Uses of Computers in Aiding the Disabled
J. Raviv (editor)
North-Holland Publishing Company

AUTOMATIC BRAILLE PRODUCTION BY MEANS OF COMPUTER

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In this lecture the problem of automatic transcription of inkprint into Braille is examined for the German language and a solution is given. For this purpose some of the German Braille rules are sketched, while a complete summary of the rules is given in Appendix 2. The historical development has been followed in describing the first and second approach to translation into Braille. The algorithms employed are outlined. A historical timetable is contained in Appendix 3. We conclude with a short evaluation and outlook.

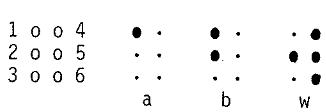
INTRODUCTION

Nowadays there are many ways a blind person can access information and communicate with the world around him. He can listen to radio or television. He can get "talking books", tapes on which a book has been recorded by a sighted person, usually an actor. He can tape his own cassette and send it to somebody else. Nevertheless Braille, the writing of blind persons, will definitely be with us for quite a while. It allows quick search and access, giving one the advantage of printed books for studying; furthermore one may make notes and use the classical methods of communication. A recent development is so-called "paperless Braille" which allows one to retrieve information from a magnetic tape and display it mechanically by inserting tiny balls from below into a stencil of six holes. On demand, a permanent copy can be embossed into paper.

I do not expect everybody in the audience to know about Braille, therefore I will first try to explain what Braille is and describe the problems that arise in automatic translation and how they may be solved for the German language. Other participants of this meeting who are experts in French and English Braille will report about those topics, so I won't go into that here.

DEFINITION OF BRAILLE AND THE TRANSLATION PROBLEM

The idea of using raised dots to make notes and send messages was originally conceived for military purposes to be used at night, but was converted by L. Braille in 1825 to serve peaceful purposes. In this system 6 dots arranged in two columns of three dots, numbered in the way shown in the figure,



are used to denote letters, punctuation signs and special characters (8 dot characters are in discussion). For instance, the letter a is given by point 1, the letter b by 1 and 2, the letter w by 2, 4, 5, 6. There are 63 different characters plus the space that may be called the empty character. Each letter in Braille is much larger than its inkprint counterpart, and the paper in Braille books has to be stiff and therefore much thicker in order to keep the embossed form. Hence Braille books are much more voluminous and unwieldly than inkprint books. This is the reason that a certain contracted form of Braille is used for literature. It is called Grade II Braille.

Grade I Braille denotes writing that transcribes each word letter by letter except for some frequent German letter combinations such as st, sch, ch and the diphtongs au, eu, ei, ie, and ä, ü, ö, äu. These letter combinations may be used only if they belong to the same etymological segment of a word. (This "simple" requirement causes a lot of trouble and makes even the simple transcription of Grade I into a major translation problem.)

In 1921 Professor Strehl, the late head of the Deutsche Blindenstudien-Anstalt (the central institution for higher education of blind persons in Germany) edited the first volume of the "Marburger Systematik" for German contracted Braille, entitled

> "Systematische Anleitung zur Übertragung literarischer besonders auch wissenschaftlicher Werke in Punktschrift."

Here the set of rules that govern the use of contractions in German Grade II Braille was documented. It should be noted in passing that blind stenographers use contractions more liberally to gain higher speed (Grade III Braille). As we will see in examples, it is not generally easy to decipher contracted Braille, even if it is only Grade II.

To demonstrate the complexity of Braille we have included as Appendix 1 a table of the Braille alphabet for Grade I as it is found in the aforementioned "Marburger Systematik". Of the 63 combinations of dots and the empty form which contains no raised dot and serves as the blank, not all combinations are used in Grade I. Our table is supplemented for the German language to contain such letter combinations as quoted above.

There are no special characters for the numbers but the letters a, b, c, . . . are used preceeded by the "number sign" consisting of the dots 3, 4, 5, 6.

The second table we have added to this text demonstrates how a Braille character is interpreted in Grade II. We do not expect the reader to absorb all of these signs and their interpretation. The reader should keep in mind that, in addition, combinations of two Braille characters denote further contractions, as is seen in the second appendix. I just hope to convey an impression of the amount of notation a blind reader has to memorize and which logical combinations he has to perform in his mind in order to read Braille fluently.

A SUMMARY OF THE RULES FOR GERMAN GRADE II BRAILLE

As Appendix 2 of this paper I have given a summary of the rules of Braille as they are explained in the Marburger Systematik, Part 2, edited by the late Dr. Freund.

The translation rules are formulated so that in inkprint the words or letter groups are written in small letters while the translated form is denoted by capitals that transcribe into the Braille character associated with it in Grade I. Some of the Braille characters, however, cannot be denoted by a letter, since they do not have such a counterpart. They are denoted by the corresponding group of letters with which they are associated in Table 2 of Appendix 1. The character 1, 2, 4, 5, 6 for example is written <er> .

Here we will not discuss all of the rules but will only explain some of them in order to have material for later reference.
Let us look at <u>rule 1</u>. It states how a Braille character that usually denotes a contraction regains its meaning as a letter. To achieve this it must be preceeded by the "dissolution sign" given by dot 6. As an example we consider the letter c, denoted by the Braille character 1, 4; usually it has the meaning "en".

To write a sentence like "C ist der dritte Buchstabe des Alphabets." (C is the third letter of the alphabet.) one would need the two Braille characters consisting of dot 6 and the second one of dot 1 and 4 to denote the "C".

Rule 2 governs the application of the listed contractions that are represented by 1 Braille character. It forbids the use of a contraction if it could lead to an ambiguity. The use of a contraction is also forbidden if the contracting Braille character could be misinterpreted as punctuation sign or if readibility could be impaired as in the case where at the beginning of a word only the dots 2, 3, 5, 6 are present. The reader might slip out of line and interpret them as 1, 2, 4, 5 .

By this rule for example the contraction "ach", given by 5, 6 must not be used at the beginning of a word, but is resolved to "A" and "CH", i.e. the character 1 and the character 1, 4, 5, 6.

Rule 3 defines priorities in case there are different possibilities for a contraction. To give an example, the letters ll, el are German contractions. In the word "Helle" it would not be clear which one to use. The rule states that

the double consonants ll, mm and st, have highest priority,

the contractions starting with a vowel have second highest priority,

and those starting with a consonant have lowest priority.

In our example we would write HE<LL>E and not H<EL>LE. But the rule also states that "be" which has lowest priority by the definition just made should be given highest priority if it is etymologically a prefix. As an example, look at the German words "Besen" and "besessen" (broom and obsessed). In the first word "be" is etymologically a part of the word stem, while in the second case it is a prefix and should be contracted. To quote another exemption, in the German word "Familie" the double vowel "ie" is spoken as "e-a", that is as two vowels and so, by the rule, it must not be contracted.

Without continuing further I think it is clear that some of the rules have a formal character that can be observed by a computer, while the last sentences make reference to the meaning of a word or to its pronounciation and therefore cannot easily be handled by it. There are about 360 contractions for German Grade II Braille with the associated rules for their application and you might feel from the above examples that we are facing an almost hopeless task if we try to get an automatic Braille coding for an inkprint text by a computer. To sketch how this problem was tackled successfully, I propose to follow the historical development.

THE INITIATION OF OUR PROJEKT AND THE FIRST TRANSLATION PROGRAMM FOR GERMAN GRADE II BRAILLE.

The project started with a chance discussion I had with a blind school teacher. His description of Braille made it look accessable to automatic production and together with one of my students R. Wais, a program was written to demonstrate how the translation would operate. Of course the initial programm only gave fair results but we were optimistic in spite of the statement of Professor Strehl, who is reported to have said that automatic translation into Braille would be impossible.

In the same year (1962, please see the timetable in Appendix 3 for a more complete listing of dates and persons) I attended the IFIP-congress in Munich and organized an informal disscussion group on Braille production that found a remarkably favorable response. In addition to visually impaired participents there were others such as J. McPherson, Vicepresident of IBM and Professors van der Poel and van der Sluis, Holland. This was the first international exchange of experience and ideas. On this occassion I learned about the existence of the translation program for the English language of Mrs. Schack (IBM) that attacked the problem pragmatically. To achieve a good translation the computer was given a helping hand by a sighted proof reader.

We were convinced from the beginning that a completely automatic solution to the problem was indispensable because there was a growing shortage of sighted people who could typeset or read Braille, and on the other hand a growing demand for reading material. We soon learned that the blind reader insists on very high compatibility with existing rules. For years a discussion went on about a reform of Grade II Braille to which we were able to contribute our experience. (For example, we noted that rules that are hard for the computer were also hard for school children). Finally, in 1971 at Vienna an agreement about some mild changes in the rules was reached.

Almost from the outset of our work we realized that it was not enough to write a program if we really wanted to help the blind. The whole production chain needed to be set up. The input text had to be prepared in machine readable form, and the output had to appear on Braille paper, not just in print.

I did not worry about the input, since I believed that there was high enough consumer demand especially in recent years in connection to the growing industry of phototypesetting.

On the other hand, there was hardly any chance of acquiring output devices when we started. Some not very reliable prototypes existed in Germany, Holland, Italy, but the best tools for our purposes were found in the American Printing House for the Blind (APH), Louisville, Kentucky. I was generously aided by V. Zickel, the head of the APH. I obtained a grant from the German Science Foundation (Deutsche Forschungsgemeinschaft) to buy this equipment, and the embossing machine was shipped to us on time. However for unknown reasons it took more than a year until the last part reached its final destination. (Last year we handed it over to the "Deutsches Museum", the science museum in Munich.) In recent years the demand for Braille output equipment has increased and is now met by a number of producers.

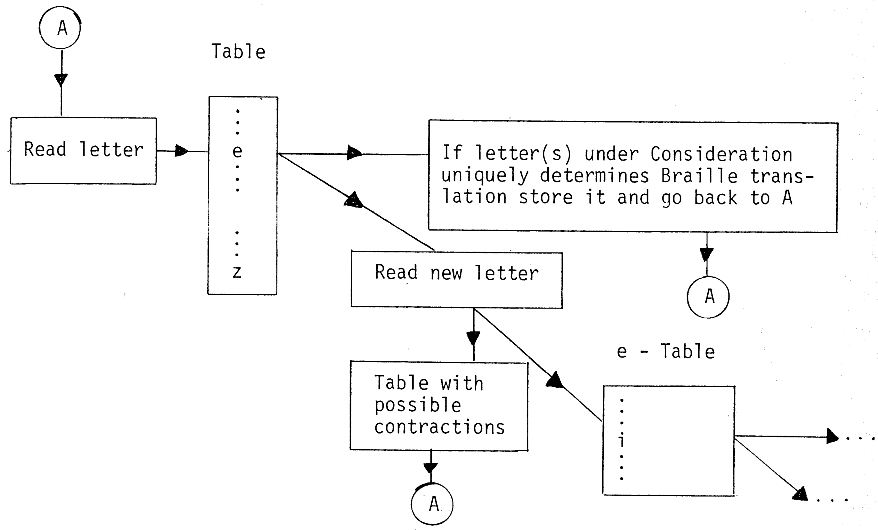
After this digression about the technical side let us come back to the main step of the production process - the translation. The translation program always considers a single word for translation, although there are some very rare examples in which the transcription into Braille depends upon the context. (This is different from French.)

In the first program we processed the word from left to right, and of course one had to look ahead to detect possible contractions. The contractions were tabulated in the computer, and to cope with the rules mentioned in the section about Grade II Braille we combined some contractions into what I called pseudocontractions to account for the priority rules. (Storing "ell" and its (usually) correct translation E<LL> may serve as an example). Our tables contained several hundred entries at the end and gave a rather good translation. This first program was implemented by my student W. Dost, and its maintenance was later taken over by B. Eickenscheidt.

To achieve a high processing speed the storage of the contractions was done in the following way. For every letter we stored either a pointer to the table of all contractions that could begin with this letter or gave (in coded form) its correct translation together with possibly necessary auxiliary signs. The table of contractions that had a definite first letter would either list all the contractions if there were not too many or itself would contain pointers to a list where the subtables of contractions that start with two given letters could be found, etc.

The translating could then be performed by a recursive technique as is indicated by the following flow-chart.

FLOW-CHART OF FIRST TRANSLATING PROGRAMM



We would compare the first letter of a word with the letter table to find out, whether it could be immediately translated or could be the beginning of a contraction. In this case the next letter would be used to enter the appropriate subtable for contractions. Possibly, additional letters had to be looked up to decide how the first letter(s) had to be converted to Braille. This being done, the translation would start again with the first untranslated inkprint letter. Here we have not specified the bookkeeping of the pointers, one for the inkprint letter processed, another for the additional letters, the counter for the stored Braille code, etc. This program achieved a very high translation speed and was in use for several years.

Improving the accuracy would mean deciding about the etymological segments, the prefixes and suffixes of a word. In the context of formating German text for printing it is necessary to recognize the syllables of a word and for this purpose a program was designed by a scholar of the German language, Dr. Hübner from IBM-Germany. He made his program available to us and has given his support ever since. Dr. Hübner pointed out that we would have to dispence with reading from left to right, but had a better chance to detect parts of words by going from right to left. Our task differed from his in that his goal was correct hyphenation, while our contractions weren't allowed to cross etymological borders. However, borders of syllables could be neglected.

We were lucky in getting a very large number of critics and admires when Mr. Klenk from the German printing house Gruner & Jahr, Hamburg, proposed a cooperative effort in editing a biweekly newspaper for the blind. The newspaper would contain selected articles from their magazine "Stern" and their journal "Zeit". They would send the compositors tape to us, we would translate it to Braille, and emboss metal plates, which were shipped to the Braille Printing House of the Verein zur Förderung der Blindenbildung, Hannover, for mass production. The printing in inkprint and Braille from the compositors tape is done almost at the same time but collating the Braille pages into one paper in Hannover is done by hand and therefore takes several days. The paper is free of charge to the blind, and the material is donated by the printing house together with the funds for printing. In 1969 regular production of this German Braille Journal was started and has gained a circulation of about 5000 readers. It seems that there are not more than this number of blind German readers that read longer articles, although there may be up to 20 000 who know Braille but find reading it cumbersome.

This project provided us with a rich stock of experience and numerous comments from blind readers. They were certainly grateful for the paper but made it clear that the translation efforts of the first program were not good enough for high quality literature. The experience gained from the "Zeit-Stern Blindenzeitschrift" was valuable in making the abovementioned revisions at Vienna in 1971. We had learned that it was necessary to make the changes of Braille so small the readers trained in the old Grade II Braille could immediately read the new one and that old material would also be readable for persons trained with the new rules.

SPLETT'S LINGUISTIC WORK AND THE NEW TRANSLATION PROGRAM

To improve the accuracy of the translation considerably deeper scientific work was necessary. The "Silbentrennungsprogramm" of Dr. Hübner was a step in the right direction but did not solve our problem completely, since in Braille it is not syllables but etymological units that are important. A taylormade solution was advisable. This was the situation when Dr. Kamp, a member of our team and a scholar in Humanities, introduced Professor J. Splett to our project. As a trained linguist he undertook an almost exhaustive analysis of the German language for our purpose. There are about 360 contractions of Braille and an elaborate system of rules. We had access to a computer readable dictionary of about 100,000 words by Mackensen andto the huge stock of material collected from the edition of the "Zeit-Stern-Magazin". One had to check the effect of using a particular contraction in transcribing a word to Braille for appropriateness.

To study a particular contraction we would select for him every word that contained this contractions's letter sequence and print them in such a way that the contractions's sequence appeared aligned in one column.

Splett and his students would then check every word to decide whether application of the contraction was correct or not. In this way he was able to make up a table of exceptions. Among these exceptions he could see whether by adding just one letter at the beginning or end of the contraction one could decide on a Braille translation that would lead to the correct translation. Of course there would again be exceptions, so one had to consider the exceptions of the exceptions, and so on. In addition to the words that contained the given letter sequence one had to consider compound words in which this sequence arose.

EXAMPLE OF ONE OF SPLETT'S SECONDARY TABLES (from Splett [6])

"richt"-table

-aufricht	→	(AUF)(RICHT)
-mitricht	→	(MIT)(RICHT)
-zuricht	→	(ZU)(RICHT)
blutrichter	→	(B)(L)(U)(T)(RICHT)(ER)
kunstrichter	→	(K)(UN)(ST)(RICHT)(ER)
patentrichter	→	(P)(A)(T)(EN)(T)(RICHT)(ER)
stadtrichter	→	(ST)(A)(D)(T)(RICHT)(ER)
trichter	→	(T)(R)(ICH)(T)(ER)
kehricht	→	(K)(EH)(R)(ICH)(T)
röhricht	→	(R)(Ö)(H)(R)(ICH)(T)
töricht	→	(T)(Ö)(R)(ICH)(T)
mostricht	→	(M)(O)(ST)(R)(ICH)(T)
estricht	→	(E)(ST)(R)(ICH)(T)
-stricht	→	(ST)(R)(ICH)(T)
stricht	→	(ST)(R)(ICH)(T)
spricht	→	(S)(P)(R)(ICH)(T)
abricht	→	(A)(B)(RICHT)
bricht	→	(B)(R)(ICH)(T)
richt	→	(RICHT)

We demonstrate the situation by an example from one of his tables, taken from his paper [6]. It concerns the contraction "richt". Usually this is the stem of a word that means "judge" or "correct". The word segment "richt" is the last entry in the table. Anything that has not been taken out as an exception during the matching process will be transcribed by replacement of "richt" by the corresponding Braille contraction. Immediately above this you see the sequence "bricht" which probably is the inflected form of "brechen". It might be found in words that are etymologically related to "breaking". However if another vowel is added we get "abricht". which may come from a word having a meaning related to abrichten="training". Going through the list from the bottom up you find longer and longer sequences along with the correct way they should be transcribed. It might be worth pointing out that at the top there are fragments of words in which, again, the original contraction "richt" is the proper translation into Braille.

One may summarize the work of Splett by saying that he essentially enumerated all of the exceptions of the German language (as far as they appeared in our material). His tables of exceptions contain about 8000 entries, representing the work of several years. To apply his tables is very time consuming, so we have structured them in a more sophisticated way. The most frequent words of the German language were stored together with their correct translation in a first table, called file A. It also contained problem words for which, in this way, the correct transcription could be ensured, e.g. foreign names. File A contains at present about 650 entries and accounts for about 40 % of the translation of a text.

If a word is not translated by means of file A it is checked against a table containing a list of the other possible contractions. That's, a window is moved over the word to see whether the sequence to be contracted can be found in the inkprint word. If a match is found the above described table associated with this specific contraction will be consulted. After processing this contraction at least part of it will be encoded for Braille and checking of the remaining inkprint string(s) is resumed. Finally the remaining letters are translated one by one.

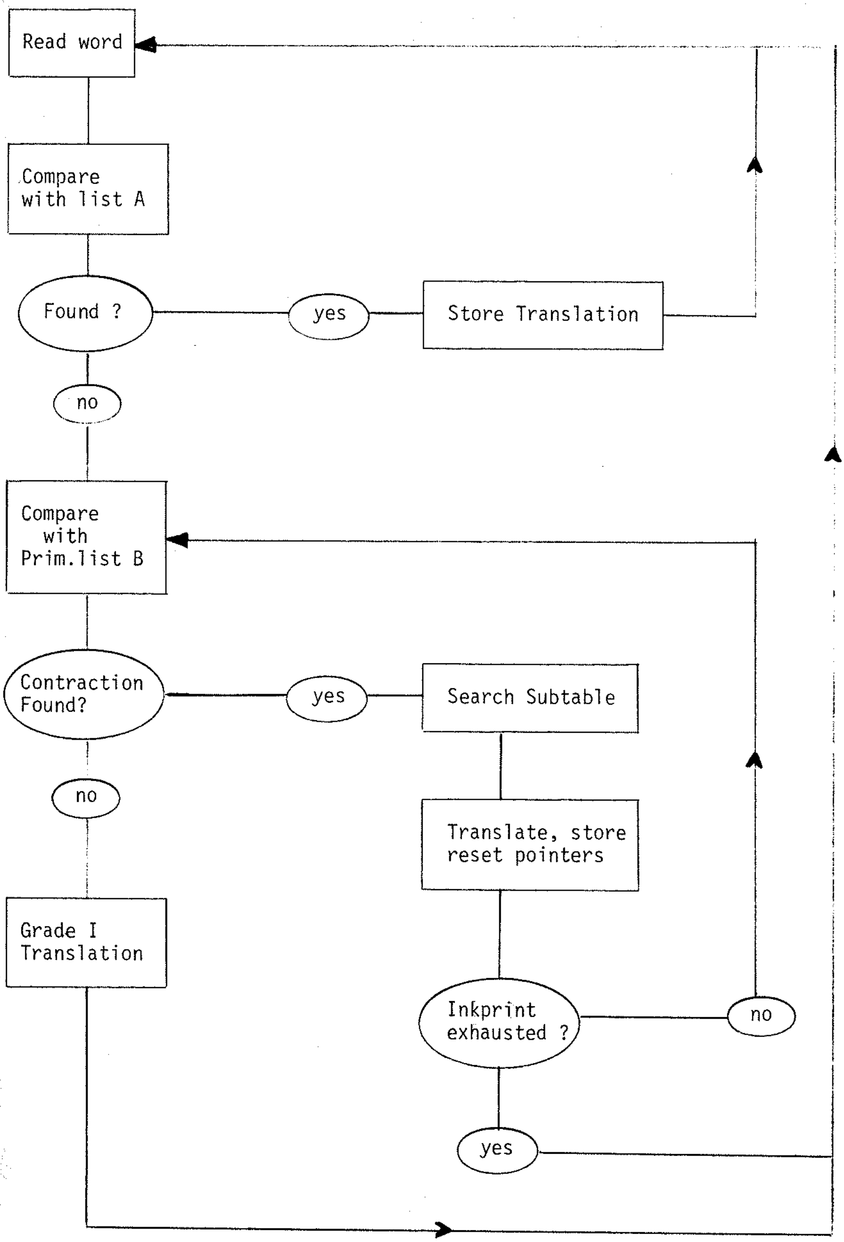
To avoid unnecessary searching the entries of file A are listed in order of the length of the words and a search is started according to the length of the word to be translated. Similarly, file B is organized according to the length of its entries, but in addition those sequences that cannot stand alone are first. If such an entry has length 6, say, it cannot be used in a word of length 6 and therefore need not be considered. Splett also eliminated cases which cannot appear because they are taken care of by a contraction that has been resolved before in file B.

