved in mobility.

Leonard (1969) assessed static and mobile balancing in teenaged children varying widely in residual vision. The mobile balancing test required *S* to walk along a narrow beam (using whatever residual vision might be available). The relation between the balancing scores is of limited predictive use: while poor static balance predicted poor mobile balance, good mobile balance did not necessarily follow from good static balance. Residual vision was also of some use as a predictor of mobile balance. *S*s with very little residual vision performed poorly on mobile balancing, but *S*s with a large degree of residual vision did not necessarily perform well.

As in the case of auditory functioning, several papers in the psychoanalytic literature provide valuable information about the early locomotor progress of blind infants and young children. Fraiberg (1968) points out that in many cases the onset of creeping in blind infants lags behind that of sighted infants, and that "for all blind children the achievement of independent walking is markedly delayed (p. 279)." Fraiberg, Siegel, and Gibson (1966) observe that often the postural readiness for creeping is present at about the normal time in blind infants, but that "the creeping pattern cannot be initiated in the absence of an external stimulus for reaching (pp. 348-9)." The apparent inability of the infant to use auditory cues as signifiers of external events and objects, discussed earlier, thus becomes a significant obstacle to the onset of locomotion. Fraiberg et al. discuss this complex issue in terms of the spatial concepts of the blind child compared to those of the sighted. Vision is not present to serve its normal integrative function for the other spatial modalities (cf. also Warren, 1973). A vicious circle may ensue for the blind infant: "until he can creep, the floor and room space cannot be mapped by him. But until he can locate and pursue objects, he will not be able to creep!" (Fraiberg et al., 1966, p. 350.) The strong implication of these observations is that methods of training must be developed to produce the integration of tactual and auditory modes for the blind infant, and to elicit creeping and walking when he is physically ready.

According to Fraiberg, then, the child's ability to distinguish and identify objects is an important stimulus factor for the development of locomotion. Tactile sensitivity thus becomes an important topic. Although there is frequent mention in the infancy literature of the importance of tactile exploration (and the transition from mouth exploration to manual exploration--cf., for example, Parmalee, 1966), there is very little research on the details of the acquisition of tactile sensitivity in the blind infant. This is an area where research would be of benefit to the field.

In summary of these sections, it is appropriate to repeat the opening truism: effective mobility for the blind depends on effective use of cues obtained through the nonvisual modalities. There is reason to believe that adequate sensitivity of these modalities does not occur spontaneously with the loss of vision. The myth of sensory compensation has been adequately put to rest in reviews by Hayes (1941) and Rice (1970). If one blind person is better than another in his use of auditory or tactile cues, it is largely because the first person has exercised these modalities more effectively. The work with infants (e.g., Fraiberg's group) further underlines this point: children who received adequate auditory and tactile stimulation are, not surprisingly, better attuned to these sources of information. The implication for mobility is clear: blind individuals should receive, beginning as early in their blind life as possible, varied and intensive stimulation of their remaining sense modalities. If these modalities are adequately exercised, they will provide an adequate perceptual basis for mobility. If they are not, it is unreasonable to expect the individual to become effectively mobile.

Body Image

Many writers concerned with mobility refer to body image and stress the importance of a good body image for effective mobility. The term body image is used in at least three ways, and in combinations of the three, and before reviewing the highlights of the literature, it is necessary to clarify the uses of the term.

Hapeman (1967) uses the term to refer to the child's knowledge of the parts of his body and of the relationships among those parts, for example, the fingers are connected to the hand. A second use of the term is represented by Siegel and Murphy (1970), who define body image as the mental "picture" one has of one's body in space. This use differs from that of Hapeman in that it refers to external space, not just to the body. Other investigators use the concept to refer to both of these levels. For example, Garry and Ascarelli (1960) speak about "awareness of body position--which is awareness of the spatial relationships of parts of the body to its axes, and of the body as a whole to other bodies (p. 9)." Mills (1970) defines body image "as a knowledge of body parts, how the parts relate to each other, how the parts may be utilized both individually and collectively for purposeful activity, and how the parts relate to the child's spatial environment (p. 81)." A third level of meaning is characteristic of the psychoanalytic literature, and it has to do with the differentiation of the ego from the external world. It is thus similar to the second use, but it carries the additional implication of a developmental process. To quote Cohen (1966), "to achieve objectivity requires confirmation of all the senses that the self is an individual, separate, and to some degree, independent of others. Since vision is the sense which inherently presents the outside world as external, it is instrumental in the natural development of ego differentiation (p. 152)."

Cohen's reference to the role of vision in producing ego differentiation is echoed by many writers. Witkin, Birnbaum, Lomonaco, Lehr, and Herman (1968), speak of the role of vision in producing an articulation not only of external space, but also of the body concept. To the extent that the lack of vision interferes with the normal development of body image (referring, now, to all three levels of definition), the blind child is at a disadvantage. A review of the implications of this disadvantage formobility is thus in order. Spatial relations, that is, structure of the external world, will be reserved for the next section, along with most of the work on the relationship of the body to the external world.

Although some writers do stress the importance of body image for mobility, few have provided a way of assessing body image concepts objectively. In Witkin et al., quoted above, the child was given a ball of clay and was asked to make a person. The creations were rated according to a five-point scale. (The clay-modeling procedure has, like the Goodenough Draw-A-Man Test, been criticized for involving the child's artistic ability to a great extent, and it may therefore not be an ideal test of body image.) Mills (1970) lists a series of questions designed to evaluate body image but does not indicate how the child's responses are interpreted as an indicator of body image. Cratty (1970), on the other hand, presents a body image survey form that requires the child to perform a large number of activities, from simple pointing to parts of the child's own body to describing movements made by the interviewer. Cratty's survey form seems to be by far the best of the few assessment procedures available--it has, for example, had test-retest reliability checks performed. It should be pointed out that without agreement on definitions and use of terms, and without objective means of evaluating concepts such as body image, progress in the study of how body image is involved in mobility will be very slow.

Several investigators report attempts to produce better body image through training. Siegel's postural training program stands out in this area, as does Cratty's. Turner and Siegel (1969) describe the use of a life-size mannequin for training and imply some success in its use, although no objective evaluation of improvement of body image is reported. Siegel and Murphy (1970) again discuss the use of the mannequin. Cratty and Sams (1968) present perhaps the best justification for body image training, arguing that a well-developed body image forms a basis from which the child can learn to structure external space. Cratty puts special emphasis on the appropriate development of laterality. The laterality notion appears in his discussion of the veering tendency (Cratty, 1967), as well as in specific sections in his body image evaluation form (Cratty, 1970). Cratty and Sams (1968) argue that for any given type of disability, body image training should be geared to the specific abilities at the individual's disposal. In particular, "the blind must rely upon kinesthetic, tactual, and auditory information when forming concepts about themselves and their environments (p. 37)." Furthermore, they point out that it is important to encourage the child to *think* as part of his training: it is through the building of "cognitive bridges" that body image can become an effective basis for the development of mature spatial relations abilities.

Cratty and Sams identify four (temporally overlapping) phases of body image development, identified as 1) body planes, parts, and movements (2 to 5 years), 2) left-right discrimination (5 to 7 years), 3) complex judgments of the body and of body-object relationships (6 to 8 years), and 4) another person's reference system. The age ranges referred to are normative figures for blind children "of normal intelligence," indicating again the authors' regard for cognitive aspects in body image acquisition. Cratty and Sams describe a number of exercises designed to produce adequate progress through these stages: the reader is referred to the published paper for the details. For our purpose, it is more important to characterize general aspects of the program. First, it appropriately has a multimodal flavor, stressing auditory, motor, tactual, and kinesthetic aspects as well as verbal mediation, and stressing the importance of providing simultaneous multimodal experience to the child. Second, as fits a set of developmental stages, it stresses experiences that are appropriate to the age (or developmental level) of the child. Third, it emphasizes the necessity of providing a variety of activities, to produce adequate generalization of concepts. Finally, it stresses the importance of a gradual externalization of body image concepts, or building a concept of external space using the body image as a basis.

Cratty and Sams emphasize the importance of the child's very early experience in producing a sound body image. The regard for early experience also appears, not surprisingly, in the psychoanalytically oriented treatments of body image. Wills (1970) serves as a good example. Like the Fraiberg group, Wills has studied the development of reaching for objects and of locomotion in blind infants and has found significant developmental lags. The lags are discussed as being attributable to the lack of vision as an external verifier of the existence and identity of objects. Without vision, the integration of tactual and auditory experience is more difficult, and a major source of stimulus for the child to reach outward and contact the external world is absent. In psychoanalytic terms, this situation is described as a lag in ego differentiation, or in the realization that there is an important distinction between self and world. The difference in vocabulary should not be allowed to obscure the fact that Wills is talking about just the same set of events as is Cratty. The effects of the absence of early vision are reasonably clear--what remains is the vital search for effective means of providing substitute experiences that can provide, even in the absence of vision, for the effective development of body image, and for the effective building of concepts of external space from a well-developed body image. The trend in the literature on the blind toward recognizing the importance of early experience is a healthy and needed one. Significant progress in this area, though, will have to await more adequate ways of assessing the body image, and the willingness of investigators with ideas about early intervention to make a rigorous assessment of the effectiveness of their techniques.

A final study deserving mention in this section is one by Guess (1966), who studied the relationship between degree of ambulation and stereotyped behaviors, self manipulation, and environmental manipulation in blind and sighted retarded males, mean age 13. Among the blind *S*s, the nonambulatory group showed higher incidence of stereotyped behaviors and self manipulation than the ambulatory group, while the ambulatory *S*s showed much more environmental manipulation. As is the case in other studies, there is a problem in interpreting these results. It is not possible to ascertain whether greater ambulatory behavior was due to greater environmental manipulation, or vice versa. In any case, the factor of inwardly vs. outwardly directed manipulation deserves further study as a factor in mobility and orientation readiness.

Spatial Relations

As was pointed out in the last section, part of the material that is referred to as "body image" belongs better in the spatial relations category. Spatial relations covers an even wider range of testable abilities than body image; these abilities have in common the characteristic that they are aspects of the way that an individual structures and deals with external space, including both his perception of the relationships among external spatial events and his perception of himself as relating to those events in space.

The range of aspects included under the spatial relations heading can best be shown by listing the various ways that different writers talk about or test for spatial relations abilities. Gallagher (1968) used a pattern board, where *S*'s task was to reproduce a complex pattern made of pegs in a board. Garry and Ascarelli (1960) used various tests, including a Piaget-type task using a tube and objects inserted into it; a container filling test, where *S* had to fill a container with items of the appropriate size and shape (similar to but apparently more difficult than the typical form board); a figure combination task, where *S* had to create a larger form out of smaller shapes; and a "sticks and discs" test, where *S* again had to create a larger figure. Witkin et al., (1968) also used several tests, including tactile embedded figures, tactile block design, and matchsticks, where *S* had to find smaller patterns of spatial organization within a larger pattern, as well as an auditory embedded figures test. Bauman (1946) used the Minnesota Rate of Manipulation Test, where *S* had to move blocks around a board in a specified pattern. Leonard and Newman (1967, 1970) used tactile maps to guide locomotion. A number of older studies also used tactile maze learning tests (e.g., Koch and Ufkess, 1926; Duncan, 1934; Berg and Worchel, 1956). Although this list is not exhaustive, it serves to illustrate one aspect of the SR concept by examples.

The second aspect of SR, relating body to external space, can similarly be characterized by citing examples. Various researchers (e.g., Cratty, 1961) have used locomotor mazes. Cratty and Williams (1966) tested *S*'s ability to execute turns of varying magnitudes, as did Turner and Siegel (1969). McReynolds and Worchel (1954) required *S*s to point or face to various geographical directions. Also in the realm of locomotor performance are Cratty's (1967) tests of veering, Cratty et al.'s (1968) test of traversing curved paths, and Worchel's (1951) test of triangular relocation.

The locomotor tests of spatial relations cited above are, of course, implicitly tests of various aspects of mobility. There are relatively few studies that attempt to look for relationships between the other spatial relations categories and aspects of mobility, although several additional studies draw this relationship by implication. Gallagher (1968) reports a correlational study of the relation between performance in the pattern board test and travel skills in adolescents. The *S*s were 33 students enrolled in residential schools. Their independent travel ability was rated by staff members. There was a significant correlation between performance on the pattern board and travel ability. Cratty (1969) reports that the direction of locomotor veering could be predicted in about 90 percent of the cases by measuring *S*'s direction of "veer" when attempting to draw a straight line away from his body on a table top.

Leonard and Newman (1967) provide a brief description of a study in which *S*s were required to solve "detour" problems on a tactual map before attempting to solve them locomotorically. Although results are given for only six *S*s, there is some indication of a relationship between tactual map errors and the total amount of time required to negotiate the whole route. A subsequent report by Leonard and Newman (1970) describes a study of the use of various types of maps and deserves special mention here. Although there was no attempt reported to predict the success of the tactual map users from pretested tactual abilities, this study represents an extremely important direction in which the study of mobility skills should be pursued. Leonard and Newman discussed individual differences in the ability to use the various types of maps; however, they did not attempt to find performance predictors of individual mobility success. Expansion of research in this direction should prove extremely valuable.

Although not explicitly concerned with the relation between spatial relations abilities and mobility, a study by Witkin et al., (1968) bears implicitly on the issue. The study was directed primarily to evaluations of cognitive patterning of the blind. The authors used several tests of spatial relations and found significant correlations among the tests. The high degree of interrelation among spatial relations measures that are similar to those found by other researchers to correlate highly with mobility skills (such as Mills and Adamschick's report of Kohs blocks) suggests an underlying ability factor that may include both spatial relation abilities and mobility skills.