In spite of all these tricks this program is slower then the first program. (A certain compromise was made in another variant of Splett's work, following a proposal of W. Slaby that was just as the other program, originally implemented in PL/I by B. Eickenscheidt. Slaby's concept lacks, however, the precision of the program described here in detail.)

The included flow-chart indicates how the new program operates.

At Bonn M. Lautsch and three other students programmed the same algorithm in Fortran, using a minicomputer. They took precautions to make the program transportable. To demonstrate the process of translation by means of Splett's tables, we give some examples. The first two examples show that a small input error, easily overlooked by a sighted person, ("Grundlage" is a German word, but "Grunglage" makes no sense) may considerably change the Braille output. The last word is somewhat longer and indicates all the steps of the transcription. (Blindenschriftprogramm means Braille translation program). It is certainly not easy to guess the inkprint meaning from a letter string that represents Braille transcription unless one knows quite a lot about Grade II Braille.

FLOW - CHART OF SECOND TRANSLATION PROGRAM



EXAMPLES OF TRANSLATION

Grundlage → <GRUND>lage
<GRUND>la<GE>
<GRUND>LA<GE>
GDLA<GE> ,<GE> has no alphabetical correspondence

Grunglage → gr<UNG>lage
gr<UNG>la<GE>
GRULA<GE>

Blindenschriftübersetzungsprogramm → Blinden<SCH>T übersetzungsprogramm
BL en<SCH>T übersetzungsprogramm
BL en<SCH>T,Ü setzungsprogramm
BL en<SCH>T,Ü,Eungsprogramm
BL en<SCH>T,Ü,EUSprogramm
BL en<SCH>T,Ü,EUSPROgramm
BL en<SCH>T,Ü,EUSPRO_GRAX
BL C <SCH>T,Ü,EUSPRO GRAX

CONCLUSIONS and OUTLOOK

The last program described based on the work of Professor Splett achieves a correct translation rate of about 997 out of 1000 different words, which amounts to 2 or 3 errors on 50 Braille pages. This number is usually exceeded by those errors caused by inprint misprints. Any specific word can be handled, however, by inserting it in our tables (in the above context it would be added to file A).

Our technique of processing Braille is used in all western countries where German is spoken:

in Germany at Bonn, Münster, Heidelberg (Rehabilitationszentrum),
Austria at Wien, Ministerium für Unterricht und Kunst,
Switzerland at Zürich, Schweizerische Bibliothek für Blind- und Sehbehinderte.

The Deutsche Zentralbücherei für Blinde in East Germany is wellinformed about our work and showed interest in adopting it. The Deutsche Blindenstudienanstalt in Marburg is installing a computer and will soon start with automatic Braille production. In Bonn we have written the programm in Fortran so that it can run on a desk computer for example. A grant that I received 3 years ago has enabled us to implement the program on a microprocessor station, work done by H.W. Kisker, so that chips could be produced and be available to furnish the Braille translation. There are now several companies in the United States and Europe which produce Braille output devices and one can only hope that prices will come down as they have in general for other kinds of electronic devices. The developments in prices for mini- and microcomputers and their peripherals make us hope that in the not to distant future every school and even many single blind persons may possess the electronic equipment needed for automatic Braille translation.

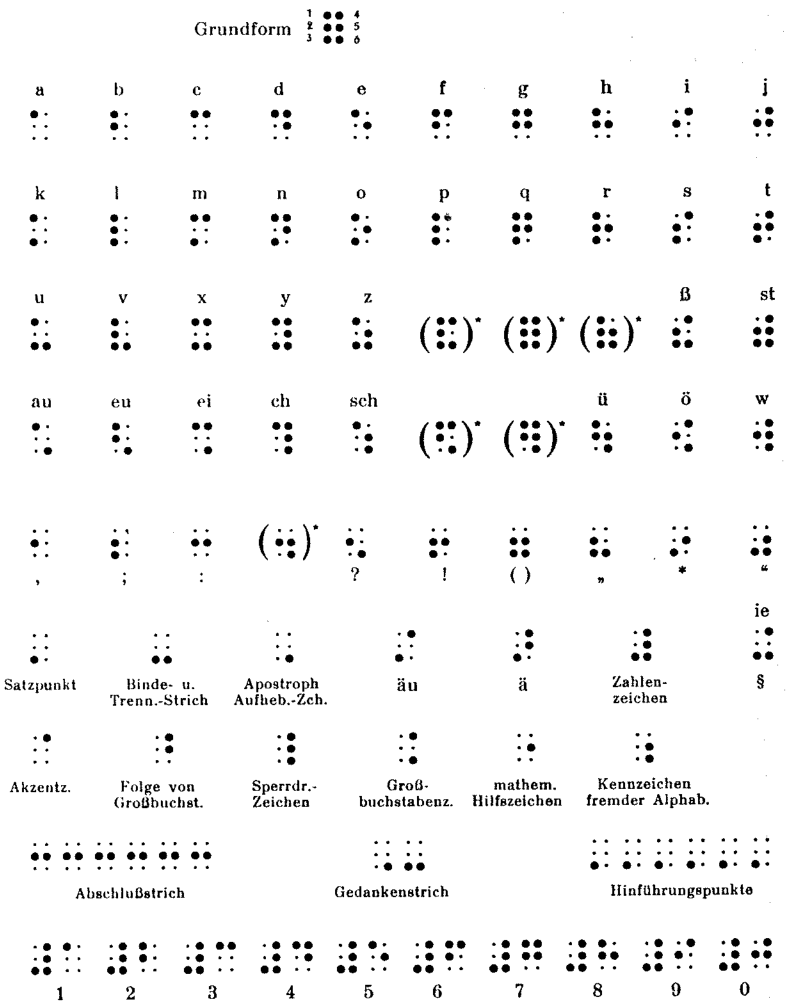
I expect, that paperless Braille has a great future: Instead of bulky stacks of paper, the blind person may store magnetic cassettes or discs as reference material. They may be used in equipment comparable to a tape recorder and read as temporary (paperless) Braille output. This technique will, in particular, make the necessary material available to the blind professional - scientist, lawer, artist.

For these needs we still have to adjust our Braille programs and work is underway. I should mention the efforts of mathematicians to do printing by electronically controlled phototypesetting. This indicates that we soon will have large numbers of mathematical texts stored in computer readable form, hence ready to be translated into Braille on request. This would greatly enhance the chance of blind mathematicians.

Communication between those working in this field has been excellent in the last decade. We hope to save time and share experience particulary in the developments mentioned last. To facilitate this cooperation it is desirable to have standardization with regard to the representation of data, the Braille characters, the interface processors and input/output devices. I think all of us are open to sharing our experience and knowledge with those persons who wish to take up the work, say, to do the same for other languages in countries which have not yet made such aids available to their blind citizens.

APPENDIX 1

TABLE OF GERMAN GRADE II BRAILLE ALPHABET



From: Marburger Systematiken der Blindenschrift
neu herausgegeben von H.-H. Schenk
Teil 1, E. Freund, Leitfaden der deutschen Blindenvollschrift, Marburg 1977

TABLE OF GERMAN GRADE II BRAILLE ALPHABET AND CONTRACTIONS

Reihe	1	2	3	4	5	6	7	8	9	10
Gruppe I	⠁	⠃	⠉	⠙	⠑	⠋	⠛	⠓	⠊	⠚
Alphabet	a	b	c	d	e	f	g	h	i	j
Laut- u. Silbenkürzung			en							
Wortkürzung	aber	bei	sich	das	den	für	gegen	hatte	ihr	jetzt
Gruppe II	⠅	⠇	⠍	⠝	⠕	⠏	⠟	⠗	⠎	⠞
Alphabet	k	l	m	n	o	p	q	r	s	t
Laut- u. Silbenkürzung							ll			
Wortkürzung	kann	läßt	man	nicht	oder	so	voll	der	sie	mit
Gruppe III	⠥	⠧	⠭	⠽	⠵	⠯	⠿	⠷	⠮	⠾
Alphabet	u	v	x	y	z					
Laut- u. Silbenkürzung			mm	el		ge	es	em	ss ß	st
Wortkürzung	und	von	immer	welche	zu	gewesen	es	dem	daß	ist
Hilfszeichen							Grundform			
Gruppe IV	⠡	⠣	⠩	⠹	⠱	⠫	⠻	⠳	⠪	⠺
Alphabet								ü	ö	w
Laut- u. Silbenkürzung	au	eu	ei	ch	sch	ein	er			
Wortkürzung	auf	wie	als	durch	schon	ein	er	über	sein	was
Hilfszeichen										Scheidez. bei Zahlen
Gruppe V	⠌	⠜	⠬	⠄	⠠	⠤	⠐	⠨	⠸	⠼
Alphabet		ä								
Laut- u. Silbenkürzung	äu		ie			ver		ck	lich	ich
Wortkürzung	auch	hätte	die	des		im				ich
Satzzeichen						Gedankenstrich Binde- und Trennungsstrich				
Hilfszeichen			§	Apostroph Lückenzeichen	Akzentzeichen Hilfszeichen Aufhebungspunkt		Mathematisches Hilfszeichen Betonungszeichen	Großbuchstabenzeichen	Sperrdruckzeichen	Zahlenzeichen
Gruppe VI	⠂	⠆	⠒	⠲	⠢	⠖	⠶	⠦	⠔	⠴
Laut- u. Silbenkürzung		be	al	un	or	an	eh	te	in	ar
Wortkürzung		besonder-		unter	vor	an	mehr	ihm	in	war
Satzzeichen	,	;	:		?	!	()	„	.	“
Hilfszeichen	Randpunkt						Gleichheits- oder Entsprechungszeichen			Artikelzeichen
Gruppe VII	⠈	⠘	⠰							
Laut- u. Silbenkürzung		ig	ach							
Hilfszeichen	Betonungszeichen Akzentpunkt									

APPENDIX 2:

SUMMARY OF GERMAN BRAILLE RULES (GRADE II)

from

"MARBURGER SYSTEMATIKEN DER BLINDENSCHRIFT"
herausgegeben von H.-H. Schenk
Part 2: Freund, Leitfaden der Deutschen Blindenkurzschrift,Marburg 1973

given are contractions and rules for their use

I) Abbreviated Vowel Groups (gekürzte Lautgruppen)
23 contractions to 1 Braille character.

Rule 1: How to retrieve the original meaning from single character
Ex.: "en" ~ (14) → "c", when written with "Aufhebungspunkt" (6)

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● ●        special dot for Dissolation
· ·
· ·
```

Rule 2: The use of contractions
They may not be used if they could be mistaken for punctuation marks, or if they are composed of 2, 3, 5, 6 only and may cause difficulties in reading.
Ex: "ach" ~ (56)   not used in "achten".