Several additional studies illustrate the training approach. Garry and Ascarelli (1960) included a section on "structuring extended space" in their training program for topographical and spatial orientation. A wide range of training experiences was provided, including ones directed to perception of surfaces, of objects and their relations to each other, and of the child's own relation to objects. A control group did not receive the training. On the spatial relations test (which, as noted earlier, included a variety of types of performance), the pretest to posttest improvement of the training group was highly significant, while the control group showed virtually no improvement. It should be noted that the control group performed much better on the pretest than the training group (42.7 vs. 16.5), and that despite the significant improvement of the training group, the control group still performed better on the posttest (46.7 vs. 31.1). The confounding of pretest performance with group assignment is an unfortunate weakness in the design of the research. However, it does seem unlikely that the entire pattern of results can be attributed to this point; the control group still could have improved substantially from its pretest performance before reaching the ceiling on the test (which was 60). In studies such as this, where there is clearly some pretest difference between groups and substantial variability within groups, it is of particular importance to try to find, in a *post-hoc* analysis, characteristics of individual subjects that are related to their performance. Extension of training studies such as that of Garry and Ascarelli to include specific evaluation of mobility skills as they may be influenced by the spatial relations training would be of particular benefit to the mobility literature.

In the report of training techniques by Turner and Siegel (1969), orientation training was included, but unfortunately no objective evaluation of the effectiveness of the training is presented. The training procedures specific to orientation included practice in making turns of 90°, 180°, and 360°, and using cues varying salience, such as a wall or the air currents produced by a fan. Trainees also crawled through tunnels designed to draw their attention to turns and orientation of body to environment. Although these training methods seem intuitively reasonable, and although the authors conclude that "this activity has proved useful not only to the student's learning program, but also to alert the therapist to specific concepts which the students lack or find difficult (p. 1363)," it would be of great value to others working in the field to have more objective evaluations available.

Cratty (1969) provides a report of a training study which does illustrate this added evaluative step. In this study, discussed earlier, 7 to 14 year old children participated in an eight week training program involving executing various turns and walking in a straight line. Feedback on the veering task was given tactually by having the child trace a piece of wire bent to the shape of the path he had actually traversed on that trial. For the turning trials, *S* was corrected by the trainer on each trial. The improvement in walking a straight line was about 24 percent over the course of the eight-week session, while the turn performance also "evidenced improvement which was significant (p. 171)." Pre- and posttests of triangular relocation were also administered, and although no direct training on this task was given, "the children evidenced a significantly improved ability (p. 171)" on this task as well. It should be noted that the improvement, although significant, still left the children far from perfect performance: the hypotenuse of the triangle measured 22 feet, and the improvement was from an initial mean error of 25 feet to a posttest mean error of 19 feet.

Two studies serve as examples of training in the use of spatial relations language. The study by Garry and Ascarelli (1960), described earlier, included a training section on language. Several aspects of training were given, dealing with distance, direction, relative location, geographic directions, etc. No separate evaluation was made of spatial relations vocabulary, but as noted earlier, very significant gains were made in spatial performance tests. Hill (1970) reports a study in which 7 to 9 year olds were given a three-month training session on the use of various spatial relations terms. The training consisted of using each word in each of a series of progressively more advanced contexts. Comparison of the pretest and posttest performance on functional use of the words showed that a significant improvement occurred for the training group. A control group that did not receive the training showed only minimal improvement.

Several points are in order by way of summary and comment on these spatial relations studies. First, although many writers stress the importance of spatial relations as a basis for mobility, the literature on spatial relations has unfortunately evolved without much reference to considerations of mobility. There are many studies of spatial relations: very few of them assess the extent to which mobility actually is dependent on spatial relations abilities. Simultaneous use of test of spatial relations and of mobility performance in future research should prove of great use to the mobility field. Second, it is impossible to overemphasize the need for adequate research design and objective evaluation in studies of spatial relations. Mobility trainers' impressions of progress made by their trainees are interesting but of limited value in assessing the relative effectiveness of different approaches. Finally, greater emphasis should be placed on the need for the study of individual differences in spatial relations as related to mobility. To what intent can an individual's mobility success be accounted for or predicted by his spatial relation abilities? This is a vital question: in order to answer it adequately, a wide range of individual characteristics that may be related to both spatial relations abilities and to mobility success should be evaluated. Although *post-hoc* analysis has its shortcomings, it can serve a valuable function in the study of individual differences.

IQ AND COGNITIVE FACTORS

The question of the importance of cognitive abilities for the mobility skills of the blind has received considerable attention, but apparently without a clear resolution. Some writers argue that the cognitive and memory demands placed on the blind person in connection with mobility are greater than for sighted persons. This idea seems quite reasonable. The discussion ensues from questions of just how dependent blind mobility is on what aspects of intelligence, and whether other factors can compensate for certain lacks. Elonen and Zwarensteyn (1964) point out that while much of the world presents itself to the sighted child without great effort on his part, the blind child must search more actively for information. Thus the blind child is more "dependent upon intensive effort by someone else to organize, explain, and interpret the myriad of confusing stimuli he encounters (p. 607)." These authors go on to point out that the intelligence demands on the blind child are manifest especially in the memory area. Leonard and Newman (1970) also stress the extra memory load for blind travelers.

Foulke (1971) notes that the blind person has to acquire a "schema" of any new environment in order to become effectively mobile in it. We would expand this notion by noting that the development of such a schema involves both paired associate and serial learning processes. The paired associate process is involved in the person's learning what stimulus configurations denote what objects and events. Learning the sequence of obstacles and path characteristics of an environment involves the serial process. Thus to the extent that IQ is related to these learning processes, it should be related to effective mobility.

The question of the relationship of intelligence to mobility is part of a much wider topic that has received considerable attention and that warrants a brief comment here. This is the question of the comparative overall intellectual or cognitive abilities of blind and sighted people. Does the absence of vision confer serious disadvantage on the blind person to the extent of lowering his overall cognitive functioning? Stated in this way, the question is certainly oversimplified. Intelligence is usually recognized as a complex set of variables that cannot necessarily be represented adequately by a single number. The question of comparison of blind and sighted people should be treated as similarly complex. In fact, as a simple question of intelligence (as measured by intelligence tests), it is virtually impossible to answer. The various tests of general intelligence used with sighted persons are usually comprised of several subtests, some of which are completely inappropriate for administration to the blind. Thus blind and sighted cannot be compared on these tests. There are also tests that have been developed primarily for use with the blind: these are probably not optimally appropriate for use with the sighted. Comparison of sighted (tested with regular IQ tests) and blind (tested with special tests) are also impossible because of lack of intertest standardization.

Still the question arises. Klein (1962) argues that "blindness itself does not necessarily produce cognitive or affective stunting. . . . Very likely this development is somewhat harder to achieve for the congenitally blind than for others. By and large, however, the cognitive achievements of blind people lead us to conclude that vision is a *medium* or *carrier* of information input, but not an indispensable medium (p. 83)." Witkin et al., (1968), in their study of cognitive patterning in congenitally blind and sighted children, found that the blind children were inferior in analytical competence (test of part-whole relation, similar to the Wechsler block design subtest), about equal to sighted children on verbal comprehension, and superior to the sighted on an auditory imbedded figures test. With results such as these, it is clearly a mistake to speak about an overall intelligence factor.

In a factor analytic study of the "ability structure" of blind and sighted adults, Juurmaa (1967) found some differences in the patterns of factor loadings. For congenitally blind adult males, an important factor emerged that was "clearly a general intelligence (g) factor." A similar factor emerged for partially sighted *S*s, but for sighted males, no such factor was found. Although the pattern of results was complex, it may provide some support for the notion, to be discussed later, that some aspects of intelligence may be more vital to the adequate overall functioning (and especially mobility) of the blind than they are for the sighted.

However inadequate comparisons of blind and sighted may be, there is no doubt that aspects of intelligence can be reliably assessed and scaled in the blind, or that relations between these factors and mobility factors can be explored to produce valuable results. We will consider first those studies that have directly evaluated the relations between intelligence factors and mobility factors, and then mention several studies which can be brought to bear indirectly on mobility.

Lord and Blaha (1970) cite results from the Detroit Metropolitan Society (1968) program bearing on the relation of IQ to mobility training success. Normal and above normal *S*s did not differ in mobility efficiency, while lower than average IQ was related to poor mobility. The result suggests that while a certain minimum IQ level is required for mobility, IQ improvements above that minimum level do not provide further benefit. Such a complex relationship is not usually reported, but it does not seem unreasonable. Bauman and Yoder (1966), in their retrospective factor study of vocationally well adjusted and poorly adjusted groups, found a significantly higher mean IQ in the well adjusted group. As was discussed earlier, the well adjusted group also differed from the other group in being independent in travel. Thus while the IQ-mobility relationship was not evaluated as a primary goal of the study, it did emerge secondarily. Patton's (1970) study of the factors characterizing students successful in mobility training lends support to this conclusion. Intelligence (evaluated either psychometrically or by caseworker) showed a 0.35 correlation with mobility performance ($p < 0.05$).

As an offshoot of their study on the effect of sensory pretraining on students' responsiveness to mobility training, Mills and Adamschick (1969) report a "rather high" correlation (specific numbers not reported) of the Stanford-Ohwaki-Kohs Tactile Block Design Test with the WAIS, but a "poor" correlation of the Kohs Blocks with the Hayes-Binet. They further report that the Kohs Block Test "does possess considerable merit when used as a predictor of success in Orientation and Mobility Programs (p. 21)." The block design subtest of the Haptic Intelligence Scale for the Adult Blind also receives mention as an effective predictor of mobility success. Gallagher (1968), for example, reports that for blind adolescents, correlations of the Haptic Intelligence Scale with staff evaluated mobility skills were significant. Finally, although only four to six *S*s were included per group-analyzed, data reported by Costello and Bledsoe strongly suggest a positive relation between IQ (WISC-verbal) and mobility ratings for congenitally blind children.

In these studies directly investigating the relation between IQ factors and mobility factors, two IQ factors seem to emerge as important, the spatial relations factor (HIS, Kohs Blocks) and the verbal factor (WISC-verbal). It seems reasonable to suggest that these factors may in fact relate to somewhat different mobility factors. As discussed in the previous section, spatial relations abilities are related to mobility because effective mobility may involve using a "spatial map" within which the individual's body position may be compared to the external spatial structure. Verbal ability, on the other hand, may be more related to the person's ability to effectively verbalize (verbally mediate) the sequences of actions involved in mobility, since memory tends to be verbally mediated. It would not be surprising, though, if a careful factor analytic study revealed identifiable separate verbal and memory factors that are related to mobility.

Several additional studies bear indirectly on the relationship between mobility and the spatial relations aspect of IQ. Berkson and Davenport (1962) found an inverse relation between IQ and frequency of stereotyped behaviors, in a sample of mental defective blind *S*s. Frequency of stereotyped behaviors was also positively related to self manipulation. It seems reasonable to suggest that these factors may be related to mobility via the spatial relations factor. That is, the preoccupation of the lower IQ children with self manipulation may prevent them from devoting sufficient attention to the structure of external space and acquiring the spatial relations concepts requisite for good mobility. Although he did not study IQ, Guess (1966) provides support for this argument as it applies to mobility. In a study also not directly concerned with mobility, Miller (1969) found that performance on Piagetian conservation tasks (substance, weight, volume) was highly correlated with IQ in six to 10 year old blind children. Inasmuch as the conservation tasks tap certain aspects of the child's knowledge about the characteristics of objects in space, Miller's study may provide another indication that lower IQ children acquire less information about the world. Mobility, as was argued earlier, depends on the development of effective concepts of self and of space, and to the extent that either type of concept is deficient, mobility may be inadequate. Cratty (1970) provides a corroboration of the self-concept or body image aspect of this formulation in his report of a positive relationship between IQ and adequacy of body image.

Warren et al., (1973) argue that IQ may be more important in spatial behavior for the congenitally blind than for the adventitiously blind. This argument applies especially to the spatial relations aspect of IQ, but the verbal aspect is also involved. They argue that the early vision of the later blind may provide them with a more organized frame of reference for or conceptualization of space. The later blind may thus be able to mediate their spatial behavior without being especially high in verbal IQ, whereas the congenitally blind depend more on verbal mediation. Thus although the spatial relations and verbal factors of IQ may be identifiably different, they may be interdependent in their significance for mobility.

In summary, the question of the relation of general IQ to mobility is probably irrelevant. However, several subfactors of "intelligence" seem quite important for mobility. Research should be directed to the specific ways in which these factors may provide a basis for mobility, and to a search for the most effective ways of preventing unnecessary deficiencies in these factors by careful studies of early experience.

PERSONALITY AND SOCIAL-ENVIRONMENTAL FACTORS

In reading case reports of blind persons, one is continually impressed with the recurring mention of personal independence as a factor in mobility. Mobile individuals tend to score higher on measures of personal independence than nonmobile individuals. The same tendency appears in the literature for children. The families of more active and mobile children are often described as supportive and encouraging of the child's independent exploration. Families of more passive, less mobile children are described as overly protective, sheltering the child, and excessively concerned with the fact of his blindness. These observations suggest issues in the final category of factors related to mobility, personality factors. We will deal with two interrelated aspects of this topic. First, are there personality characteristics, besides independence, that are found to correlate with good or bad mobility? Can we draw a personality profile of the effectively mobile person, and will it differ from that of the nonmobile person? Assuming that there are identifiable characteristics, the second aspect of the topic is, what childrearing procedures can be identified as producing a child with the poor mobility profile, and what procedures produce the better profile? Although there is very little research directed toward this extremely important problem area, we will intersperse available material on childrearing procedures wherever appropriate in this section.

The danger of the cause-effect implications of these questions must be recognized at the outset. Certain personality traits may be a *result* of poor mobility, rather than a *cause* of it. For example, Wilson (1967) notes that "the immobile person will manipulate others to satisfy his needs, thereby protecting and fostering the extreme dependency (p. 287)." The implication, and probably correctly so, is that dependency is both an effect of immobility and a past and ongoing cause of it. The situation can be expected to be similarly complex with any personality characteristic found to correlate with mobility. A person does not acquire his total personality and then either become mobile or not, nor does he develop his personality wholly after his mobility characteristics are established. Rather, the two evolve together, and the cause-effect relations will typically be difficult to unravel. It is useful, though, to review the evidence for personality factors in mobility. The person who becomes blind after a number of years has a difficult task of adjustment ahead of him. As Knowles (1969) suggests, "a certain amount of time is required after the onset of blindness for the person to recover from the shock of his disability and establish a new self image (p. 135)." By knowing something about the personality characteristics associated with bad and good adjustment, and about the social-environmental factors that influence these characteristics, we may be in a better position to help the client as an individual.

Several studies have searched in retrospect for factors, especially ones related to personality and social adjustment, that are associated with good mobility. Graham's (1965) paper, cited earlier, falls into this category. Subjects were 100 blinded male veterans, contacted through outpatient clinics of the Veterans Administration. The activities of the *S*s were evaluated and rated with an emphasis on mobility-related activity. After a rank ordering of the 100 composite scores, quartiles were determined. Much of Graham's analysis concerns the comparison of Q1, the lowest activity group, with Q4, the highest activity group. Factors on which these groups were significantly different included age (recognized as a variable having complex interactions with other relevant variables), age at loss, independence (as evidenced by whether the *S* considered himself the head of the household), self-image or attitude toward blindness, and health patterns. Not surprisingly, the Q4 sample were better off financially and were more upwardly mobile in their jobs. A social-environmental factor that was a significant discriminator between Q1 and Q4 was "a supportive and stable family condition."

Patton (1970) reports a promising attempt to identify variables that are associated with mobility training success in adventitiously blind adults. A set of 14 categories was developed, divided among three general headings. These categories are listed in Table 1. Medical reports provided information in some of the categories, while some information could be obtained by simple interview questions or observation. On six categories, judgments had to be made by a caseworker. Interjudge reliability ratings produced 84 percent agreement between two caseworkers.

TABLE 1

Patton's (1970) Item Battery, with Correlations of Each Item to Mobility Performance Score

Physiological	
Health	0.22
Hearing	0.08
Stability of eye condition and treatment	0.10
Psycho-social	
Intelligence	0.35*
Income and housing	0.10
Supportive home milieu	0.22
Motivation for training	0.33*
Need for training	0.37*
Adjustment prior to blindness	0.22*
Emotional	
Freedom from depressive episodes	0.22
Realistic acceptance of eye problem and current visual acuity	0.40*
Willingness for friends, relatives, and community to know blindness	0.33*
Willingness to leave home area with human guide	0.48*
Acceptance of white cane	0.30*

After the refinement and reliability checking of the categories, 61 adults who were undergoing mobility training were evaluated. (It is not clear from the report whether the mobility readiness battery was administered before, during, or after the mobility training itself, although it seems probable that this evaluation was performed at least in the early stages of the mobility program.) The client's overall readiness score was taken as the sum of his scores on the 14 categories. Mobility performance was rated by the program peripatologist. The correlation of the overall readiness score with the mobility score was 0.49 ($p < 0.01$). Thus the 14-item battery, taken as a whole, was reasonably predictive of mobility performance. The correlations of each of the readiness categories with the mobility score appear in Table 1. The eight starred categories in Table 1 are those factors that Patton concluded to contribute most to the predictiveness of the overall readiness score. With the exception of the intelligence factor, these items all deal with some aspect of the individual's personality or his attitudes toward his blindness.

In a study of similar design, Bauman and Yoder (1966) compared three groups of *S*s, varying in vocational success, in an attempt to identify personal background factors that may have been related to the achievement of vocational success. This study is of interest to this review because in addition to the primary criterion of vocational success, *S*s included in the high success group were also selected by independence in travel. In contrast, the low success *S*s were also selected for poor travel ability. An intermediate success group need not concern us here. Interviews and agency data, as well as the results on various performance tests, were analyzed. The successful group had higher IQ (Wechsler verbal) and was superior on manipulative ability and personality scores, but there was no difference on an interest inventory. The home and family situation of the successful group was generally better. These *S*s were less dependent, were more likely to be married, and reported both more enjoyment of family life and less concern with and attention to the fact or degree of their blindness. With respect to this last point, there was no pattern of difference in type, degree, or onset of the visual disability. Finally, the more successful group showed a much more satisfactory pattern of social involvement outside the family, as evidenced by memberships and activity in social organizations. Bauman and Yoder conclude that "much the greatest factor in freedom of travel, other than retained vision, is the combination of good mental ability and certain personality characteristics (p. 74)." Furthermore, and related to the question of the social-environmental factors, Bauman and Yoder found that the more self-sufficient and mobile individuals tended to come from families which did not make a big issue of the fact of blindness: "the pattern of family relationships is more likely to be the pattern it would have been had the individual had normal vision (p. 69)."

The "independence" factor that appears in all three of these studies seems related to the mention by Fraiberg and Freedman (1964) of a relationship between mobility and activity (as opposed to passivity). Another characteristic that is, not surprisingly, related to successful mobility, is an "outgoing personality." Trevena (1971) and Costello and Bledsoe (n.d.) note that part of successful mobility involves being able to ask questions, to be willing to engage in interpersonal exchange. The extreme introvert is at a clear disadvantage. Costello and Bledsoe also found that a good parental attitude was significantly related to mobility success in their fifth and sixth grade *S*s. Finally, Harris (1967) found that low anxiety *S*s veered significantly less in a straight-line walking test than high anxiety *S*s.

Thus if we were to draw the personality profile of a person who would be expected to be successfuly mobile, it would include some or all of the following characteristics: active, independent, not anxious, interpersonally at ease, mobility-motivated, with a "healthy" attitude toward his visual loss. Several of these characteristics are clearly not independent of one another, but the overall constellation is clear and not particularly surprising in any respect.

Although we will deal more with the question of the social environment in the next section, a preliminary summary of these factors is also in order. The families of successfully mobile individuals would be, first and foremost, supportive and encouraging of the individual's mobility attempts and his quest for independence. They would be neither overprotective nor too demanding. They would, as much as possible, treat the individual as though he were sighted, with a minimum of attention paid to his handicap.

SEQUENCES OF ABNORMAL DEVELOPMENT

We have reviewed literature relating mobility to several classes of factors, including perceptual, cognitive, and personality and social-environmental factors. The use of such a classification scheme does not confer separate identities on these areas, however. Development proceeds simultaneously along various fronts that merge continuously into one another. We cannot, except as a temporary expedient, deal with a child's perceptual development as isolated from his cognitive development, or his cognitive development as isolated from his personality development. It seems useful, therefore, to bring these sections together by considering several overall developmental sequences that can be identified as leading to poor mobility preparedness. The several sequences are by no means independent of one another, as will become clear, but it is convenient to deal with them separately. Several of the factors that are involved appear in more than one sequence: this should serve simply to emphasize the fact that development must ultimately be considered a multivariate process, rather than as a number of separate progressions.

One possible sequence is as follows: deprivation of adequate sensory and social stimulation from the external world leads to an overinvestment of the child's energy in self-stimulation, which leads to a failure to differentiate effectively between self and environment, which prevents the child from acquiring useful spatial relations concepts, making it more difficult for him to become effectively mobile within the external world. There is some documentation for each of the steps in this sequence. A number of writers point out that the blind child tends to receive less total sensory stimulation from the external world (Wills, 1970; Burlingham, 1961; Eichorn and Vigaroso, 1967). Understimulation from the external world tends to produce greater investment of energy in the child's own body. Smith, Chethik, and Adelson, (1969), for example, view blindisms as evidence of the need to keep total stimulation, lacking from the external world, at a high level by self-stimulation. Thompson (1969) and Fraiberg (1968) make similar points. (It is important to note that Sandler (1963), in discussing several cases of actively mobile children, points out that the parents tried to discourage eye-rubbing, for example, by placing objects in the child's hand to divert his attention. It is undoubtedly possible to optimize the external stimulation and thus decrease the tendency to invest excessive energy in self stimulation.) To deal with the final steps in this abnormal sequence, we refer back to the sections on body image and spatial relations, where it was argued that an effective establishment of body image is necessary to serve as a basis for acquisition of concepts of spatial relations.*

Another way of talking about one aspect of this sequence is in terms of "locus of control." According to Land and Vineberg (1965), "internal" locus of control individuals perceive themselves as in control of their environment, while "external" locus of control means that control is perceived as external to, or independent of, the person's behavior. Land and Vineberg found that blind children are significantly more characterized by external locus of control than sighted children. Sandler (1963) speaks of a similar characteristic of some blind children in terms of the lack of a "creative drive toward, or interest in, the progressive mastery of the outside world (p. 345)."

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*It is interesting again to note the commonality of ideas, but differences in vocabulary, of the psychoanalytically-oriented and other writers. One writes of ego-differentiation, while another speaks of establishment of body image and spatial relations concepts. The phenomenon that they describe is the same--different use of terms should not necessarily be interpreted as a difference in concept.

Interestingly, McGuire and Meyers (1971) note that "blind children commonly exercise a form of control by withholding cooperation and compliance, refusal to learn, . . . (p. 140)." It may be that this characteristic is a reaction to lack of control over the environment: in any case, the effect is often that the blind child is less effectively in control of his environment, or perceives himself to be less in control, and thus is less effectively mobile.

Another major abnormal sequence is related to the previous one in that the child is not well prepared with spatial concepts or thus with the groundwork necessary for effective mobility. In this sequence, the failure to develop adequate spatial relations concepts stems from a lack of adequate exploration of the environment. Fraiberg and Freedman (1964) note that blind children tend to engage in a more restricted form of environmental exploration. Similarly, Wills (1970) points out that "blind children cling to the familiar, especially in those areas where blindness interferes with mastery (p. 466)," and Parmalee (1966) advises "the mother to give the blind infant as much stimulation by way of touch, sound, and movement as possible; to keep encouraging her to give the child independence of action. . . (p. 178)."

The child's failure to explore the environment may stem from either of two major factors, 1) familial overportection, or 2) failure of the child to establish an adequate "security base," which in turn may (at least theoretically) be attributed partly to a failure to establish a solid social attachment. Many writers note that familial overprotection is often associated with cases of inadequate mobility (Burlingham, 1964; Lord and Blaha, 1968; Langley, 1961; Bauman, 1964; Thompson, 1969). Consideration of the second factor often begins with mention of Harlow's work with social deprivation of monkeys, as well as of studies of the effects of institutionalization on human infants. One of the characteristics of institutional environments is a lack of social stimulation and social reinforcement, leading in many cases to deficits in social attachment, or the ability to establish close interpersonal relationships. The Harlows' (1962) experimental work on the effects of social isolation in monkeys provides significant support for the idea that a firm emotional attachment is necessary in order for the infant to "feel secure enough" to engage in environmental exploration. The Harlows' work is cited directly by some writers on the blind (e.g., Klein, 1962) and similar notions appear in several other sources. Lowenfeld (1956) notes that "children who are unwanted, unloved, and rejected may be severely damaged in their ego development (p. 55)." Klein (1962) writes "given adequate ego surrogates, a blind child can develop into a much more sturdy adulthood than a sighted child reared in a context of affect deprivation (p. 87)." Several authors point to the importance of varied sensory stimulation in the formation of attachment bonds: McGuire and Meyers (1971) note that vision is important in the attachment of sighted children, and thus conclude that there is "an unusual risk of difficulty in early personality formation in the congenitally blind (p. 138)." Emphasizing the role of the remaining mobilities, Fraiberg (1968) writes that "not blindness alone but tactile-auditory insufficiency in the early months will prevent the blind baby from making the vital attachments to his mother and to the human world (p. 266)." Again, on a more positive note, Sandler (1963) notes that warm maternal care tends to be associated with cases of active, mobile children. It seems not unreasonable to argue that the establishment of strong, early, social interpersonal ties in blind infants may provide the infant with secure emotional security which may serve as a strong base for his active exploration of the external world, thus leading to the effective establishment of a basis for acquisition of the spatial relations concepts vital to mobility.

While on the topic of interpersonal relations, a minor (but potentially abnormal) sequence should be discussed briefly. In an earlier section, an aspect of the necessity for adequate interpersonal capabilities in adolescent and adult mobility was noted: the individual needs to be comfortable enough in interpersonal situations to be able to ask questions where appropriate, such as what is the name of this street? This interpersonal ease is not unrealted to early social experience. Some writers (Hallenbeck, 1954; Fraiberg, 1968) note the importance of strong one-to-one early personal relationships for later adjustment in social situations. To the extent that inadequate social attachment lays the basis for inadequate later social ease (Fraiberg, 1968), the child who fails to establish effective early social bonds may be at a disadvantage in later mobility.

Several other factors deserve mention in connection with early treatment of blind children and their mobility. In connection with the anxiety factor mentioned earlier, the way that the child's early fears of exploration are handled may have a lasting effect. For example, Wilson (1967) notes that the fears attendant to the child's curiosity and exploration "may cause irreparable emotional trauma if not handled properly. Much of the fear in blind children is parental fear communicated to the child. This fear reduces his self-confidence (p. 284)." In a similar vein, Burlingham (1961) points out that the blind child has less attention and concentration to devote to his perceptual experience if he is not in a state of "emotional equilibrium." Overcriticism may also produce unwanted effects: Curtin (1962) notes that in mobility training, overcriticism and the demand for attainment of too-high standards may make the trainee tense and anxious. The same point undoubtedly holds for younger children as well. To be sure, the line between overcriticism and permissiveness is a difficult one to draw in practicality. Both extremes are undesirable. So, too, are the extremes of parental overexpectations for independence and parental overprotection.