```
· ·      ● ·  ● ●  · ●  ● ●
· ●      · ·  · ●  ● ●  · ·
· ●      · ·  ● ●  ● ·  · ·
```

Rule 3: Priority of contractions
A) double consonants: ll, mm, st
B) starting with a vowel: eh, em, el, en, er, es, ig
C) starting with a consonant: be, ge, te

Ex.: helle → HE<LL>E (not H<EL>LE)

but be, ge have priority if they are prefixes

Ex.: beliebt → <BE>L<IE>BT

double vowels should be contracted into a vowel group, if spoken, as one (long) vowel

Ex.: meere → MEERE not ME<ER>E .

Those vowels which are pronounced as two vowels should not be contracted

Ex.: familie → FAMILIE not FAMIL<IE>

II) Contractions for Prefixes and Suffixes

Rule 4: Prefix contractions may only be used at the beginning of words
(be, ge, aus, ent, ex, pro, ver)

Rule 5: Suffixes
Some may be used inside of compound words, some may be inflected, others may only appear at the end of the word.

III) Contractions of Words and Word Stems

There are one character contractions and two character contractions
They are grouped in 3 lists.

Rule 6: First list - isolated contractions.
(some exceptions)

Rule 7: Second List - contractions used in isolation or in words. Inside words they are indicated by dot (2). This dot is not set if the contraction is followed by a one character contraction, a "comma contraction", or the "Umlaut point".
(Exceptions for readibility)

Rule 8: Regulations about the contraction point, if the contractions are inflected or "umlauted".

Rule 9: Third list. Inflections without the indicating dot (2).

Rule 10: Dissolution of one character contractions.

Comma-Contractions

Abbreviations of verb stems to two characters,
First being (2), or (5) for Umlaut

Rule 11: Use of comma-contractions.

Rule 12: Some may be used with ending only.

Two Charakter Contractions:

Rule 13: Use of these contractions.

Rule 14: Construction of their Umlaut.

Rule 15: Hyphenation (for formatting).

Rule 16: The contractions shall be used only if etymologically correct meaning is present.

IV) Special Characters

Rule 17: Slash, accent, special alphabet.

Rule 18: Marking of capital letters (46)

Rule 19: Transition from Grade II to Grade I.
Foreign alphabets.

V) Special Forms of Writing

Cases of ambiguity, names, units of measure, dates.

APPENDIX 3:

HISTORY OF AUTOMATIC BRAILLE PRODUCTION FOR THE GERMAN LANGUAGE

March 1962 — My first contacts with the problems of contracted Braille (Grade II) during a visit of E. Mansholt (Hannover) at Hamburg.

First demonstrative program for Braille production by means of computer for Grade I (already typical difficulties), in cooperation with my students R. Wais and W. Dost.

August 1962 — IFIP - Congress at Munich: Informal discussion group on automatic Braille production -.

1963 — Several visits and inquiries about hardware at TH Eindhoven, American Foundation for the Blind, American Printing House for the Blind, Stanford Research Institute.

1964 — Contact with Dr. G. Hübner, IBM Germany. Advice about his "Silbentrennungsprogramm" for detection of word stems and etymological fragments in German.

My move to Münster University together with my coworker W. Dost.

Application to DFG (German Science Foundation) for support of a card driven Braille embosser from APH, granted 1965, final arrival of all parts in February 1967,
1981 transfer of the machinery to "Deutsches Museum" (for Science and Technology) at Munich.

1965 — First version of program for "German contracted Braille" production operational at Computing Center of University of Münster, implemented by W. Dost.

1967 — Mr. Klenk, from Public Relations of the Printing House Gruner & Jahr proposed cooperation to produce a biweekly Braille Magazine with articles from "Stern" and "Zeit". First preliminary editions in 1968.

1969 — Since January 1969 regular production of "Zeit-Stern-Magazin", each edition about 40 Braille pages:
Linotype tape from the Printing House at Hamburg,
translation to Braille at Münster University,
printing at "Verein zur Förderung der Blindenbildung", Hannover,
Circulation about 5000.

October 1971 — Decisions about Reform of German Grade II Braille at Vienna. Some advice on computer feasibility from our working group.

March 1973 — First international workshop on Computerized Braille Production at Münster
Translation programs from inkprint to Braille for several languages are presented.

1973 — Linguistic foundations for further improved accuracy of Braille translation is started by Prof. Dr. Splett (German Dept. University Münster)
A series of seminars is conducted by Prof. Dr. Splett,contributions by Dr. Kamp.

1974 — Second workshop on computerized Braille Production at Copenhagen.

1977 — A grant from the Ministery for Research and Technology for a microprocessor station to produce a version of the translation program on a microprocessor.
By H.W. Kisker, partly supported by H. Stenzel, completed 1981.

1978 Grant for a SAGEM REM 8 BR printer from "Deutsches Blindenhilfswerk e.V.".

Completion of new program for translation to Braille for the German language, based on Splett's tables, implemented by B. Eickenscheidt, Now more than 99,5 % accurate.

1979 Third international workshop on Computerized Braille production at London.

1980 Move and transfer of project to Bonn University.

1981 Rewritting and completion of translation program in FORTRAN according to the rules of Splett and implementation on minicomputer by my co-worker Lautsch and some students.

Special cooperation with Blindenstudienanstalt in Marburg to transfer translation facilities to their new plant for Braille production.

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Uses of Computers in Aiding the Disabled
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North-Holland Publishing Company

COMPUTER AIDS IN THE AREA OF VISUAL HANDICAPS

M. TRUQUET - J. FRONTIN - D. LEVY - J. MEEKEL

Centre TOBIA (1)

Laboratoire "Langages et Systèmes Informatiques"

(L.S.I.)

UNIVERSITE PAUL SABATIER

TOULOUSE - FRANCE

Our aim is to present some projects realized by TOBIA Center, and also to mention some research undertaken by other teams working in the area of visual handicaps at Paul Sabatier University of Toulouse, the results of which will be employed by TOBIA

TOBIA CENTER

In 1973, during the workshop in Münster a paper was presented by Toulouse concerning the French transcription into grade 2 Braille.

Since Then :

- The program was written again in a portable language (FORTRAN IV) as it was in Macro Assembly Program.
- A French device was built on our behalf (the SAGEM TEM8 Braille device).
- TOBIA was created in 1977 by the former President of the University (J.C. MARTIN).

The purpose of this Center is :

- To pursue work and research in the realization and improvement of transcription programs, to develop new studies in this area.
- To realize and produce all types of transcription.

THE RESEARCH

Research realize :

. Transcription of music into Braille (J. FRONTIN).

This software is an international system for an automatic production of music.

In fact three printing modes are possible :

- The one used in Great Britain (Bar by Bar) the score is read from bottom to

(1) Transcription par Ordinateur en Braille Intégral et Abrégé.

top and one measure of each part is successively transcribed.

- The one used in the United States (Bar over Bar).

the score is read from top to bottom, a materiel line being reserved for each part. In each group, measures begin of the same vertical.

As for the previous mode chords are built from the bottom. At the beginning of each line the contracted name of the following part is mentionned.

Moreover, on the first line of the group, the running number of its first measure is mentionned.

- The one used in France : A musical line of each part is written from top to bottom. It is different of the former methods : in the melodic line, the chords are built from the uppest note, it permits to emphasize the melody. For the accompaniment lines the construction is made on the bass part.

The input :

The language implemented tries to satisfy the following criterions :

- An easier learning : a simpler grammar and mnemonic codes (easy to modify) are used.
- An easier utilisation : it avoids the redundance of the information. Some value will be taken approximatively.
- Easier proofreading and correction.
- Easier evolution of the language used.

Data processing :

Three steps are necessary

. The analysis of the data

. The transcription

. The Braille edition

The analysis :

A modulus tries to detect syntatic and semantic mistakes : (uncomplete measure, incorrect octave value etc...)

The intermediate score :

The precedent data are one after the other treated starting by the end, in order to know the maximum value of the counters (double symbols). The Braille cells are stored in a dictionnary, the access of which is made according to two data : the position of the variable inside the symbolic note and its value. The Braille material is in conformity with the musical rules, but independent on the edition mode. Consequently, chords are kept in their numeric form, their transcription depending on the chosen printing mode.

The edition :

As we have just seen there exists three modes of edition :

- The French one
- The American one
- The English one

Remark : The programs are implemented on an IRIS 80 CII. Their modular architecture gives the possibility of implementing the programs on a microcomputer.

. Transcription of mathematics into Braille (J. MEEKEL)

In ink-print a mathematical expression is represented multilinearly like :

$$\sum_{i=0}^{n} f(i)$$

A seeing person reads this expression :

" Σ for i=0 to n f(i)" which is nearly the same for the blind :
" Σ , i=0, n, f(i)".

We see that the expression must be linearized to be transcribed into Braille.

Different acquisition methods exist to do that. Many of them aim at coding the mathematical text in a linear form and reproducing the original text on an output device (grafic terminal, phototypesetter). This method supposes the use of a mathematical text editor and a good Knowledge of mathematics.

To produce Braille documents we use a system requiring three different steps :

- The acquisition of the scientific text.
- The linearization of the text.
- The Braille transcription of the linearized text.

The acquisition :

The method we selected is an off-line data acquisition with a display terminal provided of a mathematical sign generator and cartridge units.

The mathematical text is directly recorded on a tape cartridge by an operator knowing neither mathematics, nor Braille. He only has to reproduce an exact image of the original document.

The terminal employed is a HP 2644 A ; as for the caractere generator it includes 255 mathematic symbols :

- a keyboard of subscripts and superscripts
- a keyboard of logical, relational and functional operators
- a greek alphabet.

To these characters we must add the usual 128 ASCII character.

The linearization :

To be transcribed the text must be linearized. To recognize a mathematic text from a liberary text, the mathematic expression is preceded by a special code.

The linearization is realized in the same order as reading. The text is read from left to right and linearized step by step.

In a first step the main line must be determined.

Each mathematic data group has a main line.

So $\prod_{i=0}^{n} f(i)$ has a main line : π f(i) ;

"n" and "i=0" being on adjacent lines.

The main line is determinated by definite rules which correspond to the different cases.

These rules have been ordered with the frequency of their use.

The text is scanned vertically from top to bottom and from left to right until a determination case is encountered.

The following expression :

$$f(x) = x^4 + \frac{4x^2+1}{\frac{x}{2}}$$

is divided into three horizontal data groups

$$\boxed{f(x)} \quad = \boxed{x^4} \quad + \boxed{\frac{4x^2+1}{\frac{x}{2}}}$$

where "=" and "+" indicate the main line. They are the intermediary characters.

$\frac{4x^2+1}{\frac{x}{2}}$ is then separated in two blocs

$$\frac{\boxed{4x^2+1}}{\boxed{\frac{x}{2}}}$$

"/" being the intermediary character.

The Braille transcription :

A Mathematic text necessarily includes a literary part and mathematical formulas.

In a first step only the mathematical expression is linearized then transcribed into Braille.

In a second step the literary text is transcribed either in grade I, or in grade 2.

Remark : This system can transcribe either a general or a specialized scientific text. For each specification a correspondence table is necessary.

The method can be used on an international level even if different codes are used to represent mathematic signs.

Research projects

Research undertaken

. The passage from the Braille document (grade 1 or grade 2) to the inkprint document (J. MEEKEL).

This research is linked to the discovery of the DIGICASSETTE which permits to record Braille information on cassettes.

This realization will allow the teachers and blind students to work together. This transcription system will implemented on a microcomputer.

Projects

. The reconstitution of an ink-print score from a Braille score which will enable greater communication for blind composers.

. The automatic reconstitution of an ink-print score from an input data of a score. It will be a solution to proofread by a single comparison with the original document.

. Computer aid to learn :

- either Braille (grade 1 and grade 2)
- or programming languages etc...

THE EDITION

Since 1977, with only one typist and one SAGEM Braille device, we have produced more than 100.000 Braille pages.

TOBIA is a pilot Center and it has shown the efficiency of the automatic produc- into Braille.

Requests come from many countries (switzerland, Canada, Belgium...) and from many areas :

. Professional :
  - lists for ANPE (1)
  - legal texts ....

. Cultural :
  - novels
  - poems ....

. School-books :
  - grammar
  - history - geography book etc...

(1) National Employment Agency

. Student-books

- anatomy courses
- psychology courses
- literary text
- law courses...

. Ordinary life :

- bank statements into Braille ...

The Braille documents are obtained either on paper or on cassettes.

Remark : A very important experiment was undertaken with the MEB (1) to transcribe the Bible into Braille. It permits to verify that our system was compatible with several output devices. Another experiment which has been of great help to the Blind students in TOULOUSE was the transcription of exam subjects into Braille.

REALIZATION AND PROJECTS OF OTHER TEAMS
(working in the area of visual handicaped persons)

- L.S.I.- ENSEEIHT (P^{r} BRUEL A., CONTER J.) Ecole Nationale Supérieure d'Electronique d'Electrotechnique d'Informatique d'Hydraulique de TOULOUSE.

. Optical reader "DELTA"(2) which recognizes the form of the letter and gives the equivalent in ASCII code.

Three output are possible :

- A Morse output
- A Braille output on a line of 12 or 20 ephemeral Braille characters
- A Spell output

. A project to develop an automatic optical reader which will be used for Braille production as input data.

- L.S.I. (R. CAUBET)

. Automatic input of a score with the help of a drawing table.

- L.S.I. (P^{r} BETOURNE C., LIROU P., LAGARDE J.M.)

. The "Ordibraille"

It is a microcomputer adapted for the blind, with a special keyboard with 6 keys and a Braille output (ephemeral Braille Characters). It will be a complete system with, floppy discs... to be used for networks for example, especially data processings.

(1) Swiss Evangelical Braille Mission

(2) Dispositif Electronique de Lecture Tactile pour les aveugles.

Many possibilities will be possible thanks to the grade 2 program of TOBIA and other softwares. The function of which will be to help the blind in all areas like arithmetic operations etc...

- L.S.I. (D^r POLI - M.C. GENNERO)

The preparation of an experiment to transmit by the TELECOM 1 satellite, grade 2 Braille documents.

A long distance satellite produces some transmission errors. The aim of this team is to correct these errors with the methods already studied for the NADIR project.

- CERFIA (1) P^r G. PERENNOU - D^r B. CAUSSE - G. GOUARDERES

D^r B. CAUSSE and G. GOUARDERES have realized two systems used for data-banks.

. One permits to find and access to a part of a voluminous document with the help of key-words.

. The other realizes the summary of a document (either small or voluminous).

With his team P^r PERENNOU has realized two softwares :

. one permits to input data with a microphone but at the present time the words must be seperated but not linked :

"LES OISEAUX" must be read LES OISEAUX and not LES "Z" OISEAUX.

. The other software gives the possibility to output data on a syntactic voice device.

CONCLUSION

As we have seen, many teams of Paul Sabatier University of Toulouse are working in the area of visual handicaps.

If a National or a Regional Printing House for Braille was created in TOULOUSE to discharge TOBIA of the edition, it would satisfy the Braille production in many areas.

TOBIA would thus remain the experiment center, - in fact all the results would be tested in TOBIA center before being definitive used -.

The future for the blind is not bad, we only need money to realize these researches.

This future may be very near, we hope.

(1) Cybernētique des Entreprises, Reconnaissance des Formes et Intelligence Artificielle.

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Toulouse - Septembre 1981

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THE BRAILLE COMMUNICATION SYSTEM

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Braille code is central to effective communication and information handling by blind people. With the advent of dynamic braille displays, storage of braille on magnetic media, along with recent proliferation of the microprocessor and associated software tools, tasks previously known to be onerous if not impossible for blind individuals can be accomplished with efficiency and speed.

With the VersaBraille, braille is no longer a closed system which requires that written communication be processed in some fashion by a sighted person. By conducting a simple dialog with the machine, the user can configure the interfacing port to communicate with a large variety of data processing equipment. The translation from braille to ASCII and vice versa is completely transparent to the users on either side, and the selection of braille type (Grade I, Computer Braille, Foreign Languages, etc.) is made by the user. Files of data can be prepared in braille and listed on printers for an evaluation by a sighted person, and data can be entered from any ASCII terminal or any remote source (modem) and stored in the VersaBraille™ for reading or processing.

Although braille will remain a system used mainly by the blind, with the VersaBraille system the existing communication gap between the sighted and the blind world has been reduced.

INTRODUCTION

Braille code is central to effective communication and information handling by blind people. With the advent of dynamic braille displays and the storage of braille on magnetic media, braille becomes a much more useable communication medium for the blind. Editing of text, a task which the sighted can easily accomplish with a pencil, is onerous if not impossible for the blind working with embossed braille. The production cost of braille materials is high and has traditionally required substantial subsidy from the Federal Govenrment. The average title produced by a large braille printing house costs $44 per copy while the average cost of a hand-copied title is $80 per copy. Because of the great expense involved, limited centralized production facilities and equipment, and need for specialized transcriber skills, less than 5% of the ink-printed material is made available in braille.

The VersaBraille™ system is a portable self-contained word processor and information center for the blind user. It consists of a dynamic braille display and a magnetic storage media all under the control of a powerful microprocessor which makes the process of reading, writing and editing of braille text a very simple operation.

Reading habits of the embossed braille reader were carefully evaluated and compared with selective reading and text skimming methods commonly practiced by sighted readers to provide a powerful indexing scheme by which portions of braille text can be retrieved with ease and at comparable speed. Duplication of braille information, which has traditionally demanded expensive electro-mechanical embossing devices, now becomes as easy and inexpensive as duplicating a cassette on a high speed copier. In essence, this inexpensive duplication process becomes a form of xerography for the blind.

As significant as these improvements are, braille remains a closed system and the blind remain isolated from written communication unless prepared by a skilled transcriber. Family members, teachers, and co-workers still cannot communicate in written form with a blind individual unless the braille code has been mastered.

DESIGN REQUIREMENTS FOR THE VERSABRAILLE SYSTEM

An observation of any typical information system designed for the common non-professional user will bring to light two obvious conclusions: (a) the equipment (CRT terminal, printer, etc.) is not portable and (b) the equipment is not standard and varies in interfacing requirements. On the other hand a short study of the braille code commonly used among blind readers along with equipment used to produce braille code (embossers) will reveal that the braille language and the equipment which is used subscribes to a large variety of standards and written conventions.

To overcome the non-uniformity described above the specifications for the Model P2 VersaBraille have to include three fundamental requirements:

(a) easy interfacing to a large number of communication and information systems

(b) adaptability to a variety of braille codes

(c) portability.

Without flexible interfacing, each system would have been configured by a trained professional and would remain connected to the system at a defined physical location. Since many blind readers are already using embossers which produce a variety of braille codes, adaptation of any specific code will not be accepted by many potential users. This is particularly true when the braille code is adapted for foreign languages or specific professional symbols within the language. The selling price of any electronic braille machine is relatively high. This is mostly due to the high cost of production and is not likely to be reduced drastically in the coming years. The likelihood of a single user being able to afford several machines to be located in several sites (home and office) was never considered to be very high. Consequently, the final product must be portable and should be easily transferable from one location to another with minimum efforts. This last requirement complements the first one for easy interfacing by the non-professional user. Additional requirements like easy editing and indexing of text, and the utilization of conventional cassette duplicators for mass production purposes have already been satisfied in the VersaBraille system. The VersaBraille P1 system along with its unique recording format was widely in use before the P2 Model requirements were drawn. The two models were designed to be compatible.

MODES OF OPERATION

The Model P2 VersaBraille system offers all the features to satisfy the basic requirements outlined previously. The basic set of instructions used in Model P1 was not modified but rather complemented in two different ways with an additional instruction set: (a) added unalterable code to the basic machine which is used mainly for the standard interfacing requirements of any computerized input or output device and (b) additional alterable code loaded from the cassette unit which modifies and adapts the machine for three specific tasks:

(1) to display the braille information stored in the cassette on any hardcopy alphanumeric printer or a braille embosser

(2) to reproduce in part or in its entirety the braille information stored in the cassette on another braille cassette

(3) to emulate as closely as possible the functions of a CRT terminal for on-line communication

The VersaBraille can be interfaced to RS232C connectors and can communicate with asynchronous systems using the ASCII information code, but by conforming to the RS232C standard along with standard ASCII code one cannot assume that a communication between two data sources is established. Many options for both hardware and software features exist, and remembering each unique configuration is not a trivial task.

In the Model P2, all the Configuration Control Parameters (called CCP) are arranged in a two-dimensional table. The rows distinguish between the different parameters (like baud rate, parity or printer's line length) and the columns specify the choice within each option. With the help of a special built-in editor, the user selects any parameter and option within each parameter or resorts to the default values. The need to remember the different options or to use built-in switches or jumpers customary to all other terminals has been eliminated. Once the CCP are defined they can be stored permanently on a cassette (called overlays) for future use as a new set of default parameters. Without any of the overlays, the VersaBraille behaves like a standard TTY and can be used as such for the purpose of information storage, information source or as a control device. Since most systems today assume the existence of a CRT terminal as a control and display device, a high speed printer as an output device and a magnetic media as a storage device, the need for overlays is apparent.

BI-DIRECTIONAL ASCII TO BRAILLE TRANSLATION

Braille is based on a code involving a six-dot cell arranged in a 2 x 3 matrix. Various combinations of dots are used to represent different characters, symbols and punctuation marks. In 1959, standards for English-American braille were compiled and adopted. Foreign countries have adopted similar standards for braille in other languages. English-American braille exists in three basic forms. These forms are referred to as "grades". Grade I braille consists of approximately 51 characters and symbols; each one can be represented by two or three braille cells. Grade II braille employs approximately 200 "contractions" or abbreviations of various words and letter combinations. Grade III uses a larger number of contractions than Grade II. One dominating fact, which is consistent throughout the entire braille system is that the rules which define the arrangement of braille cells to form words and sentences are text dependent. In Grade I, the rules of translation are relatively simple and most of the alphanumeric characters remain unaltered. However, in higher grades the rules are more complicated and the resultant code is very contracted and represents for the most part the spoken form of the language along with the written one.

The ASCII code consists of approximately 128 characters each represented by a unique symbol. Some characters in the braille code are not represented in the ASCII system (like Capital or Numeric signs) and some characters in the ASCII code (like <, >, @ or %) are not defined in braille.

The complexity of translating text from ASCII to braille is due to the textual dependency of the algorithms and the incompatibility of symbols. For example, when the ASCII symbol "." (period) is detected, it could be translated to either a period, a decimal point, or to an ellipses sign (different braille cells) and in this case the algorithm must examine the following and proceeding characters. Or when the ">" sign is retrieved, the translator must produce a meaningful braille code ("L.T.") which will alter the braille text. When a pair of braille capital letter signs is detected the translator must remember to capitalize every sequential letter until a space is detected. Braille italic signs are not honored.

Because of the above limitations, a different braille code was developed with symbols which are identical to the ASCII code. This new braille code (called Computer Braille Code) offers a one-to-one correspondence between the braille respresentation and the printable ASCII characters it represents. The code is designed for applications where more accurate braille representation for printed ASCII material is desired. Since the code uses the standard braille cell consisting of six dots, only sixty four (out of the 126) ASCII symbols can be represented. To be more specific, in all the braille machines produced so far, no distinction between upper case letters and lower case ones was made, a fact that limited the popularity of this code among braille users. Another obstacle was lack of standardization among the manufacturers of braille terminals and embossers.

The Model P2 overcomes all the above limitations in a very unique way. An efficient bi-directional braille Grade I translator was developed which practically obsoletes the need for transcription from one form to the other. In addition, a bi-directional computer braille translator was developed which represents the entire ASCII code. The distinction between upper and lower case letters is achieved with auditory messages during the process of reading. Here, for the first time, the accuracy of the printed text is kept without altering the traditional six-dot braille cell. As to the variety in computer braille codes, this obstacle is removed by allowing the user to substitute computer braille code with another one stored on a cassette as an overlay.

To summarize the above, the user can select either the braille Grade I translator or the computer braille translator resident in the machine, or substitute any unique translator available on the cassette. The braille reader can not only use the Model P2 in his or her native language but convert text in any desired foreign language.

OVERLAYS

Overlays are software routines which are stored as chapters on the braille cassette. When read by the Model P2 and activated, they essentially modify and enhance the ability of the VersaBraille to communicate automatically with a selected peripheral. In addition, the overlays contain all the Configuration Control Parameters (CCPs) and Computer Braille Code described in detail earlier. The modified or original overlays can be stored under different chapter names as many times as needed on any standard braille cassettes. Three overlays were originally designed, and more will be added as the need arises.

The hard-copy overlay provides the means for creating an inkprint or braille paper document of a text prepared in braille. This capability can provide a great increase in efficiency for any user who does a great deal of braille writing since it eliminates not only the transcribing needs but also the tedious task of formatting the printed text. The Model P2 automatically advances through all the pages of a chapter and sends the contents of the entire chapter to the selected printer. The CCP controls all the special requirements of the specific printer. Not only all of the communication parameters like data length, baud rate or carriage return delay are optional, but also printing formats like the number of lines per page, number of characters per line or pause to allow the user to insert a new sheet of paper in the printer are all part of the selection process. The overlay never splits words at the end of lines, blanks are inserted as needed and new lines are formed automatically. Even paragraph symbols are honored where a new line along with five space indentations are formed before the new paragraph is about to start.

The duplication overlay is used for duplicating, collating and packing braille information stored on cassettes. Two P2 models are required for the duplication process. The one which controls the process from which the braille information is sent is called the "master", and is the unit in which the overlay is stored. The unit which receives the information and requires only the formatted cassette is called the "slave". Once the unit is set with the proper CCP parameters, the user can selectively copy chapters from the "master" to the "slave" in any order. The user can interrupt the process and replace cassettes at will, under different chapter names. During the writing process a new chapter is automatically allocated to the largest block of unassigned pages. When braille chapters are deleted, spare pages are unassigned and cannot effectively be utilized by the system. When an entire cassette is duplicated from the "master" to the "slave", the information is packed such that the spare pages are deleted and the new cassette has more room for additional chapters. Cassette duplication with standard equipment does not provide for the packing process.