DISCUSSION

Some of the literature reviewed in this paper was directed specifically to formal mobility training, while much of it was directed to the more general concept of mobility as represented by the opening quote by Foulke (1971). With respect to the question of formal mobility training, one may ask what are the capabilities that the child entering formal mobility training should have. According to Kenmore (1960), "the time at which a child is ready for cane instruction depends not only upon his chronological age but also upon his ability to locate, discriminate, and make use of sound, his interest in physical freedom, his body-knowledge of the world immediately around him and many other factors. . . the majority opinion seems to be that blind children may be ready to learn to use the cane somewhere between 11 and 13 (p. 29)." But blind children do not automatically have the appropriate capabilities by age 11, and it is the responsibility of the parents and professionals who deal with blind children to ensure that they are given every chance of acquiring the requisite capabilities. Hapeman (1967) points out that many blind children, especially congenitally and early blinded children, are not adequately prepared for mobility training. He notes that if blind children could acquire a set of basic concepts and abilities early in life, the attention of the mobility specialist could be appropriately devoted to the teaching of specific travel skills.

How realistic is it to think that we can provide the child with the experiences that will adequately prepare him for mobility? Much of the material reviewed in this paper indicates that this goal is not an unreasonable one. Although there are definite gaps in the available knowledge, it is clearly possible to identify factors that are associated with mobility success. These factors range widely from perceptual through cognitive and language abilities to personality and social environmental characteristics. Furthermore, and quite importantly, it is certain that we can in many of these areas exercise the influence that is needed to produce the relevant characteristics. We can provide the blind child with the stimulating sensory environment that he needs to develop his nonvisual senses to their optimum. We can provide him with a speech environment that is conducive to his acquisition of a language that is useful in mediating his representation of the physical world as well as his social relationships with other people. We can certainly influence his attitudes toward his blindness.

It is noteworthy that virtually all of these types of mobility-related factors undergo significant development in infancy or very early childhood. This is true for perceptual functioning, for the bases of cognitive growth, for language acquisition, for attitudes, and for modes of social interaction. It may well be that at least for the congenitally or early blind child, broad limits are set on his eventual mobility success in the first five years of life, long before formal mobility training begins.

Clearly much research needs to be done on the factors that prepare the blind child poorly or well for mobility. We simply do not know enough to be able to specify the details of how to deal with the blind child, although we can, as noted at various points in this review, provide at least a broad outline for such treatment. The psychoanalytically oriented writers have long recognized the importance of early experience for all children, and their concern with the early experience of the blind child has provided important information and hypotheses. For example, both Burlingham (1961) and Fraiberg (1968) have noted that some aspects of the development of blind and sighted infants are virtually identical for at least six months, and only diverge after that time. The divergence that occurs seems particularly significant for mobility--there is adequate external stimulation for the sighted child to crawl and reach outward into the environment, while the blind child may, at the normal time of the onset of locomotion, fail to be stimulated to the experience that is vital in establishing an effective differentiation between self and externality. With well designed and executed and carefully evaluated research, we may be able to discover ways to enhance the blind infant's experience at the appropriate times so that his visual handicap is a less significant aspect of his life. Our being able to do that research will depend to a large degree on adequate definitions of the problems needing research, however. Here, again, the careful and thorough observations of the psychoanalytically oriented writers serve as a useful model. For instance, Fraiberg concludes that the blind infant begins to regress at the onset of locomotor behavior because auditory and tactile information do not adequately define objects in the external world. This formulation should be treated as a hypothesis, not as final truth. As a hypothesis, it gives us hints about what we might try, and when we might try it, in order to bring the blind child successfully past this critical stage. It is not sufficient to accept Fraiberg's formulation as final: we must follow its implications and evaluate the results of our interventions. Although they are perhaps less well defined than this particular example, there are other suggestions in the literature for similarly critical times in the blind child's development, and these should also generate interventions and evaluations.

It is especially important to be imaginative in research and evaluation approaches with the blind. We should not neglect to study carefully such naturally occurring situations as the case of identical (or fraternal) twins, one of whom is blind and the other sighted. These situations are rare, but when they do occur, careful evaluation would prove of great benefit to the field. In talking about types of evaluation, we have to be realistic as well as imaginative. Although many questions about the abilities of the blind are amenable to treatment in the laboratory, many other questions are not. The dimensions of importance in blindness are many, as has become evident in this review, and multivariate evaluation approaches undoubtedly hold more promise than univariate methods. That much of the important information needs to be gathered outside of the laboratory should not be allowed to cloud the fact that the most useful information is that which is carefully gathered, quantified, and subjected to reliability procedures. As was pointed out earlier in this paper, the subjective impressions of those who work with the blind are valuable to a certain extent. But in order to develop a useful theoretical framework for mobility, as well as for other systems of behavior, we will need more than subjective impressions. We will need reliable information, carefully gathered and carefully shared.

On the basis of the material reviewed in this paper, it is certainly reasonable to be optimistic about our chances to influence the blind child to become able to "travel safely, comfortably, gracefully, and independently." The success of this venture will depend on our conduct of relevant research, on the development of applications from that research, on the evaluation of those applications, and on the continuing interplay among research, applications, and evaluation.

ACKNOWLEDGMENT

We wish to thank Joanie Kocon for her valuable assistance in conducting the literature review.

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HAPTIC AND VISUAL PERCEPTION OF SHAPES THAT VARY IN THREE DIMENSIONS*

Richard M. Baird**

The perceptual capacities of individual sense modalities and the functional interaction between them represent the primary sources of information about basic perceptual mechanisms. The interrelations between the haptic and visual perceptual systems have been profitably studied in this regard (Gibson, 1969). The two studies reported here were designed to explore this relationship further, and to clarify the effects of various stimulus parameters and inspection techniques on haptic perception. The results are of significance to the design of educational aids and materials for the visually impaired.

Both of the experiments reported herein involve stimuli which vary in three dimensions and which can be picked up and manipulated with the fingers. This may permit a more thorough evaluation of the haptic capacity for pattern perception than stimuli which vary only in two dimensions and/or those that cannot be picked up (such as patterns of raised lines or raised dots) since it maximizes the amount of kinesthetic stimulation that informs haptic perception. In neither of these studies was a limit placed on the amount of time a given stimulus could be inspected, either haptically or visually. Subjects were encouraged to take all the time necessary to insure that their responses were correct. This was done to eliminate a possible source of bias due to the generally more rapid scanning rate of the visual system.

EXPERIMENT I

Experiment I was designed to assess the abilities of the haptic and visual systems to discriminate shapes varying in three dimensions intramodally, as well as intermodally in combination. Both simultaneous and successive discriminations were included in the above conditions.

Method

Sixty college students with normal vision served as subjects. The stimuli were five pairs of molded

*Text is based in part on a dissertation entitled *The Haptic and Visual Capacities for Perceiving Shapes that Vary in Three Dimensions* submitted by the author in partial fulfillment of the requirements for the degree of Doctor of Philosophy to the Department of Psychology, University of Louisville, 1973.

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ceramic shapes of the same surface texture. Each shape was uniformly painted flat black, varied randomly in three dimensions, and displaced a volume of 58 ml ±2.

Subjects were presented with two stimuli and allowed to inspect them according to the appropriate method. They then indicated whether the stimuli were of the same or different shape. Intermodal discrimination involved presenting one stimulus visually and the other haptically. During simultaneous discriminations, both stimuli were available for inspection at the same time. During successive discriminations, the subject was allowed to inspect only one stimulus at a time, but could shift back and forth between stimuli as often as desired. Hence, successive discrimination places a somewhat greater memory load on the subject than does simultaneous discrimination. For visual inspection, subjects were provided with a set of tongs with which to manipulate the stimuli so as to minimize the amount of stimulus information available haptically. The experimental design was a 2 x 3 factorial combination of discrimination types (simultaneous or successive) and inspection conditions (intramodal haptic, intramodal visual or intermodal haptic-visual).

Results and Discussion

Analyses of error data indicated that simultaneous discrimination was significantly easier than successive discrimination ($F[1,54] = 15,02$, $p < 0.01$). This was true even though the interstimulus interval was typically less than one second and the subjects were free to reinspect the stimuli as often as they wished. Since it has been demonstrated previously that varying the retention interval from 1 to 30 seconds has no effect on subsequent recognition performance (Garvill & Molander, 1972), it appears likely that the differences in performance between simultaneous and successive discrimination reported here were due to differences in the types of information acquired and possibly the manner in which that information is processed, rather than the stability of the memorial representations of the stimuli involved.

The analyses also indicated that performance with intramodal visual inspection was significantly better than performance with either intramodal haptic inspection or intermodal haptic-visual inspection ($F[2,54] = 12.99$, $p < 0.01$). Performance in the latter two inspection conditions did not differ significantly. This indicated the relative superiority of the visual system and suggested that the exchange of information essential for intermodal discrimination occurred without detectable inefficiency when compared to the least efficient of the perceptual systems invclved.

EXPERIMENT II

Experiment II was designed to assess the relative efficiencies of intramodal and intermodal transfer of identification learning and indicate the relative contributions of general and specific factors to intermodal transfer. Also assessed was the symmetry of intermodal transfer.

Method

Eighty college students with normal vision served as subjects. The stimuli were 20 polished stones, each uniformly painted flat black, and varying randomly in three dimensions. No two were identical. Each stimulus displaced a volume of 3 ml ±0.3.

Subjects were first successively presented with a set of ten stimuli and the differentiating response (a number or letter) for each, using an anticipatory self-paced paired associate paradigm. A criterion of one errorless trial was employed. The stimuli were inspected either by touch alone, by vision alone, or by touch and vision in combination. Following a one-minute rest interval, the subjects were then required to learn either the same stimulus-response set or a different set to criterion. Stimuli were inspected either haptically or visually during this second phase.

Results and Discussion

Positive and generally symmetrical intermodal transfer was obtained. The contribution of general learning factors to this effect was negligible. These findings are in general agreement with those reported by Clark, Warm, and Schumsky, (1972), and suggest that intermodal transfer involves the learned perceptual significance of the stimuli and not nonspecific or mediational components. The symmetrical nature of the obtained transfer contradicts Gaydos (1956) and Walk (1965), both of whom reported significantly better transfer from touch to vision. While a clear explanation of this incongruence does not seem possible at this time because of differences in methodology, symmetrical transfer has been obtained with the use of both stimuli that vary in two dimensions and those that vary in three dimensions, and seems to be the more general finding. This symmetry suggests that the representational stimulus information is stored independently of the input modality and is equally accessible when either touch or vision is the non-input modality.

Intermodal transfer was found to be significantly less efficient than the empirically established level of intramodal transfer in this task ($p < 0.01$). This suggests that the representational information is not a perfect mediator of intermodal performance; the bridging of perceptual systems is clearly possible, but not perfectly efficient. The severity of this inefficiency, however, is independent of the direction of information transmission.

A comparison of transfer following combined haptic and visual inspection during training indicated that when touch and vision are used in combination, the haptic system functions as an additional channel of information, and not in a purely manipulatory role. The result in this experiment was faster acquisition during the training phase and better transfer performance in the second phase. In terms of unimodality performance, acquisition was accomplished in fewer trials with visual inspection than with haptic inspection, again reflecting the relative superiority of the visual system.

GENERAL DISCUSSION

The argument might be raised that since the subjects who partipated in these two experiments were normally sighted, they had had little experience in obtaining information by touch, and that performance which depended on touch was poor as a result of this inexperience. In an earlier study, however, Foulke and Warm (1967) found normally sighted subjects to be as successful as braille readers in identifying patterns of raised dots at a 6 x 6 level of complexity by active touch. Additionally, the failure to obtain a significant effect due to general learning factors in Experiment II of this study provides further evidence which is inconsistent with such a position.

The results of this study can be accounted for, in large part, by differences in the sensory capacities of the two perceptual systems involved, and are consistent with the hypothesis that information acquired by the two perceptual systems is handled by a single central processing unit. These results confirm the relative superiority of the visual system, which acquired more and/or more accurate information than the haptic system. This advantage was still clearly evident despite the absence of external time restrictions which might have otherwise limited haptic perception. Similarly, the stimuli utilized in this study, which varied in three dimensions, afforded no detectable advantage. This suggests that more conventional stimulus arrays varying only in two dimensions, such as patterns of raised lines or dots, can be very satisfactorily utilized in haptic aids for the visually impaired *provided* they conform to the psychophysical standards for legibility. It also seems reasonable to suggest that instructional aids and programs rely upon simultaneous comparisons rather than successive comparisons where possible, since stimuli presented for inspection simultaneously are more accurately discriminated.

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COMPUTERIZED BRAILLE PRODUCTION IN DENMARK

Svend Jensen*

The project for construction of a modern braille production center using computers has now been in existence for 4 months. The plan is to have the center ready for production by October 1974.

At the moment the following machines have been ordered to be installed in the center:

PDP 11/10
- 8 K memory
- Teletype console terminal
- 9-track tape unit
- Lineprinter interface

IBM 2821 Control Unit

IBM 1403/1100 Lines-per-minute lineprinter

IBM Lineprinter Braille Option

The translation of ink print text to braille will be performed at a service bureau using an IBM 370 computer. The programming language is FORTRAN IV. The output from the translation is on a magnetic tape, containing the ink print text and the translated braille codes.

The tape is the master book, which is kept in the library of the production center. Each time a copy of the book is ordered, the magnetic tape is mounted on the PDP 11/10 tape unit. The PDP 11/10 will then read the book, and print it in braille on paper using the IBM 1403 Line Printer. Finally the book is inserted in a ring folder without special binding.

On February 1 the system documentation of the braille translation program was ready. The documentation is in English.

*Danish Association for the Blind
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PEOPLE WITH SENSORY HANDICAPS

(English Summary from Maend Med Synshandicap)*

Ole Jensen

Hans Tage Truelsen

SUMMARY OF THE STUDY

The number of blind persons and those with strongly reduced sight in Denmark has been estimated at between 7,000 to 8,000 persons, equalling approximately 1-1/2 promille of the population. Only about ten percent of the visually handicapped adults is doing actual paid work; the rest derive their incomes mainly from disability pensions and/or, if married, from the earnings of their spouses.

All visually handicapped persons (the blind and persons with strongly reduced sight) receive their elementary schooling and occupational training at the State School for the Blind and Partially Sighted, and their higher education and further occupational training mainly at the State Institute for the Blind and Partly Sighted at Copenhagen or, to some extent, at the rehabilitation centers. The Danish Society of the Blind, the visually handicapped persons' own organization, looks after their general financial interests, and in dealings with the public authorities, as well as carrying out comprehensive information, cultural and advisory services for visually handicapped persons.

The problems of the visually handicapped, especially during the past decade, have shifted from economic to more psychological and social effects as a consequence of their handicap. This research is a qualitative socio-psychological study on these effects, and includes the practical difficulties and problems encountered by the visually handicapped, the role in society of a visually handicapped person, their role conflicts, the manner in which they accept their handicap and an elucidation of mental well being** of visually handicapped persons. Thus, the study has a psychological rather than a sociological character of the many studies into the conditions of visually handicapped persons carried out so far in this country.

The study encompassed 100 visually handicapped men who have been divided into four groups in accordance with whether the reduction of sight has supervened early or late in their

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*Jensen, Ole, and Truelsen, Hans Tage. Summary of the study and social-educational reflections. *Maend med synshandicap*. Copenhagen, Denmark: Mentalhygiejnisk Forskningsinstitut, 1973. (Publication No. 6), pp. 93-103.

**Mental well being is used here (for lack of a better term in English) as a translation of the Danish term "trivsel" which is of the same origin as the English verb "to thrive." The Danish concept "trivsel" has a broader meaning including mental well being and job satisfaction. (Petersen, E., 1967, 1968.)

lives (for the purpose of this study this should be taken to mean before or after the commencement of an occupational training by a full-sighted person) and also in accordance with whether or not the person is doing any actual paid work. All persons taking part in the study are former students from the State Institute for the Blind and Partially Sighted at Copenhagen. The finding may, therefore, not be applied direct to all visually handicapped men in Denmark, one reason being that, on an average, more of the men taking part in the study have paid work; but the study is representative of the visually handicapped men who have received their education at the State Institute for the Blind and Partially Sighted at Copenhagen during the past two decades.

It is misleading and also unfortunate from a social point of view to apply the concepts "blind" and "blindness" as a general description of persons with a visual handicap and those with badly reduced sight. The importance of the visual handicap to the person concerned will depend not only on the degree of his impairment, but far more on his own attitude to his handicap, as well as on his environments and whole living conditions. The use of concepts like "blind" and "blindness" may thus serve to disguise the great individual variations that exist among the visually handicapped.

Being a sense for the perception of distance, the sight is of great importance for the performance of the so-called locomotive actions, that is to say actions that have to do with the control of the body in relation to objects in the surroundings. In the case of persons with strongly reduced sight this field of action is greatly restricted. The reduction of sight also affects to a more or less degree the actions known as the manipulatory actions, that is to say actions that have to do with moving or holding on to objects. In the case of communicating actions, that is to say actions that are instrumental in bringing about an exchange of thoughts and ideas between persons, only certain sections are affected by a reduced sight; for example, reading and writing. The reduced possibilities of the person in question to visually perceive the actions, facial expressions and gestures of other people will also have a bearing on whether he will be able to participate in certain situations of communication and social gatherings. The reduction of sight thus gives rise to many difficulties and problems which are common for all handicapped persons. For one thing, they are all limited in the possibilities of being able to perform a variety of activities. Other problems are more related to certain groups of visually handicapped men.

The difficulties are making themselves felt in various situations of life. For nearly all visually handicapped persons it is a serious problem to move in the traffic, and the risk of being involved in light accidents or run down by a car has increased tremendously during recent years due to the heavy and more intensified traffic, the large number of parked cars, etc. Many visually handicapped persons have great problems when going about their daily practical business, such as shopping, especially shopping for clothes, the normal daily housekeeping, washing and looking after their clothes, etc. The leisure of the visually handicapped man is characterized by his limited possibilities of activity as a result of his handicap. Great problems are also encountered by many visually handicapped men at their places of work, and they have certain difficulties in various situations with regard to their relationship with other people. These facts will be more thoroughly dealt with later.

Many of the difficulties mentioned above are not only direct effects of the visual handicap, but they become exaggerated due to social disapproval.

Although the difficulties may be more or less severe for different groups of visually handicapped men, it would appear that certain features are general for all. They have to use more energy and time for the performance of their actions, they have to concentrate more for being able to perform these actions and they are generally more dependent on other people. The first two facts could very easily result in a tendency to increased strain in the visually handicapped, whereas the third fact may lead to a life, either in virtually total dependency on the goodwill of people with their sight or to social isolation from these. But it will all depend on the attitude of the visually handicapped man to his problems.

The visually handicapped man is faced every day with strong preconceived apprehensions from sighted persons with regard to his qualities as a person, and what he can or cannot do now that he has become visually handicapped. Thus, the visually handicapped men experience that sighted people--who have no actual knowledge of the visually handicapped persons--impose upon them a certain social role--a role which they certainly expect the visually handicapped persons to play. The (experienced) social role of the visually handicapped man may be expressed as follows:

1. We (the sighted) expect that you, because you cannot see, will not be quite normal as a human being either. In any case we do not expect you to be as clever as we are.

2. We expect that, due to your visual handicap and to your poorer abilities, you will not be able to participate in our general social life in a natural and relevant manner.

3. We expect you to be unable to work.

4. We expect you to be unable to cope on your own with a great many of such actions as are normal for us in our everyday life.

5. We expect you to suffer because of your visual handicap and of the situation it has brought upon you.

6. We, therefore, expect you to stand in grave need for help, both of economic help to cope with situations in your everyday life and practical business.

7. We expect you to show gratitude for the economic support and for any other help you are receiving.

The sighted generalize this role from one handicapped man to the next, and their preconceived apprehensions are automatically aroused when they see a person carrying the signs of the visually handicapped, such as yellow armband, white stick or guide dog. The role of a visually handicapped is thus believed to be the same for all, irrespective of the really wide individual differences among these persons.

On basis of this preconceived apprehension of the visually handicapped, and due to a lack of knowledge of their conditions, the sighted will often become uncertain when meeting visually handicapped persons as to whether or not they should offer help, and if so what kind of help is needed. This may easily lead to a situation in which the sighted person either draws away from the visually handicapped person or sets in with exaggerated help--a help which in spite of its good intentions may be irrelevant and so become a strain on this particular person in his present situation.

The role of the visually handicapped man differs essentially from the normal "sighted man's role" in society. The difference is especially marked in the fields of social relations and daily business, work, and the need for help. Socially, the role of the visually handicapped implies a preconceived devaluation of him as a human being with the subsequent negative consequences for his general social relations with sighted people. In the field of work the role involves great restrictions in the possibilities of the visually handicapped man to find work and in his prospects of being able to perform any job he might find. Here, the devaluation of the visually handicapped as a human being will also to some extent enter into the picture.

The difference between the role of a visually handicapped man and that of the ordinary man in society gives rise to fundamental personal conflicts in the visually handicapped man with regard to the degree to which he should accept the role of a visually handicapped person which has been imposed upon him and arrange his life accordingly, or to what extent he should reject this role and in its place aim at living his life in accordance with the normal man's role in society as for example with regard to taking paid work.

This conflict is common for early visually handicapped men and for late visually handicapped men, but the basis of the conflict is different. For the early handicapped man it becomes a question of whether he should break away, as it were, from the role of a visually handicapped. For the late visually handicapped man the conflict is whether he should turn away from the general man's role and accept the role of a visually handicapped person.

At the end, the solution of the conflict for the individual--irrespective of the group to which he belongs--will be a question of his attitude to his handicap, and subsequently the manner in which he is trying to fulfill himself as a human being.

The State Institute for the Blind and Partially Sighted and the Danish Society of the Blind may be able to assert great influence on the way in which the individual person solves his personal and fundamental conflict, because most of the visually handicapped are in contact with one or the other of these two organizations at various crucial periods of their lives. As an example it may be mentioned that many visually handicapped persons receive their higher education and occupational training at the State Institute for the Blind and Partially Sighted.

The visually handicapped man may, generally speaking, take two different attitudes to his handicap and to his situation as a handicapped man: he may within himself deny the existence of such experiences, difficulties and various other problems as are caused by his handicap. From a psychological point of view this is an irrational way in which to challenge his personal problems. Alternatively, he may accept the fact that he has personal difficulties as a result of his handicap, and then make an attempt to adjust himself to overcome the difficulties in a realistic and rational manner. The prospects of the visually handicapped man of being able to reach fulfillment of his potentialities as a human being will depend on how he functions psychologically in relation to the two alternatives. This study has demonstrated that visually handicapped men are seeking to fulfill themselves in different ways and to various degrees, and it includes the realization of the persons in question of the ways in which the visual handicap may have an inhibitive effect, their realization of how to "compensate" for the handicap and their general attitude to other people.

On a balance, persons with an early visual handicap have received an education and occupational training which have more relevance to their situation as visually handicapped than has the group of persons in whom the reduction of sight has occurred later in life. The visually handicapped find the offers of professional and skilled training--especially in the earlier days--far from adequate. Also, some of them think that their possibilities of choice among the comparatively few offers available to them are rather scanty, and they feel themselves pressed into a certain trade with far too little consideration of their personal interests. Previously, the occupational training was virtually limited to certain minor trades, to be trained as telephone operators, piano tuners and the like, or to become musicians, especially organists. During the past decade the offers of occupational training have been extended considerably by many new professions and trades.

Both the private and public sector have far too few openings for visually handicapped persons. This is due to a lack of knowledge on the part of the employers as to the actual possibilities of visually handicapped persons to perform a job and also to the negative attitude taken by employers--public as well as private--to the idea of employing visually handicapped persons; but the scarcity of jobs is also due to the rather poor possibilities that used to exist for occupational training of visually handicapped under public care.

The difficulties which the visually handicapped person meets at his place of work are, in part, purely working problems in connection with the performance of his functions, but he also encounters problems with regard to his relationship with his co-employees, being obliged as he is to depend on their goodwill and help in certain situations. The attitude and the expectations of the leaders and the personnel to the individual person would largely appear to be dependent on whether the business employs or has previously employed other visually handicapped persons, or whether it is employing a visually handicapped person for the first time.

The occupational careers of visually handicapped persons are characterized by frequent changes from one trade or activity to another. This particularly applies to such visually handicapped men as have learned one of the trades that used to be available to them, whereas persons with a higher education remain in their professions. Such persons as, after having finished their occupational training, are trying their hands on various trades and other activities, only to end up by giving up occupational work altogether, are also mainly those who have served their apprenticeship or have been trained in one of the trades available and the like.

Many visually handicapped men are finding themselves being offered the least attractive jobs, such as the less well-paid jobs or the jobs at the lower end of the job hierarchy. This applies to both private business and to the public administration. It was also indicated that, due to their visual handicap, they had to put up with the conditions of their places of work to a greater extent than is necessary for the sighted employees. The visually handicapped have greater problems if they are dismissed, due to the shortage of jobs available to them.

The importance of being able to do paid work is not a question of direct economic nature only; it offers a far greater indirect importance by giving the visually handicapped man a social status and acknowledgment as a human being. The chance of being able to hold a job is the means by which the visually handicapped person--in his own eyes and in those of others--may best be able to step out of the role of a visually handicapped person which is being imposed upon him by the sighted.

Certain conditions are of decisive general importance for the mental well being of visually handicapped men, whereas other conditions are more of importance for the well being of certain groups of visually handicapped.

The visually handicapped man will--other things being equal--thrive better (have a better mental well being) if he 1) has an openminded and rational attitude to his handicap and, consequently, better possibilities of being able to fulfill himself as a human being; 2) has a job of work to enable him to step out of his role of a visually handicapped man, and 3) has no sight left at all. In the third condition the person in question is more clearly confronted with his handicap; when faced with various situations he will not hesitate--as is often the case for persons who still have some vision left--in his decision on whether he should endeavor to cope with the situation on basis of a reduced sight or whether he should tackle the situation in the way that would be natural for persons with no sight whatsoever. On an average he is also superior with regard to making use of his other senses, especially the senses of hearing and touch.

On the other hand, neither the age of the person, his civil status, his residence nor the time in life at which the reduction of sight has occurred would seem to be single factors with any bearing on the mental well being of visually handicapped men.

Of the different groups of visually handicapped men the group made up of persons with an early occurring reduction of sight, and who are doing paid work is clearly thriving best. Next follows the group of persons in whom the reduction of sight has occurred late in life, and who have no paid work, and finally the group made up of persons in whom the reduction of sight has also occurred late in life, but who are doing paid work. However, there is no great difference in the feeling of well being between the last two groups. The group which is clearly thriving worst is made up of persons with an early occurring reduction of sight, and who have no work.

Various conditions have a bearing on the mental well being of the different groups of visually handicapped men. For the groups made up of persons in whom the reduction of sight has occurred late in life it is of decisive importance, especially for persons with no work, how their wives, if any, have been able to adjust themselves to the new situation and can give relevant support to their husbands, both practical as well as economical and personal.

The wide difference between the group made up of persons with an early occurring reduction of sight, but who are doing paid work, and that made up of persons in whom the reduction of sight has also occurred early in life but who are not doing any work has shown that the essential conflict of the visually handicapped person between his "role of a visually handicapped" and that of "the ordinary man" in society is most pronounced in persons with an early occurring reduction of sight. There are also comparatively more persons of the group of early visually handicapped with no work who have a poorer ability to fulfill themselves as human beings than among the early visually handicapped with work as well as late visually handicapped with or without work.

SOCIAL-EDUCATIONAL REFLECTIONS

From a psychological point of view the difficulties and problems of visually handicapped men with regard to their personal self-assertion lie in two main factors; 1) the attitude of the person to his handicap and 2) the social role which he feels is being imposed upon him by the sighted, i.e., the role of a visually handicapped person, and the great deviation of this role from that of the ordinary man in society. The two factors are of mutual importance.