The most complex overlay, and by far the most popular one is the terminal overlay. It is designed for on-line communication with another information source by converting the VersaBraille P2 Model as a character-oriented terminal. Standard terminals contain 24 lines of 80 characters each, and the computer systems designed to display the information on the terminal's CRT screen have not considered the limited screen size (20 characters) of the VersaBraille display. When the user begins keying braille information into the Model P2, it appears on the display upon entry. If more than 20 characters are entered, the data scrolls through the display. However, as the computer sends data back at high speed, the information would have been lost without the "continuous scrolling" feature designed within this special overlay. As the display fills up and data continues to be entered, the current page buffer (in the VersaBraille memory) is filled while the display remains unaltered. Now, the user can read the information at leisure and while the user is advancing through the text, more memory is freed to receive additional data. If the data is entered faster than the user's pace of reading and the current page buffer if filled to its maximum capacity, the current page (old information) is transferred to the cassette tape and a new page buffer becomes available. The entire process, as complex as it seems, is completely transparent to the user. The user can read the information at his/her own pace, and transmit back at any time he or she wishes. Even with this flexibility of reading and transmitting information is never lost unless the user so desires.

CONCLUSIONS

The evolution of braille technology in the past decade has been very dramatic. With the VersaBraille system, braille users throughout the world can consider future braille writing, editing, and selective reading and skimming of text as a convenient, fast and portable process. Many obstacles for braille users such as manual transcribing, interfacing to peripheral equipment and adaptability to a variety of braille codes are completely removed with the Model P2. Although, with the VersaBraille system, the communication gap between braille and printed material is now being reduced, more research and development efforts should be directed toward the removal of the last outstanding obstacle which is the expensive dissemination process of braille and printed material in a computerized form.

Uses of Computers in Aiding the Disabled
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BRAILLE TRANSLATION

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Because the braille system used in English-speaking countries is based on phonetic considerations as well as spelling, the programming of a computer for automatic transcription of print to braille is a task that is technically challenging in the same way as programming for automatic speech generation or hyphenation. Despite the technical difficulties, practical automatic braille translation systems were implemented in the mid 1960's, and by the mid 1970's commercial software packages were available. The primary motivation for developing or purchasing such systems has been to maintain or improve braille production capacity in the face of a shrinkage, relative to the demand, in the workforce of human transcribers. Outright cost reduction has been a secondary motivation.

Automatic braille translation systems are now applied to languages other than English, to non-literary (e.g. mathematics) codes, and to reverse (braille-to-print) transcription. The experience gained from these various applications suggests that a common technical approach is feasible. This approach is neither "fully dictionary-based" nor "fully algorithmic" in character, but combines elements of both.

The technology of computerized braille translation, in conjunction with other rapidly emerging technology, has already served as a considerable force for change in the way we produce, use and define braille, with corresponding impact upon the communities concerned with these functions. As for the future, such changes, together with the social implications thereof, seem likely to be even more profound.

THE ORIGIN AND NATURE OF BRAILLE

Grade 1 Braille

When Louis Braille developed the system of writing for the blind that today bears his name, he did not invent something brand new but rather adapted an existing technology originally intended for military application. Raised-dot codes were being experimented with at that time as field ciphers that could be read at night without light. Such use of dots in the service of war has long since fallen by the wayside, of course, but braille remains the pre-eminent literary medium for blind persons--testimony to Louis Braille's foresight in choosing that particular solution to a problem he knew well.

Today, 152 years later, we find ourselves in somewhat the same position--applying computers, which were originally developed to improve the accuracy of gunfire, to the problems of braille production. I shall leave it to the reader to decide whether this reflection should leave us despondent over our priorities in allocating research funds, ecstatic over war as a prime mover in technology, or merely resigned to the permanence of hostility as a fact of human nature and grateful for whatever good can be extracted from it.

In its simplest form, the braille code is indeed simple. Each character, usually called a cell, comprises six dot positions arranged in a rectangle three positions high and two wide. As a dot may be embossed or not at each position, the total number of distinct symbols is 2 to the 6th power, i.e. 64, counting the space (no dots embossed). The most obvious way to relate these symbols to the common symbols of print is a one-to-one assignment. Thus, numbering the positions 1-2-3 down on the left column and 4-5-6 down on the right, we may have dot 1 = a, dots 1-4-5 = d, dots 2-5-6 = full stop (.), and so on. The assignment must be carefully designed so that symbols that are distinguished from certain others only by translation of the same "shape" within the cell--e.g. the "d" and full stop mentioned, or any of the six symbols having but one dot embossed--are likely to be juxtaposed with other symbols that will help define position for the reader. This issue has some parallels in print; the comma and the apostrophe, for example, are distinguishable only because nearby characters usually make the vertical position obvious. However, braille has proportionately many more affected symbols (29 of the 64) and this property considerably affects the design of the code. Another, more important, factor in braille code design is the great number of print symbols in use, as compared with the 64 available braille symbols. This leads to certain print symbols being represented as two braille symbols, e.g. dots 3-5, 3-5 = asterisk (*), and to "mode" symbols that change the interpretation of characters following, e.g. a "number shift" character, followed by a sequence of symbols that would otherwise represent the letters "a" through "j," implies that the symbols should instead be interpreted as numbers. For example, the sequence dots 1-4, 1, 1-2 would ordinarily be the word "cab," but 3-4-5-6, 1-4, 1, 1-2 means "312." Capitalization and italics are also examples of print distinctions that are handled by "mode shifts." Notwithstanding these complications, codes based on these principles, once designed, present little challenge either to human understanding or to computer programs automating the conversion of print to braille. Such codes are called grade 1 or uncontracted codes.

Grade 2 Braille

In every language, a grade 1 code, oriented towards the symbols used in the written general literature of that language, is the first defined. For some languages, this code is the only one defined, at least for general literature. (Typically, there are separate supplemental codes for technical material such as mathematics and music.) But for many languages, particularly those used by larger populations such as French, English and German, the grade 1 code is commonly supplemented by a system of contractions, i.e. the representation of commonly-occurring sequences by shorter sequences, the net effect being called a grade 2 or contracted code.

One of the motivations for adopting contractions is to reduce the physical size of a given text in braille. The standard braille cell, together with required surrounding space, leads to a roughly 40:1 expansion of area as compared with typical print, and when one considers the much heavier paper used for braille, further thickened by the dots themselves, it becomes less surprising that a single dictionary can occupy all of a large bookcase. Minimizing this volume is obviously a benefit in terms of raw material costs, production time and expenses, and eventual storage costs.

Another prime motivation for shortening braille is to speed up the processes of reading and writing, which of course directly saves the user's time.

In designing a contraction system, the choice of contractible sequences is, naturally enough, very much specific to the language in question. For example, "ation" is common enough to contract in English, not so in Spanish. Moreover, the choice of representation for contractible sequences must be, if not formally unambiguous, at least unlikely to cause confusion to one familiar with the language. For example, in English, the sequence "rcvg" would be unusual and therefore is easily recognized as standing for "receiving." One can observe, however, that despite numerous individual differences, certain broad principles apply to the process of grade 2 code design, viz.:

1. Commonly-occurring sequences are identified as contractible. These tend to be not only statistically frequent but also, for human engineering reasons, morphologic elements of the language--common whole words and roots, prefixes and suffixes.

2. The contracted substitutes, and the rules governing their use, are defined so that the contracted braille remains a practically unambiguous representation of print. These rules often include limiting the use of contractions to certain contexts. In English, for example, the prefix "be" is represented by the same braille symbol as that used for the semicolon (dots 2-3); to avoid confusion, "be" is contracted only at the beginning of a word.

3. To avoid doing actual or perceived violence to the language itself--that is, to avoid introducing effects that could mislead the reader in pronunciation or understanding, a further set of rules may be imposed that prohibits use of contractions when the contractible sequence is just a juxtaposition of letters that is in a sense accidental and not the originally intended morphologic element.

It is this third principle that makes transcription of print to braille something more than a purely mechanical task--sometimes for humans as well as computers.

Problems of Computerization

Some examples, drawn from English, may help to illustrate this point. One contracts the word "mother," not only when referring to one's distaff parent but also in such derivations as "grandmotherly"; the contraction should not be used, however, in "chemotherapy." "Sion" is contracted in "lesion" and "pensioner" but not in "psionic." The contraction for "lord" is used in "lordly" and "landlord" but not in "chlordane."

While the foregoing examples illustrate cases that a human can handle fairly easily--indeed, a human is unlikely even to notice the "mother" in "chemotherapy"--there are other cases where the odds between humans and computers are more even. For example, at least according to one expert, the "and" should be contracted in "pandemonium" but not in "pandemonism"--because, presumably, the syllable boundary between the "n" and the "d" is stronger in the latter word than in the former (corresponding, perhaps, to the linguistic prominence of the prefix "pan" in each word as currently used). This example also illustrates two further points: first, that in many cases contractions not corresponding to morphologic elements are permitted, provided the disruption is considered minor, as a means of getting more mileage out of the contractions; second, as implied by the reference to an expert, the points on which decisions turn are sometimes fine enough that even humans skilled in the art cannot always agree.

One inevitable consequence of all this is that sometimes different words that are spelled alike--homographs--have, because of a different morphologic structure, different representations. An example would be "lineage." The "ea" is contracted when the word has its more common meaning of "descendants," but not when it means "quantity of lines." Likewise, "do" as the common verb and noun is contracted, but not as the musical note.

Of course, grade 2 braille is not equally complex, from the point of view of computerization, in all languages. If the contraction rules skirt the third principle mentioned above, i.e. ignore the issue of morphologic elements, or employ only those where the graphic representation of a morphologic element is unlikely to arise spuriously, then to that extent the encoding of braille will be a more deterministic and hence more computable procedure. In the early 1970's, for example, a contracted code was introduced into Scandanavia, which reduced the problem of preparing braille to a straightforward function of the printed letters, regardless of pronunciation or meaning [Vind 73]. Because not everyone involved agreed that this sort of code is best for the human users, however, the code has not been universally adopted but now competes with the older, more conventional contraction system--a fate that should be noted carefully by those who would adopt the same type of code elsewhere.

Over and above the contraction rules themselves, the regularity of the underlying language also strongly affects the regularity of the braille. If the rules of word formation are quite regular, and in particular if the written and spoken forms of a language stand in quite regular relationship, then the braille will also tend to be more regular even though the contraction rules pay the customary attention to linguistic elements. Spanish apparently does well on both these points, while English does poorly. A language such as German, with its ad-hoc approach to compound word formation, is quite complex from the point of view of computerized braille translation [Eick 79].

THE MOTIVATION FOR COMPUTERIZATION

Before considering techniques for handling this complexity on computers, we may well ask first why we should wish to do so. After all, humans can generally cope quite well with the problems noted, and where they cannot they probably enjoy a friendly debate with their peers more than computers do. Moreover, human braillists tend to be either volunteers or highly motivated professionals; consequently, the process of transcribing itself sometimes seems to cost little or nothing.

While human braillists have served and continue to serve the system well, the fact is that they could not possibly meet the demands for braille today. In the English language alone, there are some 40,000 books published each year [Clar 79]. This figure is just symptomatic of the information explosion that we have all experienced in the last two decades--in newspapers and magazines as well as books, in computerized information services, in word processing systems, and indeed in every communications medium. Now there is no subject that is of interest to a sighted person that is not at least potentially of interest to a blind person. Hence, almost independently of the size of the blind population, the braille required, at least in terms of titles as opposed to copies, should keep pace with the volume of available print information. Of course, this is a goal that, even with computers, we are not even approaching at the present time: a scant 1% of the books published each year appear in braille [Clar 79]; the fraction is no doubt even lower for less formal publications and documents such as memoranda, etc. In the author's opinion, this relative paucity of available braille is the single most important reason why the great majority of the potential users of braille in the U.S. do not, in fact, make use of it [Even 78]. For many individuals, the payoff, for the effort involved in learning the code, is simply not that great under current circumstances. This is a situation that cries out for change; the potential is there not only to serve the existing user population better but also to serve a larger population. Computers can help and can do so primarily by maintaining and enhancing the production capacity of the system.

In the early 1970's, such maintenance of production capacity, in the face of a declining supply of qualified braillists, was the only clear rationale behind computerized braille production systems. Relative costs analyses were inconclusive. By 1978, the picture had changed somewhat: not only production capacity, but outright cost savings had become an issue. Today, with the cost of labor increasing and that of computer equipment decreasing, there is no question that computerized braille translation systems can save money, though just how much depends on a number of factors that vary with the local situation and, ultimately, how one does the accounting. One producer of braille by computer estimates that a job that formerly would have required 70 hours for a stereotypist skilled in braille to set up now requires about 45 hours to key in by persons who know little of braille but have more widely applicable (and available) skills. Moreover, the setup time has been further reduced to 15-25 hours by the availability of a compositor's tape, and this time is expected to decline still further as certain aspects of processing the compositor's tape, primarily related to formatting, are further automated.

Thus, while the principal motivation for computerized braille translation remains improved production capacity, a valid secondary motivation is cost--even without counting, if indeed it can be measured, the social cost of forcing a blind person to choose a profession other than the one he or she would choose if textbooks were available in braille.

None of this is to suggest that the work of transcribers has become less valuable or that braillists are to be put out of work by machines. Quite the contrary: as the volume of braille production increases, more help, and more highly skilled help, is needed on all sides. Brailling by hand may still be the method of choice when special codes or formats are involved, and this is of course inherently more demanding work. Also, as the reader may have guessed by now, the computer software may make mistakes in contractions; if perfect braille is required, the services of a proofreader are necessary and this, too, makes more intensive use of braille knowledge than original preparation. The author knows of no lost jobs, and does know of several newly created jobs, for braillists as a direct result of introducing computerized braille translation systems.

METHODS OF COMPUTER BRAILLE TRANSLATION

General Limitations and Characteristics of Methods

We have noted above that, for English, the brailling of certain homographs depends upon which pronunciation--as governed by meaning--is appropriate in a given instance. Moreover, though homographs are one source of sound- and meaning-dependencies in English braille, they are not the only ones; certain rules governing inter-word spacing may depend, for example, on the way the whole sentence is phrased, which in turn depends on its grammatical structure and meaning. Now the extraction of meaning from natural language by computer, while not impossible in limited contexts, is still well beyond the state of the art for general literature. Consequently, there is currently no way to build a "perfect" braille translator, at least for languages such as English. Fortunately--and here again English is rather typical--the actual frequency of meaning-dependencies in normal text is quite low. Moreover, the potential for actual confusion is lower still--blind people, after all, are quite as capable of overriding "misprints" as anyone else. Finally, if perfect braille is required, it is practical to incorporate human proofreaders into the production system provided the initial error rate is low enough.

It is, therefore, quite possible as well as useful to build translators that braille on the basis of character strings--words, short phrases, word fragments, punctuation sequences, and combinations of these. Today all braille translators operate on that basis. In that respect, braille translators may be classified along with hyphenation programs, speech generators and spelling checkers, and similar text processing applications.

Specific approaches to braille translation, however, differ widely. To gain perspective, it is useful to consider two opposite extremes.

Pure Dictionary vs. Pure Algorithm

First, we have what may be called the "pure dictionary" approach. This technique is characterized by the presence of a relatively large data base containing all the words of the language, together with a representation (in some code, which need not concern us here) of the braille equivalents. The translation program proceeds through a text as follows: Firstly, a word is isolated. Secondly, this word is looked up in the data base and its corresponding braille extracted. Thirdly, the braille is sent to the output, whereupon the cycle repeats. Of course, the program will also have to contend with punctuation and inter-word braille effects but, obviously, the bulk of the work is done by the dictionary.

At the other extreme, we have what may be called the "pure algorithmic" approach. Here the basis of logic is the rules of braille, i.e. the contractible sequences together with their rules of usage. These rules may be represented directly in computer code, in an auxiliary table, or some combination; the difference need not concern us for the moment. The program, at a particular point in the text, scans the rule list to see whether any one applies at this point. If one does, then the indicated action (usually a contraction) is taken; otherwise, the next letter is translated by itself (which may be considered a default rule), and the cycle repeats. The intermediate step of isolating words may or may not be taken, depending on the nature of the algorithm. The important characteristic is that the elements of logic are the same as the elements of the braille system, i.e. the contractions, rather than the elements of the language, i.e. words.

In English, dictionaries generally run between 25,000 and 750,000 entries. English Braille utilizes 189 contractions. Consequently, we would expect to find some 200 logical elements in a program or associated table that set out to translate English by pure algorithm, while a system utilizing a pure dictionary technique would incorporate a number greater by at least two orders of magnitude.

It is evident, then, that the algorithmic approach has the advantage as far as efficiency in storage and time is concerned.

Another plus for the algorithmic approach is its unboundedness. For even the 750,000 words listed in an unabridged dictionary do not cover highly specialized technical terms, obscure proper names, freshly coined words and other such that can occur, even if only rarely. With a pure algorithm, these are treated no differently from any common word; with a pure dictionary, unusual words can only be handled manually or, in the absence of a braillist, not at all.

Still another advantage of the algorithmic approach is its relative adaptability, should the rules of braille change (as does indeed happen from time to time); with a pure dictionary, recompilation of the entire dictionary could prove quite tedious, depending on the nature of the change.

Unfortunately, despite the advantages of the pure algorithm, the pure dictionary has a distinct edge in overall accuracy. With a dictionary of 80,000 words or so, a pure dictionary technique will rarely encounter new words and, thanks to the fact that homographs with distinct braillings are also quite rare, will in fact make very few braille errors. A pure algorithm, as we have defined it, will constantly be upended by the vagaries of English spelling, in combination with the sometimes arbitrary nature of the contraction rules. For example, no simple rule for "and" could distinguish its contractibility in "pandemonium" versus "pandemonism"; for that we would require either a full dictionary or more complex (less "pure") rule--but we are getting ahead of ourselves.

Both extremes, then, are characterized by significant disadvantages: the pure dictionary is inefficient and limited to a finite vocabulary; the pure algorithm lacks fidelity. Not surprisingly, few programs fall into either of these "pure" categories; practical programs tend to combine the techniques in some respect.

Combination by Juxtaposition

Probably the most obvious way to combine a dictionary and an algorithm is simply to have both present simultaneously. Interestingly, the net effect is roughly the same no matter where one starts, i.e. whether one adds a simple algorithm to a dictionary to overcome the bounded vocabulary, or one adds an "exception list" to a simple algorithm to improve its fidelity to the rules. In either case, the dictionary or exception list must remain (or become) large to achieve fidelity, while a simple algorithm will still mishandle a fairly large proportion of new or unusual words. In other words, a translator constructed as a simple algorithm plus dictionary may work well enough but will retain some of the disadvantages of its components, i.e. inefficiency and poor performance on unusual words. Of course, these disadvantages may not be very significant if one has a large computer and the services of a braillist on hand--as could well be the case in a large production setting. The first successful computerized braille translator, installed at the American Printing House in 1964, is of this type and it is still performing satisfactorily there [Hayn 79].

Combination by Integration

A generally better approach, in the author's experience, is an "impure" algorithm that could be considered the integration of a dictionary and an algorithm into one mechanism. This approach was devised by J. Millen [Mill 70]; we refer to it here as the integrated finite state machine or IFSM.

In this approach, the elements of logic are based on neither contractions nor on whole words but rather on word fragments, together with context conditions and action rules, that act to bring about both the usage and non-usage of contractions. Not all possible word fragments are represented, of course--mathematically, the number of these would greatly exceed the number of words in the language. Rather, only those fragments that somehow matter to translation need be present. Many of these may well be morphologic elements of the language--for example, prefixes that must be recognized as such in order to avoid using a contraction across the boundary between a prefix and the root of a word. Many others are typically ad-hoc strings, devised to do the right thing with some as-large-as-possible set of words. In still other cases, a fragment plus its context rules is in fact applicable only to a single whole word, or even to a small phrase.

Because complete words and phrases can be incorporated as readily as any other fragment, the IFSM is inherently as accurate as a full dictionary. In fact, a full dictionary, as well as some pure algorithms, may be regarded as a special case IFSM. The real power of the technique, however, is best realized in the careful use of part-word fragments, whereby a heuristic is built up that makes special treatment of whole words generally unnecessary, thus staying close to the storage and speed efficiency of a pure algorithm. In English, the technique described employs a table of about 1100 entries. While this is over five times as many entries as there are contractions, it is still small enough (at about 12 characters per entry on the average) to fit, with the program, into half the memory addressable by a Z80A microprocessor, permitting an overall processing rate in excess of 400 characters per second.

Details of the Integrated Technique

The Central Algorithm

Although many details of the integrated technique were presented in an earlier paper [Sull 73], it will be useful to the subsequent discussion to provide a fairly complete account once again, together with a closer look at some of the practical techniques of table construction.

To understand the operation of this kind of translator, we must imagine a "sliding window" of some fixed length (say, 16 characters), moving along over the stream of print-equivalent text (encoded as a computer file in the ASCII code). (In actuality, the text over which the window slides is not quite in original form, but has been preprocessed so that, for example, simple carriage returns appear as spaces and the case of the text, i.e. upper or lower, has been leveled into a single case.) At any given point in the process, all text to the left of the window is that which has already been translated; text in and to the right is still to be translated.

Any information in the already-translated text that remains of potential importance in the current situation is encoded in a set of "state variables". Each state variable is an indicator, having at any given time either a true or false value, according to the truth value of some predicate of relevance to the translation process. For example, state variable sw might mean "at the start of a word" while sp means "at the start of a prefix or stem." Whenever the left end of the window coincides with the beginning of a word (i.e. there is no letter immediately to the left), we would expect to find both sw and sp having the value "true." Whenever there is a letter or letters immediately to the left, sw would have a "false" value, while sp would be "true" if the letter sequences to the left in fact constituted a prefix or series of prefixes.

The translation action at any given point depends entirely on the contents of the window and the settings of the state variables. The window, moreover, proceeds only in one direction. Together, these characteristics imply that the process is a type of finite state machine (FSM) or Markov process. For those familiar with the design of compilers for computer languages, the IFSM is thus an elaborate variation of the same general type of processor used for lexical scanners (i.e. the parts that isolate and assign types to the primitive words and punctuation marks of the language), as opposed to the parsers proper (i.e. the parts that analyze the language syntax), which are typically context-free grammars.

Specifically, the process operates from a sequential decision table, each entry of which defines three conditions to be tested and three actions to be taken if all three conditions pass. The process considers the entries of the decision table in turn, acting on the first one to pass; thus the ordering of the table plays an important role in the overall process. For convenience, the table can be considered to be so structured that (1) at any moment there is always at least one entry that applies, i.e. that no stalemate can occur, and (2) no loop can occur. The three conditions imposed by a table entry are:

1. an exact string match, i.e. a string of one or more characters that must appear as the left substring in the current window;
2. a set of zero or more "right-context" tests, i.e. character class tests imposed on the character(s) immediately to the right of the matched substring;
3. a set of conditions imposed on some (possibly null) subset of the state variables.

For example, an imaginary entry might require "xyz" as a string match, right context conditions "<letter><punctuation>," and state variable conditions "sw false, sp true." With sw and sp defined as in the previous example, such an entry would pass only when the letters "xyz" appeared following one or more prefixes (but not at the very beginning of a word) and was followed by exactly one letter and then a mark of punctuation (which could be a space). When an entry passes its tests, there are three actions taken:

1. a (possibly null) string is sent to the output;
2. the window is shifted a nonnegative number of places;
3. the state variables are transformed appropriately for the new window position.

The process cycles, thus driven completely by the tables, with minor special operations necessary only at the very beginning and end of the text.

To see how this process works in practice, it would be useful to examine in some detail an actual segment of the current American tables. In the following example, we will separate the condition part of an entry from the action part by the symbol "->"; the state variable tests and transforms will be given in square brackets, right context in angular brackets, and the window shift in parentheses. State variables sw and sp will be defined as in the previous example. (We omit showing the testing and setting of a number of other variables which play no interesting role in this example.) Finally, we will denote the braille "en" contraction symbol (dots 2-6) by the character "5"; "R" and "E" will denote the equivalent braille letters (dots 1-2-3-5 and 1-5 respectively). The segment, which deals with the contraction of "en" following "r," goes as follows:

```
1.  [sp true] RENAS -> RE (2) [sw false]
2.  [sp true] RENAM -> RE (2) [sw false]
3.  [sp true] RENAV -> RE (2) [sw false]
4.  [sp true] RENEGA -> R5 (3) [sw false, sp false]
5.  [sp true] RENE -> RE (2) [sw false]
6.  [sp true] RENOV -> R5 (3) [sw false, sp false]
7.  [sw true] RENOI -> R5 (3) [sw false]
8.  [sw true] RENO <punctuation> -> R5 (3) [sw false]
9.  [sp true] RENO -> RE (2) [sw false]
10. [sp true] RENU -> RE (2) [sw false]
```

11. [sp true] REN -> R5 (3) [sw false, sp false]

To set the stage for explaining the above, the braille rules call for "en" to be contracted normally, but not when the "e" and "n" are in separate syllables, and in particular not when the "e" is part of a prefix; in this case we are concerned about the possibility that "re" is a prefix.

In the first three entries, we recognize cases where the "re" a prefix in "rena" words such as "renascent," "unrenamed," and "renavigate." Words such as "renaissance" and "renal" would not pass the string match, and would be treated by entry 11. In these first three entries, the action taken is to send out the "r" and "e" as single letters, and to shift two characters, so that the "n" now appears at the left of the window; hence the "en" is effectively bypassed as a contraction. As in all the entries in this segment, the "at the start of a word" variable (sw) is set false (regardless of its prior setting) after the shift.

In entries 4 and 5, we consider "rene" words. In all of these but "renegade" and "renegado" and derivatives thereof, the "re" is a prefix. We recognize these exceptional cases by a string match through the "a" (because "re" is a prefix in "renege" and "renegotiate") and, in those cases, translate as the "r" plus the "en" sign, shift 3 (past the "n"), and turn off the "at the start of a prefix or stem" variable along with the "at the start of a word" variable. In entry 5, we treat the "re" as a prefix just as in entries 1-3.

Entries 6 through 9 deal with "reno" words. In entry 6, we see that "en" is contracted in "renovated," "unrenovated," and the like (because of pronunciation, despite the historical derivation of the word).

Entries 7 and 8 are both treatments of proper names, "Renoir" and "Reno," respectively, wherein the "en" is contracted. Note the <punctuation> right context required in entry 8, which will cause "reno" words other than those mentioned to be handled by entry 9, wherein the "re" is treated as a prefix (as appropriate for "renominate," "unrenowned," and "renounce," for instance).

Entry 10 will cause the "re" in all "renu" words (e.g. "renumber" and "renunciation") to be treated as a prefix.

Entry 11 will cause all other "ren" combinations appearing at the beginning of a prefix or stem to be treated as "r" "en-sign." Examples would be "renal," as noted above, "rent," "rendition" and "anterenaissance."

It should be noted that certain other "ren" situations, as in "perennial," would satisfy none of the conditions in this set because the "ren" occurs neither at the beginning of the word nor at the beginning of a prefix or stem within the word. Consequently, the logic would fall through to the later implied entry

R -> R (1) [sw false, sp false]

where "r" is unconditionally translated as a single letter; the "en" then would probably be treated by the entry

EN -> 5 (2) [sw false, sp false]

except in cases such as "barenecked" where an earlier entry of the form

ENECK -> E (1) [sw false, sp false]

would (properly) cause the "en" to be spelled out. Still other cases, such as the "ren" in "children," might well be handled with the characters to the left as a group; the word "children" is a contraction unto itself.

The example above, while simpler than many of the sequences in the tables, nevertheless illustrates most of the more important techniques used, and in particular illustrates that both "rules" and "exceptions" are handled by a single unified mechanism with this process.

Storage and Search Methods

Because the IFSM depends so heavily on constant searching of a fairly large table, it is of course of practical importance that efficient techniques be used in storing the table and in the searching algorithm. While the table is searched sequentially in a logical sense, that is not the way access is actually carried out. For the first probe, the section of the table characterized by a given initial letter is found by direct indexing. Thereafter, the internal structure is that of a tree; i.e. full advantage is taken of the fact that all of the "ren" entries can be skipped around if the string at the left end of the window is "rex". The same general notion makes it unnecessary even to store string match characters which are identical, at the left end, with those of the preceding entry. Beyond this, numerous packing techniques are used so that common cases are represented by few bits (sometimes just one bit) in the internal table representation.

Weaknesses of the IFSM

As mentioned, the process described does quite well with English braille, and the author feels (though the pudding has yet to be proved) that the same will hold true for Spanish, Afrikaans and Arabic. The earliest expression of the IFSM, a program developed at the MITRE Corporation called DOTSYS III [Sull 73], has been widely distributed and adapted. A commercial version currently counts about 20 installations worldwide, about equally divided between minicomputer production systems and microcomputer word-processing systems [Sull 81], while other derivatives, though harder to count, have probably a similar number of installations.

Nevertheless, it would not be quite fair not to mention that the method is inherently weak in anticipation of right context, and that this is a factor that might play a more important role in certain languages than it does in English.

As we have seen, the only right context tests for an entry are specific character class designations, e.g. "a vowel, then punctuation." While the character classes are arbitrarily definable through the tables, there is no provision for a more complex class of variable-length strings, e.g. "a suffix," to be designated. Such a provision would be a definite convenience if (1) there were many suffix contractions, (2) contractions across root-suffix boundaries were forbidden, (3) conflict between overlapping contractible sequences involving suffixes were common, and (4) the language were prone to compound suffixes. While there are some suffix contractions in English (e.g. "ness," "ity," "ence," etc.) and condition 2 certainly applies, conditions 3 and 4 do not apply strongly in English. To the extent that the situations mentioned in conditions 3 and 4 do occur, it is practical to use simple enumeration of the troublesome cases. For example, the suffix "ness" could overlap on the left with the contractible sequences "in," "en" or "one". To resolve the various cases, nine separate entries (for the fragments "ainess," "blueness," "citizeness," "deness," "eness," "iness," "noness," "ness" and "oness") appear in the tables, where perhaps two or three would suffice if "ness" were somehow characterizable as a suffix. There are many ways that such characterization could be accomplished, including simply a more general pattern matching scheme for expressing right context conditions. Another approach might be to employ a reverse scan; this is the approach first used in the French system by M. Truquet [Truq 73]; a later German program also used this technique [Eick 79].

Another problem with the IFSM is its conceptual complexity, as compared with the pure algorithm or dictionary techniques, which are simple enough, especially in the latter case, to be set up for user maintenance. While the introduction of specific whole-word entries into the IFSM tables is easy enough, and be left for users to do on a small scale, the construction of an effective and efficient table from word fragments requires a great deal of careful work, aided by feedback from production experience over a considerable period. To overcome this, some work has been done on "adaptive" systems that create entries automatically--a kind of "programming by example" [Hump 80].

Applicability of the IFSM to Other Translation Problems

The IFSM technique has been applied successfully to the print-to-braille problem in both American-style English and the somewhat different British-style English. Finished tables have been prepared for Spanish and Halifax code, the latter an extension of the American English tables for a particular braille mathematics code; production usage of these two is just commencing (though the Spanish tables were designed some five years ago). A working but not yet finished table exists for Afrikaans, and work on Arabic is just getting underway. In the design or contemplation stage are tables for Nemeth code (a mathematics code widely used in the U.S.) and for reverse, i.e. braille-to-print, translation. Reverse translation is becoming a more important issue as braille note-taking devices such as the Braillex, Braillocord, Digicassette and VersaBraille become more popular, with a corresponding increase in the amount of material that is originally composed in braille in machine-readable form.

Beyond these directly braille-related applications, we are finding that the translator, fitted with the right table to specify an appropriate IFSM process, can carry out numerous additional tasks, such as hyphenation and the transcoding of embedded format symbols from one compositor's tape scheme to another. Thus we may yet come to apply the IFSM to an aspect of braille (and print) processing that, in the end, is proving stickier than the contraction rules: the problem of defining text formats. No doubt this is a subject that will receive much attention in the next few years.

In applying the IFSM to these other tasks, we have not yet found it necessary to alter the central algorithm but we have found it useful to generalize the pre- and post-processing of text as it passes into and out of the central algorithm. These peripheral processes are themselves finite state machines, though of a somewhat simpler nature than the central IFSM. They are, moreover, recursive, so that conceptually any number of simple finite state processors can be arrayed on either side of the central algorithm.

THE IMPLICATIONS OF COMPUTERIZED BRAILLE TRANSLATION

Computerized braille translation systems are certainly here to stay, as least as long as braille itself is used (and that is a subject best left to another paper). In the long range, the use of such systems is bound to affect considerably not only the production system but also the user community and the definition of braille itself. The following seem, at this time, to be the most likely consequences of such usage:

1. The quantity of braille produced will increase and the per-unit cost decrease. This effect has already been alluded to above; as further evidence, several new braille production houses, some even offering braille on a one-day basis (from tape supplied by the customer), have opened for business in the last few years.
2. As a direct result of the increased quantity of braille available, there will be a resurgence in the use of braille, following on the current period of roughly level usage [Even 78, Clar 79]--even though alternatives such as sound tapes will also be more widely used and available. Blind people will simply find it more worthwhile to learn braille when there is something to read.
3. There will be considerably greater usage of grade 1 braille, even in those countries where grade 2 is common or even a standard. Many, especially older, blind persons find grade 2 just too complicated to be bothered with. We have often ignored this group in the past because of the cost of doing the transcription completely over; with computers, however, customized service becomes feasible because it costs essentially nothing extra to produce the grade 1 version as well as the grade 2 version.
4. Braillists, and of course other persons skilled in the production process, will be in greater demand.
5. Considerably more braille will originate from automatic sources, such as compositor's tapes, print read by optical character recognition machines, and communications with word processors and other computers.
6. More capable and less expensive braille display devices will appear, partly because of parallel trends in the underlying hardware and partly because of the enlarged market. There will be more pressure to use generally compatible media in these devices.
7. Blind persons will be in greater touch with the sighted world--not only through the additional material available but also through active involvement with word processing systems, data bases, communication networks and the like wherein a braille translator can serve as an integral link. There are currently a number of systems available on microcomputers, and in a few instances such systems are dedicated to provide considerable support to one individual. Several papers at the recent conference "Computing and Braille" in

Toulouse, France, dealt extensively with this type of small and interactive system [Gill 81, Hamp 81, Lars 81, Sull 81].

8. The capability to provide braille will become much more widely distributed, and accordingly the production of braille will be decentralized except where long press runs or other such economic considerations dictate otherwise.

9. The braille codes will undergo a process of regularization, to get rid of those properties that create problems for computerization, and are thus costly to the user either directly or in terms of availability, while providing him little or no corresponding benefit. This process is already underway within such bodies as the Braille Authority of North America and the Braille Authority of the United Kingdom.

10. More broadly and importantly, we can expect to see increased pressure for needlessly divergent codes, such as the American and British, and the many national mathematics codes, to be brought together. This was one of the key resolutions of the Toulouse conference.

The scenario pictured above is a happy one for both the blind user and the society in which he or she lives. Even better, of course, would be a world where technological breakthroughs had made the number of blind persons quite small, and had provided for them a practical and inexpensive means of direct access to print, thus making braille obsolete. We note with approval several current efforts towards direct access, such as the Optacon and Kurzweil Reading Machine, which are already providing quite valuable service to numerous users. Perhaps in time the necessary technical and economic breakthroughs will occur, permitting another giant step in information accessibility for blind persons. After all, military research is definitely on the rise again; with history as our guide, we are at least entitled to hope that in the end we will make the best of it.

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Uses of Computers in Aiding the Disabled
J. Raviv (editor)
North-Holland Publishing Company

A COMPUTER TERMINAL WITH A SINGLE-CELL BRAILLE DISPLAY

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In recent years there has been a marked increase in the use of computers in which the user "converses" directly with the computer by means of a terminal. The applications of the computer have also been expanding, particularly its use in the processing of texts. These developments can open up a new vista for the blind, if a substitute can be found for the screen of the terminal. One of the solutions which has already been applied is that of displaying a line of Braille by means of electromechanical cells that are controlled by a computer - the "paperless Braille." The special solution presented in this article is that of a terminal with a single-cell Braille display.

INTRODUCTION

Although this is a working conference mainly for computer specialists, I will take the liberty of opening my presentation by describing a situation that is known to all of us in the computer field - a meeting of this kind affords an opportunity for us to distant ourselves and to view in perspective matters that we are deeply involved with in our day to day lives, and in this case also in relation to their significance for the blind population. This may also be of benefit for those among us who are not in the computer profession and who are unaware of these facts.

As great as the impact of computers is on our society, it is still in its initial stages. In these very days, we are in the first stages of a revolution, in which the computer is becoming a device of direct use for a growing number of persons, professions and activities. I should like to stress that even if five and ten years ago the use of computers in various spheres of our economic and scientific systems had already reached a significant scope, this was still an "intermediary" activity. Data was fed to the computer by means of forms and punch-card operators, and the information was received from the computer by means of reports printed on paper; it was still "paper work." In addition to the fact that there is a growing involvement of computers in our daily lives, the style is also changing, and we are increasingly going over to systems in which the user "converses" directly with the computer. This "conversation" is carried out mainly by means of CRT terminals (terminals with a television screen). This activity involves feeding and receiving information from the computer without the use of paper.

The subjects that computers deal with are also expanding. While in previous years, computers dealt mainly with numerical data, in recent years there has been a growing use of computers to handle texts, and clear evidence of this are the word processing systems now commonly employed in offices and the photo-typesetting systems that are now rapidly replacing relief printing. We are rapidly approaching a situation in which most printed texts will be produced by means of a computer, and one in which the volume of texts stored in computers for the purpose of retrieval or transfer is increasing. Naturally, other spheres of activity exist, but I have mentioned the main ones that are relevant to the subject at hand.

I will point to three more subjects which are only in their inception and which may have even more wide-spread application than all the others. These are: the office-automation and the electronic mail (of which word processing forms a part), the Teletext systems of various kinds (View Data, Video Text, etc.) which are already in use in a number of countries. These systems enable communication from any home with a telephone to public computers and through them to public and private data banks. Such systems already make possible the reading of newspapers, shopping, receipt of weather reports, stock exchange data, train and airplane timetables, etc. Last, but by no means least, is Computer Assisted Instruction - CAI. Although it is true that progress in this sphere has lagged behind the expectations of those who foresaw the use of such systems, there is no denying the fact that they are being implemented. I can even point out that there are already more than twenty thousand pupils studying with the aid of such systems in Israel.

I should like to re-emphasize that all of the types of systems I have cited are those in which the user "converses" directly with the computer, and the information received from the computer is displayed before the user on a CRT screen.

What does this have to do with the subject before us? In my view, this development may solve one of the dominant restrictions imposed by blindness, which is the access to written information. The solution is far from complete; however, it will be one of very meaningful scope, particularly in the area of rehabilitation. The solution will be possible if an alternative to the screen display can be found.

SOLUTIONS FOR THE RECEIPT OF INFORMATION FROM THE COMPUTER BY THE BLIND

As for the possibilities in principle to bring information to the knowledge of a blind person, one cannot indulge in too much philosophizing. So long as we are not speaking in terms of science fiction, the possible solutions lie in two directions: hearing and touch. However, we should bear in mind that the category of blindness includes the partially sighted, and that therefore the additional possibility of an enlarged display exists.

These in fact are the three directions in which developments have been made and there are now products on the market that function with a greater or lesser degree of success.

The talking terminal - there are a number of models on the market, and I had the occasion to hear one of them, the text of which was a program in BASIC. In my view, an audio output is not the ideal solution for programming. There are of course programming languages and types of applications that are more suitable to this means of communication. However, in principle I can see some difficulty in absorbing audio information which is full of numbers and meaningless combinations of symbols submitted by the programmer (symbolic names), and in cases where the columning of the information is of importance, a further difficulty exists. On the other hand, such a solution can be ideal for reading texts and for defined applications in which the user fills out a "questionnaire" or receives information in defined professional areas. One of the underlying advantages of this solution is that in certain cases it is also required for sighted users, and as a result greater development efforts are made in this direction. I heard the results of such a development made for the purpose of announcing a weather forecast to pilots, and the level of the "announcement" was excellent.

Braille embossing on paper. This could probably have been the first solution for obtaining information from the computer for the blind user. This solution would have been a good parallel to the hard copy terminal except that in my view it cannot compete with the paperless-Braille display when dynamic interactive operation is involved. (There are those who argue that even if the paperless terminal is preferable, there is still a need for the possibility of receiving Braille printed on paper).

The Braille paper terminals are generally unwieldy and noisy, but their main shortcoming is that they do not meet the needs of the methods and programmes that have been developed for CRT terminals.

Paperless Braille display. What is meant here are electromechanical cells which have Braille points controlled by a computer, the content of which is variable. This is a perfect counterpart to the CRT screen. The first devices developed with the possibility of a display of this kind were mainly for use as a "stand alone" device (and not as a terminal) for the purpose of reading and writing. The information was recorded on a cassette. It was possible of course to obtain cassettes from another source on which books or other material was recorded in Braille (digital recording) and to read them by means of this device. On these devices there is only one line of electromechanical Braille cells which in most cases contains 32 characters or less (in some of them only 20). Some manufacturers developed in these devices a possibility to hook up to an external computer, so they would then function as terminals. Devices were also built which were designated solely to serve as terminals, and one of these, the device developed by Schonherr, of Germany, appears to me to be the model that in principle incorporates the correct philosophy of a Braille terminal. I shall refer to this model in greater detail later on.

Terminals for the partially sighted. In this sphere, I do not know of any solution that is being commercially marketed. I am familiar with an improvised solution, which is to display the entire screen picture on a larger monitor. This solution can be beneficial in the case of a mild handicap, but in cases of more severe handicap, a selective display with a possibility of scanning the screen, is required.

PROGRAMMING AS AN OCCUPATION FOR THE BLIND, AND THE TERMINAL

I refer to the occupation of programming in connection with the question of terminals, first of all because this is an occupation I am familiar with, but furthermore because there is an objective justification for doing so, since a population already exists within this occupation that is awaiting this solution.

The unsighted began to join the programming profession back during the period of the "conventional equipment" - this was the name given at the time to the IBM machines that were programmed by wire bridges. I know that Israel was one of the pioneers in this area,and a number of blind persons were absorbed into this profession successfully. About twenty years ago, the transition from these machines to computers began. This was a period of crisis for these programmers, but the punched card still served as a good solution for the blind, and despite the inability to see printed results, I know of cases in which unsighted programmers made a greater contribution in their work than sighted programmers did, due to their skill, capacity for concentration, and diligence.

We are now at the end of a further period of transition. The use of cards is disappearing; programming, debugging and testing are carried out by means of terminals. The programming tools being developed for the use of programmers are all designed for this kind of programming method. The blind programmer who cannot use a terminal finds himself in a clearly inferior position in contrast to the sighted programmer, and it can be established with certainty that with the present programming methods there will be no room for a blind programmer unless a terminal enabling interactive communication is placed at his disposal. On the other hand, if such a terminal were to be placed at the disposal of the blind programmer, it would advance his ability to compete with the sighted programmer far beyond what it was during the period of the card and the paper.

It is worthwhile mentioning here two additional developments which if realized would also contribute to the efficiency of the blind programmer's work:

A. The storage of manuals on magnetic means would enable their perusal by means of the terminal. This method exists, however not on all computers, and of course not all the installations are prepared to store such information on line.

B. A method of analyzing and defining a system by means of a computer. There are beginnings in this direction but it is difficult to assess the scope of the use of this idea in the future. If it materializes, the blind programmer would even be relieved of the need to receive the definition vocally, and to prepare separate notes for himself (in Braille or recorded).

REQUIREMENTS OF A BRAILLE TERMINAL

I previously mentioned the terminal developed by Schonherr, which seemed to me in principle to be the most correct solution (from the standpoint of the user). Schonherr's device is not a terminal on its own but is a module that connects up to an existing terminal. The communication with the computer is carried out by means of the ordinary terminal and its keyboard. The module's function is to open up a Braille window for the information on the screen. The "window" consists of two lines of Braille with 40 characters in each, that represent a complete screen line. The user can bring to the Braille "window" any line displayed on the screen by means of a special keyboard for this purpose.

The great advantage in this approach is that the unsighted user may, on the face of it, function in exactly the same way as the sighted user - he uses the same tool and can see everything that the sighted user sees. The fact that the tools and the methods are identical has great importance from several points of view:
- All of the programming tools that were developed for programmers are also at the disposal of the blind programmer.
- The communication of the blind user with his work colleagues is on the same basis.
- The training of the blind user to utilize the device is simple and can be carried out by his fellow workers.

Even though I view this principle as being the best one (in contrast to constructing a different and special tool for the blind user that operates according to its own rules), when one gets into the details, questions arise which do not have simple answers - not everything that takes place in the terminal is revealed through the "window", and on the other hand, an addition of special devices may be required for the blind user which are not included in the ordinary terminal but which arise from his special needs.

Among those problems which the Braille window does not solve is the problem of information as to the status of the terminal, which is frequently provided by means of indication lights and special possibilities of displaying the text on the screen (double brightness, a "negative" display, and in future, color as well).

Another subject to be considered is that of the editing method which is recently becoming a common part of a programmer's work, and is nearly exclusive in word processing systems, which is the "full screen" editing method. In this method, the user brings the cursor to the point in the text he wants to deal with, and in this manner defines the spot where he wants to make a correction. On the face of it, it would seem that such activity would be possible only for the sighted user. However, it could also be possible for the unsighted user if a special device were added. (In our view, this possibility is of great importance since it could open the way for the blind to enter the word processing profession).

I will now try to define the main features I would look for in a Braille terminal:

A. As much similarity as possible in both tools and method to those being used by sighted users in the same system.

B. A Braille display of a cell or cells with 8 points that permits the display of information on the screen in a manner conveniently read, with a possibility to locate spots - a knowledge of where the cursor is and a knowledge of where the symbol being read is located (on the screen). A possibility to indicate accentuated data on the screen.

C. Receipt of audio or tactile information as to special conditions and on the status of the terminal (on demand or whenever a change occurs).

D. A possibility to carry out full screen editing - a convenient ability to bring the cursor to a point located in the Braille display.

E. A possibility to read data edited for printing on paper with a width of 132-140 positions. This is in fact a demand for a change from the existing situation in normal terminals, most of which handle line widths of only 80 positions. In our view, this is essential for the blind programmer so that he can handle outputs edited for printing.

I have related to the terminal features from the viewpoint of the user. From the manufacturer's standpoint, there will be a central requirement to permit simple adjustment to various standards of hook-up and the ability to imitate various types of terminals. The programme that runs the terminal must be "familiar" with the various possibilities existing on the market, and in an initialization process would receive the appropriate parameters which would direct it to the suitable method of operation.

For this purpose, IBM is a world in itself, and the solution, which is only a partial one, that we can give to this problem is either to develop a special terminal (perhaps along the lines of the Schonherr terminal) or to connect up to IBM in "Remote" - a port that is ready to receive TTY terminals. However, in the latter case, its utilization would be limited to programmes which are at the disposal of this type of terminal.

THE BRAILLE TERMINAL WHICH WE DEVELOPED

The unusual and outstanding feature of our terminal is the use of a single-cell electromechanical Braille display. The initial reaction of many people to this display method would be to take exception to it; however it will soon become apparent that the inherent limitations of this method - in our particular solution - are not significant in certain uses. On the other hand, this display method has advantages which could hardly be obtained in any other manner.

I might also stress that although the outstanding element of our terminal is the single-cell display, this could be replaced by a line display. However, in that case the advantages deriving from the use of a single cell would be lost.

The terminal and the Braille display were constructed by us as an integrative system - it was not an adaptation of a Braille display to an existing terminal. The terminal operates on a TTY standard, which is the accepted standard in most computers, although not in IBM computers. (IBM can also receive a terminal of this standard but only on special channels and with certain restrictions).

The elements included in the terminal are as follows:

1. An ordinary keyboard

2. CRT monitor (optional)

3. Braille display cell system

4. A system of switches to control display and speech

5. A speech system (to vocalize the names of the letters and symbols

and status signals).

There are two elements in the system that call for a detailed explanation, and these are the display cell system and the system of switches.

The display cell system is comprised of a single Braille cell with 8 pins mounted on a carriage that can be moved along a rail (30 cm. long). The rail is divided into 80 imaginary sections, each such section representing the place of one character on the terminal line. The reader rests his reading hand on the carriage with his reading finger resting on the Braille cell,and moves the carriage (by force of his hand) in the direction of reading. As the carriage moves, the Braille symbols "flow" under his fingers. The rate at which the letters are received is according to the speed of the carriage's movement. The reader to a large degree emulates the method of reading Braille symbols on paper. The terminal system "knows" the location of the carriage (in order to display the appropriate character), and this knowledge serves several purposes, one of which is to indicate the character displayed in Braille on the monitor screen (for the purpose of communicating with a sighted person). The movement of the indicator on the monitor screen corresponds exactly with the movement of the Braille symbols under the finger of the Braille reader.

The system of switches best explains the possibilities of the terminal, and in particular the advantages of the single cell. The system contains 12 switches that have the following functions:

1. Switch to move the window to the next line.

2. Switch to move the window to the previous line.

3. Switch to move the window to the line whose number is struck immediately afterwards (by means of the ordinary keyboard).

4. A switch transferring control of the window to the cursor.
Upper position - the window will show the line where the cursor is.
Lower position - the Braille cell will display the contents of the character which the cursor is on (regardless of the location of the carriage).

5. A switch displaying the number of the line and the column - the Braille cell shows a two-digit number (the 4 upper points are the decimal digit, and the 4 lower points are the unit digit).
Upper position - the number of the line on the screen is displayed.
Lower position - the number of the displayed column is displayed.

6. Display of a long line. When the content of the line exceeds 80 characters, the switch transfers to a line of 80 right-hand characters or 80 left-hand characters.

7. A switch that actuates the vocal system to announce the names of the letters and symbols displayed in Braille.

8. Movement of the cursor to the cell location. The switch sends an instruction to the computer to move the cursor to the place displayed on the Braille display. (This is the great advantage of this method, which allows full screen editing activity).

9. Receipt of the next page. When lengthy information is displayed

on the terminal in a scroll mode, the terminal stops after each 24 lines (to allow the user to check them). Pressure on the switch brings the next 24 lines.

10. Reset - when this knob is pressed, the terminal is released from any locked state, and at the same time gives a vocal notification of the terminal status.

11. Vocalization of the struck characters - each stroke on the keyboard causes the name of the struck letter to be vocalized on the speech system.

12. Direction of display. In reading a "narrative" text, the user can read each even line from right to left (thus avoiding the need to move the carriage back in order to read the next line).

In the system, there are vocal reactions to illegitimate requests. For example, if "the next line" is requested when the present line is the last one, or the "previous line" when the present one is the first line. There is a vocal indication as well when the cell is "standing" on the character where the cursor is. The indication is heard only at the instant of encounter.

A SINGLE-CELL BRAILLE DISPLAY - PROBLEMS AND ADVANTAGES

I assume that the idea of a Braille display by means of a single cell must have occurred to many people, especially since it is so simple from the mechanical standpoint. However, this concept cannot be a complete one unless a solution is found to control the reading rate (with the possibility of stopping, slowing down, going back).

The essence of our idea is emulation of the normal method of reading - the finger moves over the line as if it were a line of continuous symbols. However, there are undoubtedly a number of substantive differences between the two methods:

A. In normal reading, the finger caresses the points, whereas here the points rise and fall under the finger.

B. Proficient Braille readers use more than one finger (of the same hand). Even if only one finger does the reading, there is a pre-orientation as to the lengths of the words, which aids in increasing reading speed.

C. Braille readers use both hands, especially in order to move quickly from line to line, but also in order to get some orientation about the rest of the line.

D. There is an additional difference and that is the absence of a full page laid out before the reader. Of course, this difference also exists with regard to the alternative to the single cell, which is the line of paper-less Braille cells.

As might be expected, these differences caused a lowering of reading speed, and we shall expand on that later.

On the other hand, this method has two advantages which for certain purposes may be extremely meaningful:

A. A line may contain 80 (or more) letters (in contrast to 40 letters in a normal Braille line of the same length).

B. The computer "knows" which letter is being read (it should be pointed out that this feature may also be obtained with a line display, but it would require a special device).

The advantage of having a possibility to include a larger number of letters in a line is significant in particular when there is a need for an identical representation of a Braille line with a printed line. This will be especially important if the blind become active in the area of word processing, and is also important for programmers when the display of a printed page (containing 132 symbols or more) is required. It is of course possible to meet these needs by using a line of cells containing a larger number of cells (or by splitting a line into two or more lines), however this would make it more costly and cumbersome. The fact that the number of line change-overs (in fluent reading) would decrease is an added advantage.

However, the most significant advantage derives from the computer's "knowledge" of which letter is being read:

A. The user can request vocalization of the letter (Could this be utilized for teaching Braille?)

B. The user can request information as to the location of the letter - very important in programming and editing.

C. The user can request that the cursor be brought to the same place. This is the most important thing of all, because it affords the opportunity of full screen editing to the blind person as well.

Beyond these advantages, the idea of a single Braille cell provides an extremely important opportunity to a population, albeit a limited one in number, which is the possibility for blind persons who have lost the sensation in their fingers (or the fingers themselves) to read Braille, since such a cell can be affixed to another part of the body. We are not going to deal with this subject, but it is worth keeping it in mind.

As stated, the main idea behind this method of reading is a sort of emulation of the ordinary manner of reading. However, in order to gain practice in speedy reading, and perhaps also for the purpose of reading a continuous text, we added in our system an option for reading in another manner in which the Braille letters "flow" under the finger at a set rate without the reader moving the carriage. The reader can change the speed of the "flow" very simply, while reading, and can also stop or go back several words or even lines in order to re-read them.

With all the special possibilities afford by the single cell, when all is said and done the main test of the system is the convenience and speed of reading as compared to existing systems. At the time this article was written it was not yet possible to evaluate this aspect in an organized manner - the prototype was completed only four weeks ago and its mechanical system, which is the main factor affecting the convenience and speed of reading, was unsatisfactory. In order to obtain a general orientation, we carried out measurements of the reading speed of the two participants in the experiment: Vered, who is a very rapid Braille reader, and Michael, who is a slow reader (his mother tongue is not Hebrew). The measurement was carried out on a silent reading of a Hebrew literary text. It is important to point out that contractions are not used at all in Hebrew, and that the average length of a Hebrew word is five letters. The speeds attained for the single-cell reading were after about 20 hours of practice, and for the "flowing" letters after about six hours of practice.

The following are the reading speeds in words per minute:

Reading method	Vered	Michael
Reading with two hands from paper	250	46
Reading with one hand from paper	150	45
Reading with single cell - moving carriage	35	18
Reading with single cell - "flowing" letters	64	-

It is worthwhile pointing out here that paperless-Braille systems of a line of cells (that exist today) from the outset do not permit reading at the speed which is possible from a Braille paper page, and the relevant comparison in this case should be with the other paperless-Braille systems. For this purpose, I can quote data which were presented in an article by Bourgeois and Ashcroaft published in Visual Impairment and Blindness, in May 1981. The average reading speed (aloud) that was attained with a paperless Braille system was half of the reading speed achieved from Braille paper.

I estimate that the next prototype will solve a number of mechanical and ergonomical problems that exist in the present system. These improvements along with more practice will lead to better reading speed achievements. Nonetheless, I do not believe that this system can compete with the paper Braille system, from the standpoint of reading speed. The method of reading by means of a single cell can, in my view, be suitable for those needs in which rapid reading is not required, among which I include programming and proofreading. The special possibilities available in this system compensate in these uses for the loss of reading speed.

An additional aspect which should be considered when weighing the advantages of one system against the other is that of price. The electronic elements of computers are becoming cheaper, but this is not the case with the mechanical elements. The single-cell solution can bring about a significant reduction in the cost of the system.

Uses of Computers in Aiding the Disabled
J. Raviv (editor)
North-Holland Publishing Company

COMPUTER GENERATED GRAPHICS DISPLAYS

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There is a need for hardcopy and transitory graphical displays for the blind. However relatively little is known about the optimum presentation of graphical information in a non-visual form, particularly for multi-modal displays.

Most computer-related aids for the blind are for conveying textual or numerical information by tactile or auditory displays. These displays may be time invariant such as braille embossed on paper, or be transitory such as a refreshable braille display of raised pins. However there is much information which sighted people have presented in graphical form which is difficult to present clearly in textual form to the visaully handicapped.

The conventional approach is to use an embossed map or diagram, with the text displayed as braille. Variation in the type and elevation of point, line and areal symbols can facilitate the tactual reading of a graphical display. For instance Schiff, Kaufer and Mosak (1966) showed that a line saw-tooth in cross-section can be useful for conveying directional information since the line is smooth in one direction and rough in the other.

Of the thirty systems that have been developed for producing embossed maps and diagrams for the blind (Gill, 1974), most are very labour intensive and therefore expensive if paid staff are employed. The problem is exasperated by the optimum conversion from a visual presentation to a tactual one being more of an art than a science. At present this conversion requires human intervention in all but the simplest graphical representations.

Here is an obvious application for computer-aided design; the task has similarities to the preparation of artwork for integrated circuit masks or a multi-layered printed circuit board. One such system was developed some years ago (Gill, 1973) but there have been few developments in recent years.

This system uses conventional interactive graphics on a visual display unit for the design stage, and the computer then controls an engraving machine to produce a negative master. A positive is made in epoxy, and plastic copies are vacuum formed from the positive master.

This system produces good quality tactual output but it would be improved if the computer could directly generate the embossed map or diagram. However this would only "solve" part of the problem. There is an increasing requirement for a refreshable non-visual graphics display.

There are about six paperless braille devices commercially available (Gill, 1981), but they all have a single line of braille display. Maure (Foulke, 1981) and Rose (1979) are developing page braille displays which will have advantages over line displays for tabular material and simple graphics. However there is a limit to the amount of graphical information that can be displayed with evenly-spaced single-elevation dots.

This problem will become more acute with increasing use by the blind of digital information systems. For instance the British Telecom Prestel viewdata system can now be output in braille (Gill, 1981); this is just the alphanumeric data with the graphics being ignored. This is the type of system which will be much easier to use when page braille displays are commercially available at a reasonable price.

The problem is not only one of hardware but a difficult software one since the optimum conversion is likely to require a complex algorithm.

If the text is displayed in braille it does not mean that the graphics must be in a tactual form. For instance one could consider a display which uses both auditory and tactual stimuli. Such a proposal is not new but little research has been done in this area. One possible configuration would a x-y plate which when touched gives an audible signal which varies in frequency and amplitude according to two dependent variables at that x-y coordinate.

Before designing such a display it is important to ascertain the factors which determine ease of use by a blind person. This is a far from trivial task which has received comparatively little attention.

Research has been mainly concentrated on audio displays partly because they are much easier to design and build. Pollack and Ficks (1954) studied multi-dimensional auditory displays in which each variable had only two states. They found that, in general, multiple stimulus encoding is a satisfactory procedure for increasing the information transmission rate associated with such displays.

Roffler and Butler (1968a) found that listeners could locate auditory stimuli accurately in the vertical plane when the stimulus was complex and included frequencies above 7kHz. Roffler and Butler (1968b) then found that subjects tended to place the audio stimuli on a vertical scale in accordance with their respective pitch. Higher-pitched sounds were perceived as originating above lower-pitched sounds.

A variety of two dimensional auditory displays have been built; for instance Black (1968) developed a display where the horizontal coordinate was represented by time delay and amplitude of the signal and the vertical coordinate by frequency (100-400 Hz). Fish and Beschle (1973) also used frequency (200-7000 Hz) for representing the vertical position of the scan but interaural differences (up to 40 dB) for the horizontal.

Phillips and Seligman (1974) developed a multi-dimensional auditory display in which frequency, amplitude and timbre are all utilised. Robinson (Gill, 1975) also developed a two dimensional display, where the frequency of the signal depends on the vertical coordinate and time delay for the horizontal. However there has been little systematic comparison of the various types of auditory displays even though Kramer (1962) mentioned the need for this nearly two decades ago.

Davall and Gill (1975 & 1977) developed two performance parameters for assessing displays but they would be difficult to apply in practice to multi-modal displays.

That the foregoing has been more a catalogue of problems rather than solutions reflects the lack of research on computer-generated graphics displays for the blind. It is important that the next generation of displays are scientifically designed to be optimum for the user and not just the easiest to manufacture.

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Uses of Computers in Aiding the Disabled
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North-Holland Publishing Company

OPTIMUM DESIGN OF TACTILE DISPLAY FOR A READING AID

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A letter presentation mode designed for high recognition accuracy was prepared for a reading machine. Experiments showed that the drawing mode achieved better recognition accuracy than the static or scanned mode. The new procedure, which applies the psychophysical effect of apparent movement, was introduced to overcome the length of presentation time during the drawing mode. The results, showing 90 % correct response, were achieved at 0.5 s of mean display time. In addition, 68 % accuracy was achieved at 0.3 s for 46 Katakana readings. Based on these results, a reading machine designed for the blind, using a micro-computer system.

INTRODUCTION

Up to now, many reading machines have been designed for the blind. These systems mainly use the direct translation method in which the optical image of letter is converted into a tactile pattern, consisting of a combination of the spatially corresponding outputs, such as the OPTACON system (Linvill and Bliss 1966). However, these systems require a long training time for practical use. For reading Japanese characters, however, these systems are of no use because of their compliacted shapes involved. Recently, a reading system which uses artificial voices produced from character recognition by a computer has been developed (Goodrich 1979). However, in the Japanese language the same pronunciation often has different meanings, or one specific character has several different pronunciations (Figure 1). Therefore, it is difficult to design such a system using only simple components.

	ヒ	ひ	日	火	比	非	陽
	KATAKANA	HIRAGANA	KANJI (CHINESE LETTERS)				
ENGLISH MEANING			DAY	FIRE	COMPARE	NOT	SUN
ANOTHER PRONUNCIATION			NICHI	KA	KURA:BERU	ARA:ZU	YOU

Figure 1
Japanese letters which are pronounced the same as /hi/