The attitude of the person in question to these factors becomes decisive for his ability to fulfill himself as a human being, for his mental well being and for the shape of his whole future life.

The following are some social-educational reflections on what would seem the best measures to use to further such situations and conditions as would offer the optimal possibilities for the visually handicapped man, seen on the basis of the findings of this study.

REGARDING THE ROLE OF THE VISUALLY HANDICAPPED MAN

The role imposed on the visually handicapped originates from two conditions, 1) from sighted people who have the kind of apprehensions that make up the role, and 2) the personal experience of the visually handicapped, his attitude to and ultimate acceptance of the role imposed upon him. Thus, it would be possible to change the role by altering one or both these conditions.

Any attempt to influence the sighted to change their apprehensions of and their preconceived attitudes to the visually handicapped can virtually only succeed by giving them relevant and positive information about the problems of the visually handicapped persons as a result of their reduced sight. The information should primarily be given through the mass communication media (books, articles and the like; TV, radio, films, etc.). Here it would be important that the information about the visually handicapped should be given to such sighted people with whom the visually handicapped already have some contact; employers of visually handicapped persons and the other employees of businesses and institutions where visually handicapped are working.

The visually handicapped person may himself be able to assert influence on sighted people; depending on the way in which he chooses to react in various situations of his relationship with the sighted; more about this later.

The other side of the role which could be changed is the manner in which the visually handicapped personally experiences his role, his attitude to and his acceptance, if at all, of the deviation of his role from that of the normal man in society.

Here, the schooling and higher education as well as the occupational training of the visually handicapped are of paramount importance. This would mean that the State School and the State Institute for the Blind and Partially Sighted, the Society of the Blind (the advisory service) together with the parents and the families of visually handicapped children and adults would form essential links in this sector of the social-educational work. One essential aspect of this work is that the "role of a visually handicapped" is not disguised from him. On the contrary, the various aspects and sides of the social role which many sighted persons impose upon the visually handicapped in general should be made clear to the individual with as much relevance and openness as possible. At the same time it should be pointed out to him that there are passable ways out of this role, and he should be given all support in any attempt he might make to take one of these roads out.

To find a job is one important road that is open to the visually handicapped. In order to make this road even more passable than it used to be, and for a larger number of visually handicapped persons, more and better jobs must be made available on the one hand, and on the other hand, more facilities for better occupational training of visually handicapped must be created. More private businesses and public institutions and administrative departments must be made interested in employing visually handicapped persons. It may here be said that all public institutions and administrative departments are under a moral obligation to employ visually handicapped persons. The facilities for occupational training under the care of the blind should be extended, both with regard to the trades and higher education, and they must appear as an offer to the individual person, thus giving him a choice of trade or profession in accordance with his personal interests and abilities.

Both conditions relating to the aspect of creating work for the visually handicapped persons are normally resting with the public care of the blind, the State Institute for the Blind and Partially Sighted and the Society of Blind in Denmark.

THE ATTITUDE OF THE VISUALLY HANDICAPPED PERSON TO HIS HANDICAP

The visually handicapped person will primarily achieve a realistic relation to his handicap--which is one condition for his being able to work with the effects hereof in a relevant manner--by being made fully aware of the various ways and directions in which his handicap may act as an inhibition. Endeavors should, therefore, be made to ensure that the visually handicapped person will not be isolated from various day-to-day situations which might be practically difficult for him to cope with, neither should he be isolated from the sighted or from their world as such. It should be the aim of the work of social-educational nature carried out by institutions to allow the visually handicapped person to try himself in practical situations and functions as well as in social situations.

With regard to social situations, and especially to situations of relationship with the sighted, efforts should be made to ensure that the visually handicapped will be able to participate in some other way than has been the case so far for most visually handicapped. Due to the lack of a first-hand knowledge of the visually handicapped and to their preconceived attitude, and also due to their uncertainty in the meeting with visually handicapped persons, sighted people will often over-interpret or direct misinterpret the participation of the visually handicapped and his whole placing in such situations. The visually handicapped should, therefore, more directly emphasize what he can or cannot do as a visually handicapped person in the areas that are relevant to the situation in question. The visually handicapped person should, as it were, take the initiative to "define the situation" in an active way to or together with the sighted.

In order that the social-educational work may be of optimal significance for the individual visually handicapped it will be necessary to come to agreement on the main lines of work to be carried out by the various institutions which have public care of the visually handicapped and that carried out by the Danish Society of the Blind.

COMMENTS ON HEARING AID DESIGN

Richard Rosenthal*

In 1968, my ear, nose, and throat specialist told me that my hearing loss was not bad enough to warrant an aid, but I should study lip-reading. A month later, an audiologist at the New York office of the Veteran's Administration told me that my loss merited amplification, but no aid could help me because of my type of impairment. Aids would amplify in lower frequencies where I did not need gain and the resultant noise would mask sounds in upper frequencies where I did need help. The Education Director of the New York League for the Hard of Hearing, which I attended for lip-reading lessons, did think I might benefit from an aid. She put a note to this effect in my file. But I was not informed of her enlightened view, for I was believed to be "under the care of the Veteran's Administration." To tell me would have been "unethical."

In 1970, I chanced to be interviewing a professor of otolaryngology at the medical center who, observing my strained, edge-of-the-seat posture and intent focus on his lips, interrupted my questioning to advise me firmly to get an aid, no matter what anyone had told me. Later that week, delighted that help was possible, I consulted an audiologist at the New York University Medical Center. He suggested a CROS aid (acronym for Contralateral Routing Of Signals). In a CROS aid the midrophone and receiver are on opposite sides of the head.

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Armed with this advice, I sought a CROS from the Veteran's Administration, but was told that for my type of loss a CROS would be less than useless. They issued me an in-the-ear aid instead, an Otarion "Listenette" which one audiologist there said also would not help me; no aid would because I had a sharp sensory neural fall-off. To my surprise, the aid did help a little, even though, according to the May 1971 issue of *Consumer Report*, the VA had given it a "below average performance score" and was not considering it in its purchasing plans. But months later when I became eligible for a spare aid from the VA, another audiologist said that my loss did lend itself to a CROS, but they hadn't told me because I had good vision. The CROS's wiring system is usually housed in spectacle frames, and as I didn't wear glasses, I surely wouldn't want to add to the embarrassment of my hearing handicap by seeming to have a visual handicap, no matter what the CROS would do for my hearing. I bought a CROS from a dealer.

I also encountered similarly obtuse conflicts of counsel as to how I should use hearing aids. Earlier, when I was issued the in-the-ear aid, the Veteran's Administration psychologist in New York, as part of the post-fitting counseling, advised me to keep the aid's volume at the lowest effective level, almost, she suggested "as if you don't know sound is being amplified." Months later, during a check-up on my CROS, an audiologist at the New York League reprimanded me for "avoiding sound." Why didn't I, she said, keep the volume at a higher level, "even if it seems a little loud."

Add to these conflicts the diverse judgments, regularly rendered the hard-of-hearing, on the best hearing-aid frequency response for people with a sensory neural loss. I have been variously and firmly exhorted to use an aid which emphasizes low frequencies, high frequencies, and all amplified frequencies about the same.

There is still more intradiscipline conflict when one inquires about deafness education.

I have been professionally advised that auditory training is only for people with some form of damage in the brain's hearing center and that auditory training is for almost everyone with impaired hearing. I have also been advised that lipreading is a valuable supplement to residual hearing and that it is to be avoided as "counterproductive to auditory concentration."

Beyond this, of course, we have the senior theological war in all of rehabilitation, the oral-manual battle, as heated, uncompromising and perplexing to the deaf today as it was 200 years ago when oralist Thomas Braidwood of Edinburgh swore his apprentice teachers, under bond, to have no truck with those heathen French hand signs. The history of deafness education is fascinating. For an informative and charming account one may read *Deafness* by David Wright, the British poet.

However, despite the absence of firm conclusions in the arena for which they are trained--deafness rehabilitation--audiologists are somehow in agreement about an area in which their knowledge is peripheral: psychology.

Their conventional wisdom, that the hard-of-hearing prefer without exception to conceal rather than conquer their handicap is, I am sure, the greatest obstacle to better aids and greater acceptance of them.

When I found my CROS of limited value at meetings, parties, movies, and other situations in which there was noise or the source of sound was distant, I set out to get a better aid, one of manageable weight and size that would stress quality rather than smallness. I approached scores of leading audiologists, agency executives, and hearing aid manufacturers, offering $5,000 and considerable enthusiasm for such an aid. Significantly, most agreed that such a device could be made and would provide better fidelity and range than conventional aids. But without exception, each and every rehabilitator who would discuss my suggestion replied firmly that no one would use it. In many cases, I was told more bluntly, "You will never wear it."

Finally, after three years and no progress whatever, though I disliked forsaking medical clearance for an aid, I went outside the deafness system and, with the help of an electronics engineer, assembled my own aid from a custom-made five-watt amplifier, a rechargeable 12-volt NiCad battery pack, a Sennheiser cardioid directional condenser microphone, and a Stetostet-type earphone with home-cut urethane foam plugs resting lightly at the entrance to the canal. The aid weighs about four pounds and occupies 5 by 8 by 9 inches in its canvas pouch, which I wear on my chest or hip. It cost about $500, but nothing since in upkeep or batteries.

The aid has made an enormous difference in my ability to participate in conversation and enjoy sound. Business meetings, movies, parties, and restaurants, which I once avoided, are now pleasures. I also enjoy better speech perception and pleasure of sound in quiet surroundings, as do the great majority of people with "mild," "moderate," and "severe" sensory neural losses who have tried it informally in comparison with their conventional ear-level and body aids.

With few exceptions, people in the deafness field have avoided my aid. Rather they have followed a pattern consistent with the literature of their field. While audio engineers and technicians, young people, and the general public invariably regard the aid with respect and interest, deafness professionals display little curiosity and often, looking right at it, say that "No one will wear it."

Other assumptions of deafness professionals, like the presumption of patient embarrassment, seem to stem less from valid research than a predisposition to regard hearing aid users as dependent and incompetent.

One such view declares that we must adjust to only one aid or set of binaural aids at a time. I have no trouble switching back and forth between my bigger aid and the CROS, which I still use when driving or expecting to carry heavy bundles, as I had no trouble previously switching back and forth between my in-the-ear aid and CROS. Hearing aid users frequently tune in to more than one sound amplification system anyway, when, for example, they use special attachments to hear TV.

Another questionable aspect of adjustment counseling is the frequent advice to tune to one volume setting and strive to keep it there regardless of variations in aural environment. There is much too much diversity in the loudness and carriage of the human voice and the aural environments of homes, streets, or work to inflict such a proscription on us. We can learn to manipulate volume controls, though it would help if volume controls were larger. Bigger knobs would be especially helpful to arthritics.

I also question the frequent location of tone controls behind tiny, usually unmarked, difficult-to-reach screws that require a jeweler's screwdriver or a trip to a dealer or audiologist for adjustment. Tone controls should be accessible and clearly marked, as they are on radios, so that hearing aid users can depart and return to previous settings knowing where they are and have been.

Perhaps accessible tone controls would reduce the frequency of "servicing visits" dealers allude to when justifying high prices.

Extendable microphones would be a tremendous aid to speech perception. This should be easy enough to design for body aids, either by adaptations of the main case so people could hold it or by clip-on arrangements to microphones. Under the British National Health program body aids are equipped for this.

I suspect that the constrictions of one aid, one volume control, inaccessible tone control, and locked-in microphone approach stem largely from the assumption that hearing aids are prosthetics for the handicapped, who must be protected, rather than sound systems for normal people with inadequate hearing, who want to fend for themselves.

Actually, everyone's hearing is inadequate at one time or another, as in church, theater, courtroom, and other facilities where people must hear from a distance or acoustical engineering has been poor. In such situations, people with normal hearing could benefit from hearing aids.

Indeed, I see no reason the entire nation should not become hearing aid conscious; why hearing aids should not be marketed for the hunter, the theater-goer, and voyeur. The time has come to challenge the stigma attached to hearing aids, to wipe it out with technological and promotional "know-how" as this "know-how" is now erasing the arithmetically handicapped with efficient, inexpensive, and good-looking pocket calculators.

Clearly, drastic changes are in order. It is ridiculous that I, a layman without credentials in engineering or a deafness profession, was able to assemble an aid far superior to any of the scores of conventional aids I tried over a course of years. But before change can occur, hearing professionals must learn to base their counsel less on preconceptions of our personalities and more on respect for the independence and pleasures that accrue from hearing. Recognition that hearing loss often requires psychological adjustment has burgeoned into a litany that justifies pat, inhibiting treatment, and dissimulation of the options we can pursue on our own behalf.

SPECIFICATIONS

Amplifier

Supply	12-18 V,dc
Current	50-350 mA
Input	50 W-20 mV
Output	50 rms
Frequency	50 Hz-25,000 Hz 4N load 0.3 percent distortion ±3 dB

Power Pack

NiCad Rechargeable	50 mA hours 12 V

Microphone

Sennheiser MKE 401 Supercardioid pressure gradient transducer

Earphones

Stereo encapsulated--frequency response 100 to 8,000 Hz; light, less than 1/2 oz.; worn with urethane plugs about 1/2 inch in diameter which rest at entry to ear.

UNDERSTANDING MACHINE GENERATED SPELLTALK ADAPTATION TO SPEECH PROCESSING OF A NON-SPEECH CODE*

Kevin Sullivan*

There is an established need for prosthetic reading aids for the blind. No single method will replace all the functions of sighted reading, however tens of thousands might be served by the Spelltalk generator. Spelltalk, a 100-percent phonetic language taken from written English, should be regarded as a dialect, more Chaucerian than modern in sound, but, of course, identical in words, order, and grammar to modern written English. Each word is spelled out with re-named letters, the new names being phonemes which correspond most closely with the corresponding letters in American speech. (Conflicts in name assignments are settled on a subjective basis.) Each letter is "pronounced" separately and always in the same way.

Spelltalk, shown to be learnable by previous work, is synthesized by a new and simple self-contained generator which is described in detail.

A new and simple synthetic means is employed which involves a total of nine fixed-frequency damped oscillators, three noise generators each with a controlled spectrum, a variable-frequency (the pitch) triggering means for the oscillators, intensity contouring means, electronic switches, and timers. The frequencies selected, the means of their addition, and the contouring form were determined by analysis of voice at constant pitch produced using an artificial larynx.

Two sighted subjects, each with a teletype machine, were involved in the learning process. Spelltalk output was the link between them in their conversations. The teletypes would, at command, "speak," repeat, or type out the message if the subjects could not understand. One blind subject worked from taped prepared lessons and with a single teletype.

Tests show that this synthetic output is perceived as speech. The efficiencies of Spelltalk and low-quality synthetic phonetically-correct speech shows that experienced readers found no difference in comprehension.

Various computer-controlled testing procedures were developed and learning curves were determined. Some directions for improvement are suggested.

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*Abstract of a Ph.D. thesis in Electrical Engineering at Carnegie Mellon University, Pittsburgh, Pennsylvania; R. L. Longini, Advisor.

RESEARCH ACTIVITIES AT THE DEPARTMENT OF VISUALLY HANDICAPPED OF THE EDUCATIONAL UNIVERSITY OF HEIDELBERG*

According to the German tradition of having both research and teacher education at universities, the activities of the Department for Visually Handicapped at the Educational University of Heidelberg can be divided into two main fields: 1) the training of teachers for the blind and partially sighted, 2) research in the field of the visually handicapped. The latter is in the areas of research activities at the Department of Visually Handicapped of the Educational University of Heidelberg. The scientific work of the department is subdivided into the following main areas:

Education of the Blind, represented by Professor Dieter Hudelmayer, who is engaged in research in concept formation of the blind, educational media for the blind, social education, and socialization of the visually handicapped.

Education of the Partially Sighted, represented by Professor Franz Mersi whose main fields of scientific work are history and philosophy of the education of the visually handicapped, training of residual vision of partially sighted and low vision children, and vocational rehabilitation of the partially sighted.

Theory and Methods of Teaching the Visually Handicapped (Didactics), commissarially represented by Rudolf Schindele, assistant lecturer. Schindele's scientific work is mainly concerned with educational and social integration of the visually handicapped, development of curricula and organizational educational patterns for the blind and partially sighted, and comparison of educational systems for the visually handicapped in different countries.

Psychology of the Visually Handicapped, represented by Associate Professor Helga Weinlader whose scientific work has been concentrated on social psychology of the visually handicapped, test development and psychological diagnostics and evaluation of the blind and partially sighted, and compressed speech.

Sociology of the Visually Handicapped, represented by Professor Walter Thimm who is engaged in research on social interaction and role performance of the visually handicapped, attitudes and attitude change in regard to the visually handicapped, and social rehabilitation of the blind and partially sighted.

Scientific work in the fields listed above is also carried out by the two scientific assistants of this department:

Nico Bley, assistant lecturer in education of the visually handicapped, specializes in the theoretical foundations and practical realization of visual training programs for the partially sighted, and in the development of educational media for this kind of handicap.

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Karlheinz Pfeiffer, assistant lecturer in psychology, is particularly concerned with problems of perception of the blind and partially sighted.

Some of the research work done at the department for the education, psychology and sociology of the visually handicapped are given in the summaries which follow. The staff of the department would be very pleased if specialists doing research on the same subjects could contact them for mutual exchange ofinformation and materials.

*Causal ascriptions for achievements of blind and seeing persons.**
Helga Weinlader

Blind persons often report that they are treated differently than other people. It is often mentioned in literature that seeing persons are astonished when a blind person can earn his living. On the other hand, exaggerated expectations of the abilities of the blind are also reported. To approach these experiences in a scientific way, attribution theory seemed most adequate. This theory dichotomizes the explanation of facts as being caused either by the person (internal) or by the environmental setting (external). Several authors (Kelley, 1967; Weiner and Kukla, 1970) have suggested also that the dimension of time should be considered. Was this fact brought about by factors that are constant in time (stable) or by factors varying in time (variable)? The first category (internal/external), which corresponds to the well known concept of "locus of control" (Bialer, 1961; Phares, Wilson, and Klyver, 1971; Rotter, 1966), has consequences for the feeling of responsibility, pride and shame, and reinforcement. The second category (stable/variable) has consequences for future expectations.

The following hypotheses were tested:

1. For blind and seeing persons, different causal ascriptions are used to explain the results in comparable tasks.
2. Different emotional consequences (pride and shame) will be inferred depending on whether it is a blind or seeing person who shows the observed behavior.
3. The reinforcement (reward) for the achievement in comparable tasks will be different for blind and seeing persons.

Method

A questionnaire was developed in which a blind and a sighted person were described as having to perform a task. The outcomes of this fictitious task were manipulated, so that in half of the questionnaires the blind had success while the seeing failed and vice versa. Three different tasks were used ranging from difficult for blind persons, easy for seeing persons; to easy for the blind, and difficult for the seeing. Thus six forms of questionnaires were used. The respondents (N = 286 normally seeing persons, chosen to be a representative sample for Germany according to several variables) were asked to indicate the presumed causes of task outcomes (ability, effort, task difficulty, and chance) and the emotional consequences for the persons described, and also to assign rewards to these persons.

Results

Hypothesis 1 was confirmed: the blind, when successful, were usually judged to have a special "ability"; the causal ascription chosen for failure was mostly "task difficulty." For the seeing, these effects were not found. Hypothesis 2 could be accepted only partially. There was no difference in the ascribed emotional consequences for blind and seeing if they were successful. In the case of failure, the blind was judged to be (significantly) less ashamed about the result than the seeing.

Hypothesis 3 was confirmed. Being successful or failing, the blind received greater reward than the seeing.

*A summary in partial report of the author's doctoral research.

This rather cursory description shows that the results are in accordance with the experiences originally reported by blind persons. It seems possible, however, to analyze and specify the conditions under which the contradictory judgments are used.

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Concept-attainment in blind children.
Dieter Hudelmayer

The research in the area of nonverbal concept attainment (in the sense of Bruner, Goodnow, and Austin, 1956), is aimed at testing whether early visual deprivation has a general effect on information processing capacity of 9 to 15 year old blind children. Forty congenitally blind or early blinded scholars were individually matched with two fully sighted students according to sex, age, and verbal IQ. With auditory tasks no significant difference between blind and sighted children was encountered. On the other hand the sighted mastered the tactile tasks very significantly better than the blind. The difference between blind and sighted is, therefore, not interpreted as general impairment in nonverbal concept attainment. The superior performance of the sighted on one type of task is attributed rather to the effect of visualization. (A full report on this research has been published in: The Visually Handicapped; International Archives for Research; Schimdele Verlog, Neuburghweier/Karlsruhe, Germany, No. 1, 1972, 42-49.)

The blind in modern society.
Walter Thimm

The author's doctoral dissertation is subdivided in four main sections: 1) the statistical delimitation and description of the conception "blindness," 2) the interpretation of the social situation by the blind, 3) empirical investigations concerning the socialization of the blind, and 4) the social self-image of the blind and the image of the blind as seen by society.

The exact statistical evaluation of the concept blindness, as tried in chapter one, is complicated by the "statistical dilemma" in this area. Nevertheless the author is able to provide the following statistical facts: The number of blind persons in the Federal Republic of Germany can be estimated at 60,000. In the age group 6 to 18 years, male persons outweigh females by about 20 percent. A comparison of present data with those from 1880 shows that the percentage of blind persons under 15 years has only slightly decreased within the last 90 years. After an analysis of the relations between blindness and social policy, and blindness and school, the first chapter concludes with an attempt at sociological delimitation of the concept blindness, which shows that blindness is no longer an exact criteria as soon as the social consequences of a visual handicap are to be estimated.

The interpretation of the social situation by the blind is attempted in chapter two through an evaluation of the self-description of the German Association of the Blind, and by the self-testimony of several blind persons. Two main areas in the self-image of the German Association of the Blind can be distinguished: they regard themselves responsible for giving society adequate information about the blind, and they see their organization as the "legitimate representative" of the blind. The author points to some discrepancies within the ideology and attitudes of the association. As an example he shows that, while according to the association the main aim of social integration, the vocational integration, has been nearly achieved, only about one fourth of the blind can actually be regarded as fully integrated. The results of some investigations on the vocational situation of the blind demonstrate a discrepancy between the subjective expectations of the blind and reality: the fact that nearly 90 percent of the blind are employed within just four different vocational categories: shorthand-typists, telephonists, industrial workers, and blind artisans, shows that blindness really causes decisive vocational limitation. Besides the percentage of jobs with little social prestige is strikingly higher for the blind than for seeing persons.

The results of some investigations on the social status of the blind as given in chapter three also demonstrate an evident difference between the wishful thinking of the self-help organizations and reality. The fact that blind adolescents rate the social rank of occupations frequently taken by the blind one grade too high indicates an unrealistic judgment of their social status by the blind.

Chapter two also gives the results of a questionnaire study by which the stereotype of "blindness" among the seeing was investigated. Though 80 percent of the persons questioned are ready to ascribe full efficiency and achievment to the blind, they give up the principle of payment according to the work actually done, when blind people are concerned (72 percent). The results of a profile of polarity indicate that the blind is seen by the seeing as "a sorrowful man who is struck by misfortune, and who in his quiet and shackled way tends towards introversion." The correlation with other stereotypes and a factor analysis of the dimensions leading to the stereotype about the blind indicate that the blind is seen as a lonely person with good-natured civility, but with some emotional peculiarities. An analysis of the factorial structure of the auto-stereotype of the blind shows so few differences to the stereotype held by the seeing that in accordance with the theory of "self-fulfilling prophecy" it can be assumed, that the "wrong" stereotype of the seeing decisively influences the auto-stereotype of the blind.

In the last chapter the author tries to arrange and analyze the results with respect to different theoretical models. Some concluding remarks point to the importance of role analysis for a future sociology of the handicapped.

Partially sighted children in regular class rooms

Franz Mersi and Helga Weinlader

Rationale

The present investigation tries to shed some light on the special situation in which partially sighted students find themselves attending a regular class room without special help. We wanted to learn something about their scholastic achievement, intelligence level, social status and their emotional adjustment.

The sample of partially sighted children used in this study consisted of 33 students, who had been identified to have a visual acuity of only 0.3 or less during a study of the Ophthalmologic Clinic of the University of Heidelberg composed of all children in grades 1-4 in four representatively chosen districts.

The following questions seemed most important to us:

1. Are there any differences between the partially sighted students and nonhandicapped children of the same age?

2. Are there any differences between these children and their class mates?

3. Are there differences between partially sighted children attending regular classes and those attending special school settings?

By answering these questions, several questions concerning the adequate educational system for partially sighted children should be resolved.

Are the educational needs of these students satisfied in regular classrooms?

Are there any critical points in intelligence, visual acuity or emotional adjustment up to which a placement of partially sighted students in regular school is reasonable?

What factors are responsible for the placement in special schools?

Which one of the school settings will contribute to a more favorable development of the child?

The instruments used in this project were:

1. To measure school adjustment: Achievement Test, marks, test of locus of control, questionnaires for children and teachers.
2. Intelligence: HAWIK (German version of the WISC), Colored Progressive Matrices Test (CPMT) of RAVEN.
3. Sociometric Status: Sociogram.
4. Emotional Adjustment: Children's Anxiety Text (KAT), Rosenzweig Picture Frustration Test, and several questionnaires for children, teachers and parents.

All the partially sighted students (N = 33) in 33 different classrooms were tested together with their class mates (N = 982). The testing was done by students of our department: Gromer, Kubel, Krieger, K. H., Krieger, R., Oeldorf, Rupp, Schlipper, Schoner, and Weber.

Results

School adjustment. The differences in reading, writing, and vocabulary between the partially sighted and their class mates were no greater than chance. In arithmetic, however, the normally seeing children were significantly better ($p < 0.05$). By a comparison of the test scores with the marks, it could be shown that teachers were treating the partially sighted students in the same way as their other students.

Concerning the locus of control, there was only a very weak difference between the samples which could be explained by chance. Relating this measure to achievement motivation, the conclusion can be drawn that there are no differences.

By means of questionnaires, teachers were asked to judge the partially sighted student as compared to the best and the poorest student of the class room. Intelligence, memory, work behavior, adjustment and behavior in stress situations are judged to be normal. Concentration and productive thinking of partially sighted student is closer to that of the poorest student, inferiority is judged to be the same as in the poorest and as for contact and neuroticism the partially sighted students are judged even below this group.

A questionnaire for children was to answer the question: Do partially sighted students see and judge their situation at school differently than their class mates? Only for single items (not within the total dimensions) differences could be stated: the partially sighted students claimed to be less anxious about mistakes and less nice to others, have fewer friends, and their friends accept their proposals less frequently.

Intelligence. The partially sighted students had a significantly lower mean IQ (CPMT) than their class mates. Also the distribution on the quartiles differed significantly from expectation. Also with the HAWIK we found a significant difference in the total IQ, as well as verbal and performance IQ. By reviewing the scores according to a factor analytical model, the partially sighted students deviate from the normal population in the verbal and the perceptual factor. The distribution of subtest scores of this sample is rather different from distributions of other groups of visually handicapped students.

Sociometric status. The partially sighted students received significantly less positive and more negative choices. There was no difference in the amount of (positive + negative) choices given and received by the partially sighted students.

Emotional adjustment. According to the anxiety test, the partially sighted students did not differ from the scores of the normally seeing children. They often showed less anxiety than the latter. A questionnaire for parents was to define the dimension of introversion/extroversion. It was shown that the partially sighted students are significantly more introverted than their class mates. (See also the results of questionnaires for school adjustment.)