In the present paper, a tactile communication system which produces the shape of a letter was studied. This kind of system has the following advantages: (1) As has already been noted, a specific Japanese letter has several different pronunciations or the same pronunciation has different meanings. Furthermore, a letter has its own meaning by itself (e.g. Kanji). For these cases, it is easier to communicate by an original letter image, rather than by an artificial voice or the braille code, (2) Some adventitious blind people are more familiar with letters than braille, or in some cases, it is difficult for them to learn braille. However, it is easy for them to recognize the shape of a letter with a known image, (3) A reading machine with sound output cannot help a deaf and blind person. Therefore, a communication aid which uses the tactile sense is the most useful for these cases.

There is much literature on the studies of tactile letter perception. Research is mostly concerned with two types of presentation modes, for direct translation (Bliss et al 1966 ; Taenzer 1970 ; Hill 1973 ; Loomis 1974, 1980 ; Craig 1980). One is the the static mode, in which all elements defining a letter are turned on and off simultaneously, and the other is the scanned mode, in which a letter is moved across a tactile display. The achieved mean recognition accuracy, however, has not exceeded 80 % for either of these modes, except for alphabet reading. In Japanese books over two thousand letters are used, which are also complicated in shape. Therefore, it is necessary to consider another type of presentation mode which can achieve a high recognition accuracy.

THE DISPLAY MODE

The first experiment was designed to examine the effect of the display mode upon recognition accuracy.

METHOD   A tactile display consisting of a 10 X 10 matrix of solenoid vibrators with an interstimulator spacing of 15 mm, both vertically and horizontally, applied to the abdomen. To establish a well defined stimulus, the tactor was vibrated at 50 pps (pulses per second) with a force of 3.3 N. Letters were displayed on the matrix by activation of the tactors by a minicomputer. A set of 46 Katakana (Japanese phonetic letters) was generated. The following four modes were examined: static, scanned, drawing by stroke order and drawing by random order. For the drawing modes, each element of letter was sequentially presented by either handwriting order or random order. The interstroke interval of each element was set at 500 ms for the last two modes. The display time was 3.5 s for the static mode, 3.2 s for the scanned mode and 3.6 s for the two drawing modes. Five trials were used with each subjects. A total of eight subjects from 18 - 37 years old were used in the experiment. Four of them were blind. 7 were men and 1 was a blind woman.

RESULTS   The mean percent correct response for each subject as a function of the display mode are given in Figure 2. Inspection of Fig.2 shows that the two drawing modes achieve high recognition accuracy, while the static and scanned modes were poor in accuracy. This tendency was almost same for both the blind and the sighted subjects. A mixed model analysis of variance reveals the mode differences to be significant at the 0.01 level ($F=343.3$, $df=3/24$), while the subject differences were not significant at the 0.01 level ($F=0.395$, $df=1/24$).

Therefore, the drawing mode appeares to be very promising for tactile reading for both blind and sighted person. However, the drawing order does not appear to be important.

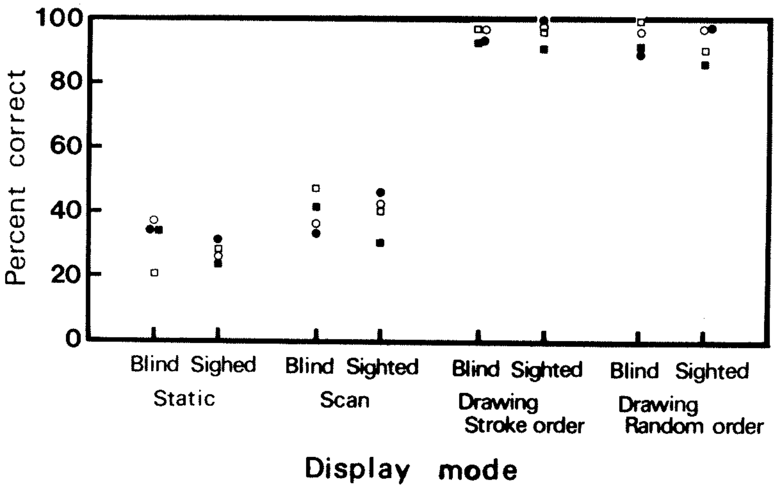

Figure 2
Percent correct response as a function of display mode for both blind and sighted subjects

IMPORTANCE OF THE INTERSTROKE INTERVAL

For the drawing mode, the gap time between one stroke and another is considered to be an important factor. In the second experiment, electrocutaneous stimulation was used to produce a time controlled stimulus to examine the gap time. Since the first experiment showed that the drawing order was not important, the writing order was changed when two letters had the same writing order or similar shapes, to avoid a confusion.

METHOD Concentric electrodes with an outer diameter of 7 mm and an inner diameter of 3 mm were arranged on a rubber sheet, with a spacing of 12 mm. Constant pulse trains (400 pps, with 0.1 ms of pulse width) were supplied to the electrodes. These conditions were determined by the results of a previous psychophysical experiment (Kume and Ohzu 1980). The electrode display consisting of 7 X 5 matrix elements was applied against the forearm with paste treated to establish a well defined stimulus for a long time course. Each electrode was activated for 100 ms (at 400 pps) by a micro-computer (Figure 3(b)), to display alphanumeric letters.

In the first part of the experiment, 26 letters and 10 numerals were displayed using following three modes: (1) no interstroke interval was used even when a change of stroke is occurred, (2) a constant interstoke interval (300 ms) was assigned, (3) multiple intervals (300 ms for the first, 500 ms for the second and 700 ms for the third) were assigned if a letter had two or more strokes. Furtheremore, the writing order was changed if letters were confusable with each other.

In the second part, 10 letters (A,F,H,K,M,N,P,R,T,Y) that were confusable, were presented according to the drawing mode (Figure 3(c)). To examine the effect of the interstroke interval, the following six lengths were tested: 0, 0.05, 0.1, 0.2, 0.3 and 0.5 s. Two sighted undergraduate students took part in the experiment.

RESULTS The percent of correct responses for the first part of the experiment were respectively 46.3 % for mode (1), 65.4 % for mode (2) and 82.2 % for mode (3) after 10 readings each. These results suggest that the interstroke interval and the writing order strongly affected recognition accuracy.

Figure 3(a) shows the effect of the interstroke interval. The percent of correct response was raised about 20 % as the result of the extension of the interval up to 300 ms. However, there was no increase in correct response beyond this length.

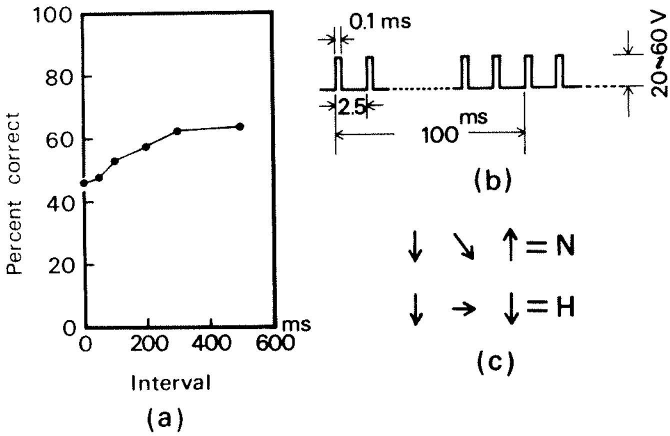

Figure 3
Results and conditions of electrocutaneous stimulation
Figure 3(a) represents the effects of the interstroke interval upon the percent of correct response. Figure 3(b) illustrates pulse wave form supplied to each electrode. Figure 3(c) illustrates a schematic representation of the drawing mode.

TACTILE DISPLAY

The next experiment concerned the design of a tactile display and how to achieve a high reading rate on that display. Considering simple and low cost component, concentric electrodes are easiest and cheapest to use. The problem, however,is that the dynamic range between the absolute and the pain threshold is too narrow. Therefore, frequent adjusting of the threshold is necessary on account of impedance change of the skin. Furthermore, electrical stimulation is not always acceptable for users. So this form of tactile display was not pursued further.

Therefore, the mechanically stimulating component was used for further tactile research. The designed display consisted of a 10 X 7 matrix of small solenoid vibrators, with an interstimulator spacing of 7 mm, in both raw and column directions. This display stimulated against the palm of the hand. The tactors were arraged on a loosely convex metal plate to fit tightly against the palm. Each solenoid was operated at 80 pps with 8 ms of pulse width.

EFFECT OF DISPLAY TIME USING THE MECHANICAL TACTILE DISPLAY

For a reading machine, a short display time is desirable for reading many lettes. However, this depends entirely upon human perceptive ability. In the third experiment, the effect of display time upon recognition accuracy was examined, using the mechanical tactile display.

METHOD A set of 46 Katakana was displayed using the drawing mode. Each tactor was controlled by a mini-computer for both time and location to represent letters. They were activated using the following four gate times: 25, 50, 100 and 200 ms. On purpose of time compression, a letter was displayed at two interstroke intervals (40 and 80 ms). Therefore, mean display time became 0.48, 0.92, 1.80 and 3.54 s at the 40 ms interval and 0.54, 0.98, 1.85 and 3.59 s at the 80 ms interval, respectively. Sighted two men and two women took part in the experiment. They were aged between 21 and 38. A set of 46 presentations was repeated five times for each display time in random order.

RESULTS Recognition accuracy (percent correct), averaged for the four subjects, are given in Figure 4 (open and filled circles). Inspection of the figure shows that there is no difference in the two interstroke intervals for a period longer than 1 s of display time. On the other hand, the longer interstroke interval was superior when the display time was shortened.

Unfortunatly, the display time could not be compressed further, because of successive point by point stimulation. If the gate time for each tactor was compressed, the display time became shorter. However, we could not perceive a well defined stimulus. Therefore, recognition accuracy was down.

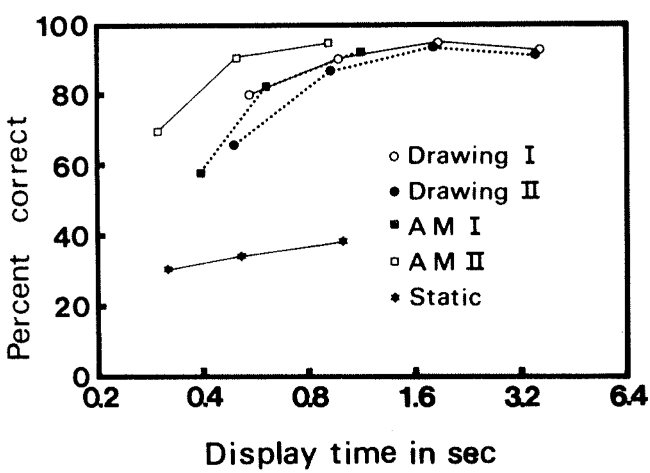

Figure 4
The effect of display time upon percent correct response for each drawing mode.
Circles mean the results of the third experiment and squares mean the that of the fourth experiment. Stars represent the results of the static mode.

A TIME COMPRESSION STRATEGY

To localize the start, variation and end points of each stroke, and to perceive the motion of the stroke are important factors for the drawing mode. A plan which compresses the display time is to exclude intermittent information existing between these points. Psychophysically, only two points of stimulation separated by some distance can establish a moving sensation at an appropriate onset time interval. This effect is known as apparent movement (e.g. Kirman 1974). The fourth experiment investigated the possibility of this time compression plan.

METHOD The experimental apparatus and subjects were same as in the third experiment. Each stimulation defining a stroke element was given by actuating two tactors at a same time to establish a well defined sensation. The gate time of each stimulus was one of following durations: 25, 50 or 100 ms. The examined display modes were: (1) after the end of the first stimulation, the second stimulation was presented (AM-I), or (2) the first and second stimulations overlapped at the middle of the gate time of the first (AM-II). If the gate time was 50 ms, 100 ms was necessary to establish a stroke for mode (1), while 75 ms was necessary for mode (2). Therefore, 25 ms was more compressed for mode (2). A schematic diagram of this experiment, is given in Figure 5. The mean display times examied were 0.39, 0.68 and 1.26 s for mode (1), and 0.3, 0.5 and 0.9 s for mode (2), each containing a constant interstroke interval of 80 ms.

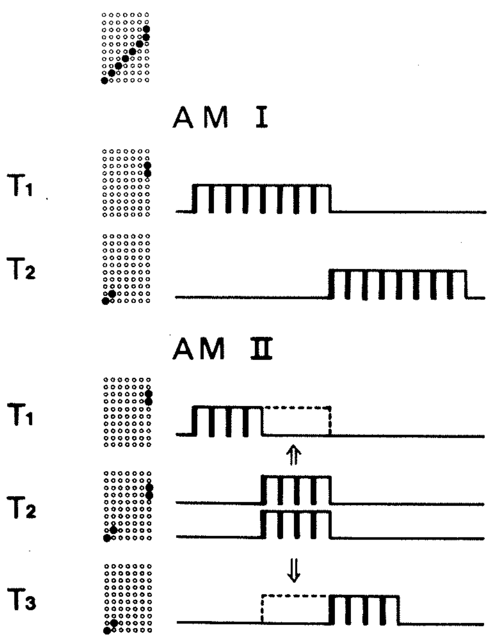

Figure 5
Schematic representation of stimulation mode which establish a moving point stimulus

RESULTS The percent of correct response as a function of the mean display time, averaged over the four subjects are given in Figure 4. Of great interest is that the mode (2) achieves high recognition accuracy, while mode (1) only compresses the display time oL the third experiment. The overlapped stimulation of mode (2) presents good apparent motion. The time condition which produces an apparent motion is in accord with the results of a current psychophysical experiment (in preparation). For comparison, the result of the static mode examined at the same time range is also given in Figure 4.

CONSTRUCTION OF A READING MACHINE FOR THE BLIND

A reading machine was designed for trial based on the results obtained through the above experiments. The components of the system are reprsented schematically in Figure 6. The tactile display used in the system was same as that used in the third experiment.

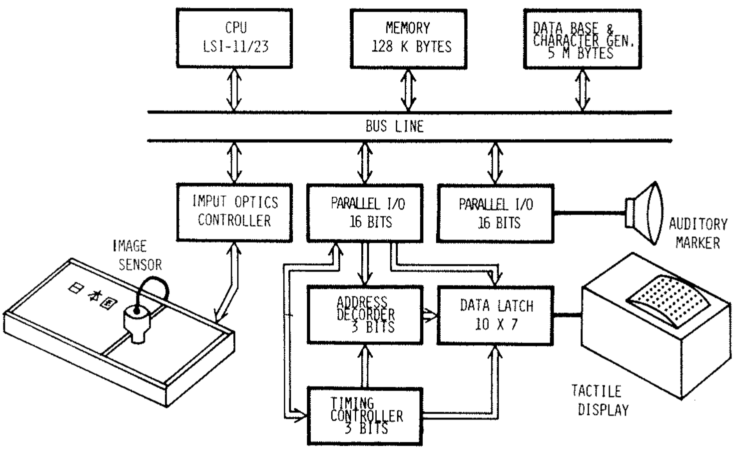

Figure 6
Schematical illustration of the reading machine

TACTOR CONTROLLER It is necessary to actuate two or four tactors at a time for the drawing mode proposed in the fourth experiment (AM II). To realize the the mode, a 10 X 7 data latch was used. A column of 10 bits is randomly accessable at a time, by selection of one of seven addresses. Each bit of logic in the data latch gives a signal to each corresponding tactor to actuate or not.

CHARACTER GENERATOR Output sequences which follow the drawing mode were written in units of 16 bits (2 bytes). The first unit of 16 bits is assigned to the dictionary of each letter code. The following bits are assigned to the data pattern and control: bit 0 to 9 gives the output pattern, bit 10 to 12 gives the address in which the data pattern (0 to 9) is written, bit 13 is the on and off control of the data latch, bit 14 is the interstroke interval which inserts or not, and bit 15 is the end of the sequence (end of output). The bit assignment is shown in Figure 7. A total of 18 K bytes memories were used to generate 365 letters (71 Katakana including 25 special forms, 71 Hiragana, 221 Kanji and 2 special codes). These are used in a second grade elementary school textbook.

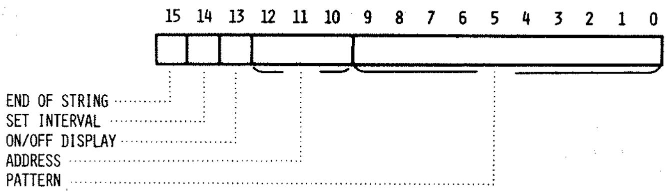

Figure 7
Bit assignments of the character generator

INPUT OPTICS AND THE CONTROLLER This is an important component for a reading machine. In the beginning our system took the strategy of converting constant font, sized and formatted letters. A 100 x 100 elements of CCD (charge coupled device) image sensor was used to sense a 5 mm X 5 mm letter. In the image sensor hood, two LED (80 mcd each) lighting sourses were provided, to obtain a high S/N signal. The sensor hood was mounted on the pen driving unit of a digital plotter, to move over a printed matter automatically. The mean conversion time was about 16 s to get signals from a line of 26 letters.

PATTERN IDENTIFICATION The electronically converted signals of a letter were normalized into a 32 X 32 bits code. Two stages of matching processes were used to identify a letter. The first was course matching, which categorized letters according to the raw and column directional distribution of a letter image. The second was mesh matching with identical letters on a data base. It took about 2.6 s to identify 365 letters with an accuracy of 91 %.

SYSTEM The electronic signal from the image sensor was loaded in memory, in a 0 or 1 code. A micro-computer (LSI 11/23) with 128 K bytes memories was used to control the system. A 5 M bytes disk was added for the data base of pattern matching and tactile character generation. In the system, a unit of 4 K bytes is loaded in memory from the disk to search an output sequence. The tactile display was controlled by a 16 bits parallel I/O register. Also an auditory marker sound was generated by another I/O, to announce the start, end or interval between letters to the user.

CONCLUSION

Throughout our research on tactile letter perception, one promising display mode which achieves high recognition accuracy was proposed for complex letter. On the basis of our experimental results, a reading machine for the blind was designed, using a micro-computer system. Although field testing and further improvement is necessary for the system, the proposed mode has a wide capability for tactile communication, because of its easy perceptibility.

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Uses of Computers in Aiding the Disabled
J. Raviv (editor)
North-Holland Publishing Company

MICROCOMPUTERS, VIPs, AND THE COMMUNICATION NETWORK

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One serious handicap caused by visual impairment is experienced when visually impaired people must perform tasks that require reading and writing print. With microprocessors, microcomputers, and a judicious selection of peripheral devices, visually impaired and visually unimpaired people can exchange written information comfortably. However, solutions of this sort involve high technology, and without careful planning, they can easily become so expensive that solutions they promise will never be enjoyed by more than a few. I will explore an approach that might make these solutions affordable by those who need them.

INTRODUCTION

The major handicaps people experience as a result of the disabilities caused by visual impairment are encountered when they engage in tasks that demand independent mobility, communication by reading and writing print, and acquiring information from visual displays, such as the dials on instruments. The disabilities responsible for these handicaps can be significantly reduced by the intelligent application of technology, by using residual vision more effectively, or by using other perceptual systems to acquire the information that can no longer be acquired visually.

One can reasonably argue that of the two handicaps, the one resulting from limited ability to travel independently is the more serious, because independent mobility is an instrumental skill. Many of the tasks in which VIPs (visually impaired people) want or need to engage are only performed at certain places, and regardless of the skills with which they may have prepared themselves or the technology that may be available to serve them, if they cannot get to those places, they cannot perform the tasks. However, the mobility problem has proved to be surprisingly intractable. Significant progress has been made by devising methods to train blind pedestrians to travel independently, but even after training, their mobility falls far short of the mobility of sighted pedestrians, and technology has not closed the gap. As a result of developments over the past few years, we now have a powerful technology at our disposal, but we lack the basic understanding of human perceptual and cognitive abilities that is needed to guide the application of technology.

There is greater cause for optimism in regard to the handicap that results from the inability to read visual displays of information and to display information visually. For quite some time, it has been apparent that computers could be used to solve the display problem, but until the advent of microcomputers, it was also apparent that because of their high cost and limited availability, computers would not provide a general solution to this problem. However, microcomputers have arrived, and if we take proper advantage of their capabilities, we stand a good chance of solving the display problem inexpensively, and therefore, of making that solution available to large numbers of VIPs. On the other hand, if microcomputers are not exploited carefully, they may amount to little more than another expensive solution that is available to only a select few, and we will have missed our chance. It is about the different ways in which microcomputers have been and might be used that I want to talk today.

THE DISPLAY PROBLEM

Much of the important communication that takes place among humans depends on the ability to read and write, and to exchange written messages, and it is the print code that is used for most of this communication. Of course, those who are blind, or whose visual impairments are severe, would be excluded from written communication altogether if there were no alternatives to the print code, and would lose the opportunity to participate in many of the world's most important affairs. They would feel the full force of this handicap were it not for the partial solution offered by such alternatives to the print code as braille and recorded speech.

Because there are serviceable alternatives to print, the handicap with which VIPs must contend is not as debilitating as it might be, but it is still a handicap, and particularly so when they work cooperatively or competitively with sighted peers, at school or on the job. Braille is an esoteric code known by only a few. Those who know it can exchange written messages with each other, but they cannot exchange written messages with the readers of print with whom they must interact, and readers of print make up an overwhelming majority whose members cannot, in reason, be expected to go very far in accomodating to the disabilities of the few VIPs in their midst. It would be possible for VIPs to exchange with their sighted peers messages that are written by recording speech and read by listening to recorded speech, but information stored in this way is so difficult to retrieve and to read selectively that sighted people with print as a ready alternative could not be expected to tolerate for long a system of communication based on the exchange of recorded messages. The intercommunication of blind and sighted peers can be facilitated by human assistance, but human assistance is expensive.

Fortunately, there is now a widely available technology that can be brought to bear on the solution of these problems. Computers make feasible the development of systems that can solve the display problem by translating from print to braille, and from braille to print; and that can produce parallel displays of text in braille and print, and for that matter in the form of synthesized speech. Such systems can store large quantities of information, and find stored information for blind and sighted operators alike. They can serve as powerful tools, useful to both blind and sighted operators, for the composition and editing of text, the computation of quantitative results, and many other functions.

Much of the visually displayed information that is not readily available to VIPs is acquired, not by reading displays of written language, but by reading the dials on instruments and machines. The counters on dictating machines and copying machines are familiar examples in the office. In the factory, there are pressure gauges and thermometers. In the machine shop, there are measuring devices that permit the exact positioning of cutting tools and precise measurement of the materials that are being formed. The laboratory abounds with instruments which use transducers to obtain the electrical analogues of natural events that provide the information displayed on analogue and digital meters. The information displayed by these meters is essential. It constitutes the feedback that is needed for the regulation of processes, and it provides knowledge of the outcomes of processes. VIPs who cannot acquire this information easily are seriously handicapped. However, as in the case of written text, computers can solve the display problem by processing the electrical analogues that inform visual meters in order to obtain the signals that will cause auditory or tactile meters to display equivalent information.

Computers capable of solving the display problem have been available for many years, but until recently, they have been too expensive for individual ownership, and only a few VIPs who happen to have access to computer facilities established for other purposes have had the opportunity to use computers to solve their display problems. However, we are now in the throes of a revolution brought about by the introduction of microcomputers that is changing the ways in which millions of people play and work. Because microcomputers have real computing power, are easy to operate, and relatively inexpensive to own and maintain, there has been an enormous growth in the number of computer users, and computers are being used in many ways that could not have been justified when they were large, expensive to buy, and expensive to maintain. Microcomputers are now common fixtures in the offices of small companies which could not have afforded computer services before the revolution. They provide instruction for students, and record the outcome of that instruction. They are programmed by students for the solution of problems. Many thousands of hobbyists use them simply as toys because they are fun to play with and affordable. Because microcomputers are well on the way toward becoming ubiquitous, our perception of computers is rapidly changing. We no longer see them as incomprehensible devices that are operated by highly trained specialists who are the guardians of impenetrable mysteries. Anyone can now own and operate a computer, and can program it to perform personal services that run the gamut from frivolous amusement to the solution of problems at school or work. The impact of microcomputers on the lives of VIPs could be even more profound and beneficial. However, before this can happen, certain impediments must be removed.

THE PERIPHERAL PROBLEM

Microcomputers, like large computers, can go a long way toward solving the display problem that is principally responsible for one of the major handicaps of VIPs, but in order for this possibility to become a reality, there is another problem that must be solved. It is not a problem with microcomputers, themselves, but with the peripherals by means of which they display information in those forms that can be used by VIPs. In some cases, display devices that would be useful ar still under development. In other cases, they have been developed and are commercially available, but much too expensive. Many of the peripheral devices that can be operated by microcomputers were developed before the microcomputer revolution was well under way, and their developers supposed that they would be connected to the large computers maintained by organizations such as companies, universities, and government agencies. When a peripheral is used in this way, its cost is a small fraction of the total cost of the computer installation, even if the peripheral is a special purpose device that costs several times as much as a standard peripheral, and the value to an organization of the service performed by the specialist who uses it may very well justify its cost. In any case, the specialist uses it for the purposes of the organization, and not for personal purposes beyond the purpose of remaining employed.