At present results of the picture frustration test are not yet available. Also the intercorrelation of the several instruments will be necessary for the final evaluation of the situation of partially sighted students in regular class rooms.

Visually handicapped children in different educational settings
Rudolf Schindele

A comparative empirical investigation of the school achievement, social adjustment, social competency and sociometric status of visually handicapped students in regular and residential schools.

The general design of this investigation and its results in the area of social adjustment are given in the article "The Social Adjustment of Visually Handicapped Children," earlier in this journal.

Visual exercises, visual training, education of vision--Concerning the theory of teaching the partially sighted
Nico Bley

In the first chapter of his doctoral dissertation the author analyzed and compared the three concepts visual exercises, visual training, and education of vision, which have been so relevant in the historical development of the education of the partially sighted.

The concept visual training stresses the training factor. Early educational experiments (Heller, etc.) are described. Then the ophthalmological aspects of visual training are presented: the different theories (Bates, etc.), pleoptic and orthoptic, etc. This first part of the dissertation ends with a definition and examplification of the visual training concept: visual training as a special educational principle, visual training programs, etc.

The second chapter deals with the psychological foundation of the education of the partially sighted (psychology of perception, early learning, research on deprivation) and with the ophthalmological-psychological foundation (stabismus amblyopia, theoretical foundations, etc.).

A third part of the thesis is mainly concerned with the organizational pattern of teaching and the educational principle, visual training. Special emphasis is thereby given to the dimensions of visual training such as reading and writing, the problem of diagnosis and measurement, the cognitive dimension (perception-thinking), the social-emotional dimension (education-visual contact), psychomotoric aspects (eye-hand coordination), etc.

After a detailed description of the media for visual training, the concluding chapter deals especially with visual training at different age levels: in infancy--in the parental home (early screening); in kindergarten and preschool age; at the different school levels (elementary school, junior high school, senior high school). Here the principle of visual training is exemplified in relation to different school subjects like geography, art, etc.

Studies in compressed speech for use with visually handicapped students in Germany
Helga Weinlader

Considering the vast amount of publications in the field of compressed speech, the promising results and the widespread application of rate-controlled recordings in America, we thought this means of transmitting information could be of high value for visually impaired German students also, especially for those who have difficulties in reading printed materials.

Since the comprehension of acoustically presented messages is highly dependent on the language used, we had to start at the very beginning. The first problem was training the student to *listen* to compressed speech.

To obtain a standard of normal speaking speed and a measure as to the amount of compression, we studied several normal speakers reading different materials (novels, scientific articles, stories). As a result we concluded that, for the German language, defining speaking speed as syllables-per-minute is a more adequate measure than words-per-minute. A training program for listening to compressed speech has been developed and will be tested in further studies.

Factor analytical investigation of the intellectual achievement of visually handicapped children
Manfred Hengstler

The author first presents a very extensive discussion of factor analytical research that has been done using the HAWIK (German version of the WISC) with normal-vision students. A summary of investigations in which the HAWIK was used with visually handicapped students is then presented.

The main investigation involves the testing of the following null-hypotheses--the structure of the HAWIK intelligence profile of partially seeing students is independent of:

1. Distance visual acuity.
2. Level of near vision.
3. Age.
4. Grade level.
5. Type of school attended.

The structure of intelligence of blind students is independent of:

1. Visual acuity.
2. Age.

These hypotheses were tested by comparison of means, correlations of subtests, and factor analysis. The sample consisted of $N_1 = 207$ visually handicapped students and $N_2 = 62$ blind students. Age range: 7 to 15 years. The following results were obtained.

1. The lower the visual acuity (distance vision) the more verbal orientation there seems to be. This is true only for an upper range of visual acuity. There seems to be some critical point (severity of handicap) beyond which other techniques are necessary.
2. Theories on the possibility of verbal compensation cannot be confirmed in general by the results.
3. Older students tend to show a more differentiated intelligence structure.
4. Great differences are found between grades 1 and 2. Different aspects of intelligence seem to develop at different but specifiable times.
5. Partially sighted students attending special schools were able to reach a higher level of intelligence and showed a more structured intelligence pattern.
6. For the blind students, the correlations between the subtests were higher among older students as well as among those of lower visual acuity.

Behavioral disorders among partially sighted children
Monika Hoffeld

In this study the hypothesis that more children with behavioral disorders are to be found than in the normal population was put to the test. Parents and teachers of 43 boys from 6 to 10 years were asked about behavioral anomalies of the children, using standardized interview. These children were the total population of this age in three different schools, chosen as being representative. For the comparison with the normally sighted, data from another investigation, gathered with the same interview instrument, were used.

The following results were obtained:

1. In regard to the overall symptoms, there was no difference between the partially sighted and the normally seeing *S*s.

2. The partially sighted, however, showed more serious disorders than the normal sample.

3. The partially sighted boys showed (significantly) more often stereotypic behavior and thumb sucking. Lack of concentration was more striking in the normally seeing children.

Parents and teachers differed significantly in their judgment of the children concerning psychomotoric activity, thumb sucking, affectivity, and anxiety.

Speech disorders among students of schools for the partially sighted
Hans Schrimpf

Theoretical considerations concerning the consequences of a visual defect for the function of control and completion in speech perception as well as the experience of instruction at schools for visually handicapped have led to the assumption that more speech disorders are found in schools for the partially sighted than might be expected according to a normal distribution. In recent years, this problem was the subject of empirical investigation in this country. The present study fits into this context. To hypothesize: among partially sighted students there are to be found more students with speech difficulties than among students who are not visually handicapped. As an introduction, several kinds and degrees of visual and speech disorders were described and classified according to their meaning and genesis.

Five additional hypotheses were formulated on the basis of the review of the literature.

To test these hypotheses, 171 students of three schools for partially sighted (Waldkirch, Augsburg, Karlsruhe) were classified according to their degree of vision (three groups) and reported speech disorders. To identify any possible hearing difficulty, 154 students were tested. Learning disability, multiple handicap, and crossed laterality were identified. The prevalence of speech disorders was compared among groups of different visual acuity, between normal partially sighted and those with learning disability, hearing defects, multiple handicap, and crossed laterality, and also between partially sighted students and students in regular classrooms. The total sample of partially sighted students with speech disorders was classified into the different kinds of speech deficiencies.

Orthography of partially sighted children. Investigation with 5th and 6th graders.
Helmut Schuster

A discussion of the social implications of orthography, a review of the general solution to the problem, and discussions of special education.

Two hypotheses were formulated:

Partially seeing students (in special schools) will make more mistakes than normally seeing students; there will be a correlation between level of near vision and the ability to write correctly.

The spelling ability of 63 partially sighted students in five special schools (grades 5 and 6) were tested with a standardized test (Diagnostischer Rechtschreibtest DRT 4-5) and compared with the population of the standardization. The first hypothesis can be accepted; the second hypothesis was rejected. The results were tested for significance.

There were also some interesting results concerning the different age levels and multiple handicaps of the students in special schools as compared to the normal population. The results were interpreted against the background of different methods of teaching orthography. Final suggestions were formulated as to how to improve the spelling ability of partially sighted students.

Optacon reading by blind adults
Ingrid Zierer

The author was a coworker at a course for reading with the Optacon, held for 13 blind patients of a rehabilitation center (Berufsforderrungswerk Heidelberg). She designed a textbook for this introductory course and controlled the learning progress of the course as systematically as was possible under the circumstances. After 16 weeks of training (about 29 hours of training) the *S*s could read a passage consisting of single words in a random order with an average reading speed of 7.6 words-per-minute. The ratio of recognition was 97 percent. The recognition of a single letter took an average of 2.6 seconds. Besides a detailed specification of the training itself and its results, the paper contains the description of the Optacon as well as a summary of reports of training courses with the Optacon in the United States. The Optacon manual, developed for adults, can be obtained from Berufsforderrungswerk Heidelberg; a manual for children is planned.

The blind in modern literature.
Benno Zender

The aim of the author is, by means of a review of literature published since the end of World War II, to show and analyze how the blind person is represented in literature.

The analysis focuses in particular on the way different authors describe the basic mood of blind persons and their interactions with the world of the sighted. Chapter I discusses those novels in which blindness is seen as destiny (Bjarnhof, Twersky, Walpole, Barwick, Brecht, Gunnarsson, Eich). Blindness used as symbolism is the subject of Chapter II (Gide, Jens, Grisch, Durrenmatt, Lenz, Beckett). In the last section, a selection of lyric poetry concerning blindness is analyzed.

Name: Audio Yo-Yo

Source: Blick Clinic for Developmental Disabilities, Inc.
P.O. Box 351
137 East Avenue
Tallmadge, Ohio 44278

A balanced yo-yo which emits a 2.9-kHz tone can be located in space, it is claimed, by detection of Doppler displacement.

Name: Braille Display System

Source: Clarke & Smith Manufacturing Co., Ltd.
Melbourne Works
Wallington, Surrey, England

Availability: Prototype stage development, samples 6 months, general availability September 1975

Price: Approximately £300 for 25-character display ($750.00).

The device displays material encoded on magnetic tape as grade 1 braille, one line at a time. It consists of three sections: 1) the playback deck for the magnetic tape, 2) the control electronics, and 3) braille display unit. Originally developed as a personal reading machine, it could also function as a computer terminal. Further specifications include: 12-, 25-, 72-character, 6-dot braille, bit-serial input, solenoid-activated dots, line setup 10m sets, data-input rate lm/bits/sec, size for 25 character 9" x 7" x 4-1/2", over requirement 18v + 5v.

Name: Telephone for the Blind and Deaf (Braillophon*)

Source: Hannover Centre for the Blind and Deaf-Blind, Hannover, West Germany

Availability: Commercial prototype. Siemens, West Germany

Braillophones are connected to a PABX. Call is made by means of a rotary dial. Pocket receiver vibrates to let the called party know that there is a caller on the line. When a "call" starts, the sender types message on keyboard of braillophone and receiver reads a paper tape strip containing braille characters comprising message.

*Not to be confused with the Braillophon of Prof. Dr. W. Boldt of Dortmund University, Dortmund, West Germany.

Name: A Calculator for the Blind

Source: Ken Cummins
School of Engineering
University of California, Irvine

Availability: Laboratory prototype

A calculator consisting of two physically distinct units: a tactile output device and a main calculator unit. Both are packaged in a clear plastic housing. The output device has a 10-digit capability, but displays one digit at a time represented by four sensing pegs and using a modified braille configuration. A rotary switch selects digit to be displayed; the readout pins are reset by hand.

Name: Digital Position Readout System

Source: Elm System, Inc.
Arlington Heights, Illinois

Availability: Prototype

A tactile display for any binary-coded digital output (digital voltmeters, electronic counters, etc.). The device provides a readout for each of seven digits, and for polarity. Each digit is represented by a line of four holes containing pins. The pin positions are BCD weighted as 1, 2, 4, and 8. The actual number is the sum of the weighting of raised pins.

Name: Electronic Calculator for the Blind

Source: A. J. Croft and D. I. Smith
Clarendon Laboratory
University of Oxford, England

Availability: Experimental prototype

A calculator with a 12-digit capacity and one memory. A unique feature is the audio output in the form of a code analogous to roman numerals using a low or high pitched tone followed by up to four pips. Digits 0, 1, 2, 3, and 4 are the low tone, and the number of pips give the digit. Digits 5, 6, 7, 8, and 9 use the higher tone which adds five to the number of pips. A crisp "pop" indicates the decimal point. The special circuits and power supplies are built on five printed circuit boards as an integral part of the calculator. Can be connected to loudspeaker or headphones.

Name: Line-Group Sequential Reading Aid

Source: Harry S. Shapiro
2527 Derbyshire Road
Cleveland Heights, Ohio 44106

Availability: Experimental prototype

A system of printing symbols to aid the eye of a reader in following ink print. Marginal indicia start each line and the next succeeding line. Indicia are machine-readable as well.

Name: Reading Machine

Source: Arbeitsgemeinschaft Fur Rehabilitationstechnik
Universitat Stuttgart e. v.
700 Stuttgart
Schloss Solitude, Haus 3
GFR

Availability: Experimental prototype

A character recognizing reading machine with braille display. At present the identification ability is restricted to typewriter capitals and the braille symbols are presented on a papertape printer.

Name: Telebraille

Source: Dr. Frederick M. Kruger
National Center for Deaf-Blind Youth and Adults
105 Fifth Avenue
New Hyde Park, New York 10040

Availability: Experimental prototype

A system comprising a method of sending braille information in reencoded form over telephone lines. The unit is housed in an attache case. Within the case are a loudspeaker and six keys (corresponding to the six dots of the braille cell). Grade I or II braille is entered via the keys, is transduced into frequency-shifted binary strings which are then sent over the telephone line. The person receiving the call places the telephone receiver in a cradle, which feeds the earphone output into a code converter, which utilizes the binary strings to drive pins arranged in a braille cell configuration, which is read by the recipient's finger. Modifications planned for the future include a standard keyboard (with code converters) for those who do not know braille code.

Name: Variable Speech Control (VSC--update)

Source: Murray M. Schiffman
Cambridge Research and Development Group
Westport, Connecticut

Availability: preproduction prototype, Sony, Matsushita Electric Industrial Co., Magnetic Video Corporation

Price: About $50 plus cost standard audio equipment

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Editor's Note: Readers interested in obtaining copies of the above publications may be guided by a resonse to our inquiry from Mr. G. T. Wescott, Manager, Billing and Distribution, Printing and Publishing Office, National Academy of Sciences, "We are unable to send copies of the documents to recipients on your mailing list. Our supplies are limited and this mailing would completely deplete our supply. If you wish to advise those persons on the mailing list of the availability of the reports, we should be happy to supply the individual requests as long as we are able. When our supplies are exhausted, the reports will be available from the National Technical Information Service."

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