When a VIP who is not a highly trained specialist contemplates using a microcomputer for personal purposes such as composing and editing the text of a term paper or letter, keeping a record of income and expenses, and so forth, he will shortly discover that the peripheral he must have in order to gain access to the services of the computer may cost him several times as much as the microcomputer to which he connects it. He may pay as little as $800 for the microcomputer, but several thousand dollars for the privilege of reading its output in braille or of listening to an output of spoken words and characters. Table 1 is a list of peripherals, including interactive terminals and display devices, together with their approximate prices, that typify the choices available to those VIPs who want to find out how they can use microcomputers to their benefit. I imply no criticism of the devices listed in this table. They are all well engineered and quite serviceable. The prices charged for them are certainly not expressions of avarice on the part of their manufacturers, but simply reflections of the realities with which one must contend when a technically complex device is offered for sale in a market that is vanishingly small in comparison to the market in which such devices as CRT terminals and matrix printers are sold to sighted computer users. Nevertheless, if a way is not found to lower the barrier imposed by the prices that must be charged for these devices, VIPs will simply find that the microcomputer revolution has passed them by. They will be precisely where they were before the revolution, and the services of microcomputers, like the services of their predecessors the large computers, will be available to only a select few. If this problem is not solved, such devices as automatic braille page embossers and terminals with transitory braille displays or speech displays will, in the future as at present, be purchased, for the most part, by a few companies, universities, schools, libraries, and state and federal agencies. Most of the VIPs who could benefit from the use of microcomputers will be repelled by the formidable costs that must be met in order to use them, and they will never know what they are missing.

Table 1

Peripherals for VIPs

Device Name	Type of Peripheral	Manufacturer	Price (U.S.$)
LED-120	Automatic brailler, embosses a line at a time	Triformations Systems, Inc.[a]	$ 14,500
LED-15	Automatic brailler, embosses a character at a time	Triformations Systems, Inc.	7,400
FSST Model 3 (Free Scan Speech Terminal)	Interactive terminal with speech display	Triformations Systems, Inc.	3,995
Digicassette DC20M	Braille reading machine and interactive terminal with transitory display	Triformations Systems, Inc.	4,850
VersaBraille	Braille reading machine and interactive terminal with transitory display	Telesensory Systems, Inc.[b]	6,700
Total Talk	Interactive terminal with speech display	Maryland Computer Services, Inc.[c]	5,900
Brailink 3	Interactive terminal with transitory braille display	Clarke & Smith International, Ltd.[d]	13,000
VERT (Verbal Emulator Real Time)	Microcomputer that adds speech display to standard CRT terminal	Automated Functions, Inc.[e]	5,895

[a]Triformations Systems, Inc.
P. O. Box 2433
Stuart, Florida 33494
U.S.A.

[b]Telesensory Systems, Inc.
3408 Hillview Avenue
Palo Alto, California 94304
U.S.A.

[c]Maryland Computer Services, Inc.
Thomas at Bond
Bel Air, Maryland 21014
U.S.A.

[d]Clarke & Smith International, Ltd.
Melbourne House
Melbourne Road
Wallington, Surrey
UNITED KINGDOM

[e]Automated Functions, Inc.
4545 Connecticut Avenue, N.W.
Washington, D.C. 20008
U.S.A.

One approach that can be taken in seeking a solution to the price problem is to think in terms of more modest peripherals which, because they provide a bare minimum of functions, can be made available at a lower price. By itself, this approach will never eliminate the price barrier, but it may make a useful contribution. As a case in point, consider the project carried out by Mrs. Bettye Krolick, a volunteer transcriber of print music into braille, and Mr. Robert Stepp, the engineer who developed the system she wanted.[1] Mrs. Krolick realized that she could work more effectively if she could enter the characters required for braille music on the keyboard of a microcomputer, proofread and edit the CRT display of those characters, and then use the microcomputer to drive an automatic braille page embosser. She could afford the microcomputer, but if she had to pay $10,000 or more for one of the commercially available automatic braillers, this approach would be out of the question. Instead, she asked Mr. Stepp to help her find a solution. He modified a Perkins Electric Brailler, costing $400, so that the pins that emboss dots can be operated electrically, designed the solid-state logic needed to convert the ASCII characters sent by the microcomputer to the parallel code needed by the brailler, and provided a buffer in which to store characters sent by the computer, so that the brailler can emboss characters at a rate that is slower and more variable than the rate at which they are sent by the computer. This automatic brailler embosses characters at a rate of nine or 10 characters per second. The operator must return the carriage manually, advance the paper to the next line manually, and manually put in a new sheet of paper when a sheet has been filled. In comparison to the printers now in use, its performance is quite unspectacular. However, it does emboss braille of high quality, it is fast enough for many purposes, and it could be made available at a selling price many times less than the selling prices of the automatic braillers that are now commercially available.[2] With a little additional development, it could be made to function as an interactive terminal, and we might be quite surprised at the number of VIPs who would be willing to tolerate the inconvenience of such a terminal in order to gain access to a microcomputer.

In the long run, the best way to lower the price barrier imposed by the high prices that must be charged for sophisticated peripherals--the barrier that keeps VIPs from realizing the benefits of microcomputers--is simply to avoid using them whenever possible by designing systems which are software intensive. If a microcomputer system is designed to require peripherals which perform only those functions that cannot be performed by the microcomputer itself, they can often be reduced to simple hardware components; for instance, a transitory braille display apparatus instead of a transitory braille terminal. Consider the following example.

A VIP is shopping for a microcomputer with which he can communicate through an interactive terminal capable of displaying a full line of braille characters at one time. Here are a couple of the options that he might consider. He can purchase a microcomputer for perhaps $1,500, and one of the transitory braille terminals manufactured by Clarke & Smith. This terminal affords a number of facilities. It has a keyboard, a facility probably provided by the microcomputer, as well. It makes use of a microprocessor, supported by read-only and random-access memory, which enables it to manipulate text in a number of useful ways. However, this facility could also be provided by a program run on the microcomputer. It has a built-in minicassette deck, so that it can store information for later use. However, the microcomputer probably also has provision for storage on cassette or disk. The terminal can display a line of up to 40 braille characters at one time, and this is the one facility that cannot be provided by the microcomputer. If the VIP decides to go this route, he will pay approximately $13,000 for a terminal with facilities which, for the most part, could be provided by the microcomputer to which it is connected.

On the other hand, he may decide to buy a microcomputer system of the type sold by Futura Computer Products.[3] He will pay $8,000, and for that money he will get a microcomputer with 48K bytes of working memory, two disk drives, a transitory braille display apparatus of the type developed by Schoenherr,[4] and an operating system with the software needed to support the transitory braille display apparatus, an assembler, and several higher level programming languages. The only component in this configuration that is not a component of a conventional microcomputer is the transitory braille display apparatus, and the facilities provided by the system are similar to the facilities of the alternative system. Eight thousand dollars is still a rather high price, but if the Clarke & Smith terminal were connected to a microcomputer like the one sold by Futura Computer Products, the total price of that configuration would be approximately $16,000. Thus, the system sold by Futura would be significantly less expensive. It would be even less expensive than it is were it not for the high cost of the transitory braille display apparatus, which accounts for nearly half of its price.

To take another example, suppose, instead, that our VIP does not read braille, and that he wants a microcomputer which displays its information by speaking. Again, he has a couple of options to consider. He can purchase a microcomputer for perhaps $1,500, and an interactive talking terminal, such as the Total Talk manufactured by Maryland Computer Services and sold for $5,900, or the FSST Model 3, manufactured by Triformations Systems, and sold for $3,995. The talking terminal has a keyboard, but as before, the microcomputer may have one, as well. The talking terminal has a microprocessor supported by read-only and random-access memory that allows it to store in working memory and manipulate a large quantity of text, but this facility could also be made available by a program run on the microcomputer. The Total Talk includes a speech synthesizer operated by a microprocessor that runs a program stored in read-only memory. The microcomputer to which the Total Talk is connected does not have a speech synthesizer, but the synthesizer could be operated by a program run on the microcomputer. The talking terminal has a visual display unit. Some microcomputers have visual display units as integral components, but most do not, and so the visual display facility need not be redundant. However, it may also be altogether unnecessary, because the VIP who will use the system may have no occasion to share its use with sighted peers.

Alternatively, our hypothetical VIP may decide to purchase a microcomputer for around $1,500 and a Type-'N-Talk for $349.[5] When Type-'N-Talk is connected to an RS 232C port of a computer, or when it is inserted in the line that connects a printing terminal or CRT terminal to the RS 232C port of a computer, it translates text generated by the computer into spoken words. Without intervention, Type-'N-Talk processes the stream of characters generated by the computer and attempts to render as spoken words the characters between adjacent spaces in the text. Programmers and others who need to identify each character would not be able to use this display. However, with software that causes intervention by the computer to which Type-'N-Talk is connected, it can be made to pronounce each character generated by the computer, and can therefore provide a full speech display for a relatively low cost.

I do not, by making these comparisons, mean to imply any criticism of the interactive terminals I have discussed. They are excellent terminals which reflect truly imaginative engineering. When they are used in large computer facilities or connected to time-sharing services over telephone lines, they do a commendable job of meeting the need. When they are connected to microcomputers, they may very well afford more convenience of operation than the alternative approach. However, their cost is prohibitive for most of the VIPs who could use microcomputers to their benefit.

THE LIMITED APPLICATION PROBLEM

A microcomputer system that relies on software run on the microcomputer for the performance of as many functions as possible, and that uses the simplest and least expensive peripheral that will do the job, is an important step in lowering the price barrier, but it is only a first step. There is another step that may be just as important. The system should be designed for flexibility, so that it can be used for as many purposes as possible. With the advent of solid-state and especially integrated circuit chip technology, many developers have used microcomputer components, such as microprocessors and chips with read-only memory, to construct a number of single fuction devices. The talking calculator, the talking thermometer, and the talking multimeter are familiar examples. There are many situations in which single function instruments are clearly needed and we are fortunate to have them, but the VIP who operates a microcomputer system should be aware that it can also solve the display problem solved by the single function instrument, if the appropriate transducers or meters are connected to it, and if it is programmed to do so.

The VersaBraille is a reading machine that uses a transitory braille apparatus to display text. The operator can use a built-in keyboard to write text, which can be entered in working memory for editing or reading, or in storage on a cassette. The VersaBraille gives braille readers an ability to search for and retrieve information that cannot be realized as well when they must search text displayed in braille on pages in the conventional way. One model of the VersaBraille can be used as a computer terminal. Properly employed, the VersaBraille is a very useful machine, but its functions could also be implemented on a general purpose microcomputer system that uses a transitory braille display apparatus. The VIP who used his microcomputer system in this way would pay a price. He would, for instance, lose the convenience of portability. However, he would be served by a braille reading machine with the functional capability of the VersaBraille, and he would not have to spend another $6,700 for this capability.

Dr. David Lunney and Dr. Robert Morrison, both members of the Chemistry faculty at East Carolina University,[6] have provided a truly impressive example of the use of a microcompter system to replace a large number of single function instruments and devices. In the Fall semester 1977, a blind student named Richard Hartness, enrolled in the Freshman Chemistry class taught by Dr. Morrison, and there were no provisions for making the contents of the course accessible to a blind student. Dr. Morrison discussed this problem with Dr. Lunney, engaged his interest, and together they began a search for those adaptations of instruments and procedures that would allow Mr. Hartness to function independently and effectively in the Chemistry laboratory. They soon realized that although all of the laboratory instruments could probably be modified so that a blind student could read their meters, the cost of modifying many different instruments would be prohibitive. Instead, they decided to use a microcomputer, equipped with a speech synthesizer, to which all of the standard laboratory instruments and transducers could be connected. With support from the U. S. Office of Education, they have nearly completed development of this microcomputer system, which they call ULTRA (Universal Laboratory Training and Research Aid). Table 2 lists many of the transducers and instruments that can be connected to and interpreted by ULTRA.

Table 2

ULTRA Flexibility

1. ph Electrodes	8. Gas chromatograph
2. Specific ion and reference electrodes	9. Liquid chromatograph
3. Spectrophotometer	10. Piston buret with optical sensor
4. Infrared spectrophotometer	11. Conductance cell
5. Scanning ultraviolet-visible spectrophotometer	12. Temperature probe
6. Nuclear magnetic resonance spectrophotometer	13. Calorimeter
7. Spectrophotofluorometer	14. Electronic balance
	15. Temperature probe for electric oven

All of these instruments and transducers can be connected to ULTRA with little or no modification. For the most part, the speech synthesizer is used to announce their readings. In some cases, continuously varying values of variables that must be monitored continuously are displayed as tones that vary in frequency. In addition to these functions, ULTRA provides the services of a full, scientific calculator, and it has a number of programs for processing the data it collects. Finally, it has a flexible operating system whose facilities include an assembler, and several higher level programming languages, and it can also serve as a computer terminal. The estimated price of ULTRA will be between eight and ten thousand dollars. The cost of all of the modifications of instruments that would be needed to make ULTRA unnecessary is not known, but one can safely guess that these modifications would cost many times as much.

AN OPTIONAL SOLUTION

ULTRA performs a rather special set of functions that may not be of interest to many VIPs, but the approach taken by Dr. Lunney and Dr. Morrison in designing it is a powerful one that invites generalization. ULTRA, itself, could easily be augmented by adding options in both hardware and software that would allow it to accomodate the needs, preferences, and interests of a much more numerous and less specialized group of VIPs. What we need, if microcomputers are to become realistic possibilities for VIPs at large, is a microcomputer system which affords a selection of entry options, display options, storage options, input/output options, and software options that will allow each VIP to design the microcomputer that best serves his present needs, and that can be redesigned by adding options as his needs change.

Table 3 lists some of the options that might be available to users of the microcomputer system I have in mind.

Table 3

Options for VIPs

ENTRY OPTIONS	Typewriter keyboard Braillewriter keyboard
DISPLAY OPTIONS	Transitory braille apparatus that displays a line at a time Transitory braille apparatus that displays a page at a time Brailler that embosses a character at a time Brailler that embosses a line at a time Speech synthesizer with fixed vocabulary Speech synthesizer with unlimited vocabulary Video monitor for displaying standard or enlarged print Printer
INPUT/OUTPUT OPTIONS	Serial ports for use with RS 232 devices Parallel ports for exchanging data with and controlling external devices Parallel ports with analogue-to-digital and digital-to-analogue converters
STORAGE OPTIONS	Cassette 5-inch diskette 8-inch disk
SYSTEM PROGRAM OPTIONS	Operating systems such as CP/M Assembler Higher level programming languages (FORTRAN, BASIC, Pascal, etc.) Programs for communicating with entry and display devices and I/O ports

Table 3--Continued

USER PROGRAM OPTIONS	Full scientific calculator Print-to-braille translator Braille-to-print translator Text editor Spelling editor

Of course, a microcomputer capable of supporting these options would need ample working memory, and should have a standard, flexible, and widely used bus structure, such as the S 100 bus, to facilitate its connection to external devices. Table 4 presents examples of the selections of options that might be made by several typical VIPs.

Table 4

Individualization by Combining Options

VISUALLY IMPAIRED HOBBYISTS	Terminal made by modifying Perkins Brailler Cassette for storing and loading programs Card with read-only memory for storing operating system BASIC
VISUALLY IMPAIRED OPERATOR OF UNIVERSITY SWITCHBOARD	Braillewriter keyboard Transitory braille apparatus that displays a line at a time One disk drive Disk-oriented operating system File containing names and telephone numbers of staff and faculty members Program to search file for requested numbers
VISUALLY IMPAIRED SOCIAL WORKER	Printing terminals such as I/O Selectric Speech synthesizer One disk drive Disk-oriented operating system Calculator program Program for putting information on forms in the right places Text editor Spelling editor
VISUALLY IMPAIRED SHOPKEEPER	Terminal made by modifying Perkins Brailler Matrix printer One disk drive Disk-oriented operating system BASIC Bookkeeping program Program for computing income tax Calculator program
VISUALLY IMPAIRED CHEMISTRY STUDENT	Typewriter keyboard Speech synthesizer Matrix printer Two disk drives Disk-oriented operating system Assembler Several higher level programming languages Programs for processing data received through I/O ports connected to laboratory instruments

Table 4--Continued

VISUALLY IMPAIRED LAWYER	Typewriter keyboard Automatic brailler that embosses a line at a time Daisy wheel printer One disk drive Disk-oriented operating system BASIC Text editor Print-to-braille translator Braille-to-print translator
VISUALLY IMPAIRED PROFESSOR OF ENGINEERING	Braillewriter keyboard Typewriter keyboard Transitory braille apparatus that displays a page at a time Matrix printer Video monitor to facilitate work with students Two 8-inch disk drives Disk-oriented operating system Assembler Several higher level programming languages Programs for receiving data through ports connected to which laboratory instruments are connected Text editor Spelling editor Print-to-braille translator Braille-to-print translator
VISUALLY IMPAIRED COMPUTER PRO-GRAMMER	Braillewriter keyboard Transitory braille apparatus that displays a full page Matrix printer Two disk drives Disk-oriented operating system Assembler Several higher level programming languages

The combinations of options shown in Table 4 constitute a very small fraction of the possible combinations. I attach no special importance to the combinations I have suggested. Their only purpose is to illustrate the flexibility of the microcomputer system I have in mind. You may disagree with my selections. If you do, please feel free to make your own selection. By so doing, you help to prove my point, which is that it would be possible to design a system that could be tailored to meet the present needs of VIPs, and changed to keep pace with changing needs, and which with proper planning, could be offered at a price that would allow them to join the microcomputer revolution.

FOOTNOTES

[1]Mrs. Bettye Krolick's address is 602 Ventura Road, Champaign, Illinois 61820, U.S.A.. Mr. Robert Stepp's address is 509 East White Street, Apartment 8, Champaign, Illinois 61820, U.S.A.

[2]Dr. T. V. Cranmer, Director of the Division of Special & Technical Services, Kentucky State Bureau of Rehabilitation Services, State Office Annex, Frankfort, Kentucky 40601, U.S.A., in collaboration with Mr. Taylor Davidson, the Division's Chief Engineer, has also determined modifications that will make a Perkins Brailler function as an automatic brailler, and will provide a parts list, and mechanical drawings and schematic diagrams on request.

The address of Futura Computer Products, Inc., is 3028 Aquadale Lane, Cincinnati, hio 45211, U.S.A.

Dpil.-Ing. K.P. Schoenherr, Aid Electronic GmbH, Berlin, Wilhelm-von-Siemens-trasse 16-18, 1000 Berlin 48, GERMAN FEDERAL REPUBLIC

Type-'N-Talk is manufactured by the Votrax Company--Department RT, 500 Stephenson ighway, Troy, Michigan 48084, U.S.A.

The address of Dr. David Lunney and Dr. Robert Morrison is: Department of hemistry, East Carolina University, Greenville, North Carolina 27834, U.S.A.

Uses of Computers in Aiding the Disabled
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COMPUTER AIDED WORK UNITS FOR THE HANDICAPPED

Presentation of a current project

Stig Becker
The Swedish Institute
for the Handicapped

Sten Staxler
Teleplan
Sweden

SUMMARY

A project to develop computer aided work units for the handicapped is currently underway in Sweden. Three central trial units for three disabled groups, the visually, hearing, and mobility impaired, have been established. Almost a dozen other decentralized work units are also under construction, which will be included in the evaluation.

Large-scale production of peripherals and software components would greatly reduce costs. For this and other reasons an organized international cooperation is deemed important.

INTRODUCTION

In Sweden an interesting project with computer aided work units, adapted for the handicapped, is underway. The authors of this paper are responsible for the project. Stig Becker is with the Swedish Institute for the Handicapped and works in the department for research and development. Sten Staxler is project administrator at Teleplan, one of the largest consultant firms in Europe within the field of telecommunications, electronics and data. Our hope is that this presentation of the project will inspire an organized international cooperation in concern to using computers as technical aids for the handicapped.

BACKGROUND

Telecommunication technology has undergone an explosive development. But the information flow is primarily directed to the non-disabled person. Anyone, who has difficulty in seeing, hearing, walking, speaking or understanding, risks greater isolation. The consequences often being that disabled persons are left outside of the information process. Even for the non-disabled person can these consequences suddenly become reality, due to illness, accident or other causes.

Two years ago the Swedish Institute for the Handicapped, which bears the responsibility for research, development, information and education in connection with technical aids in Sweden, initiated an investigation of the consequences, that the telecommunication development would have on disabled groups. This investigation was to study the development in a ten-year perspective and suggest different kinds of projects, that could follow-up the evaluation.

The initiative was the starting point for an extensive cooperation between the institute, Teleplan and several authorities and organizations in Sweden. The results of the investigation were presented during 1980.As the most immediate area to work on was deemed the automization of working life.

The continuing computerization seems not only to increase the difficulties, encountered by disabled groups, to enter the job market, but also to increase the risks for those already established there, to be thrown out again. The job market for the disabled can therefore get even smaller.

This situation led the National Swedish Board for Technical Development to finance a project, whose aim was to develop office working units, equipped with new technical aids, for all groups of disabled persons. The working units can be located in all environments: industries, administrations, homes, nursing institutions and common offices for remote work in local suburbs.

The project was started in the spring of 1981 and is expected to continue throughout 1982. A progress report is planned to be published at the beginning of 1982.

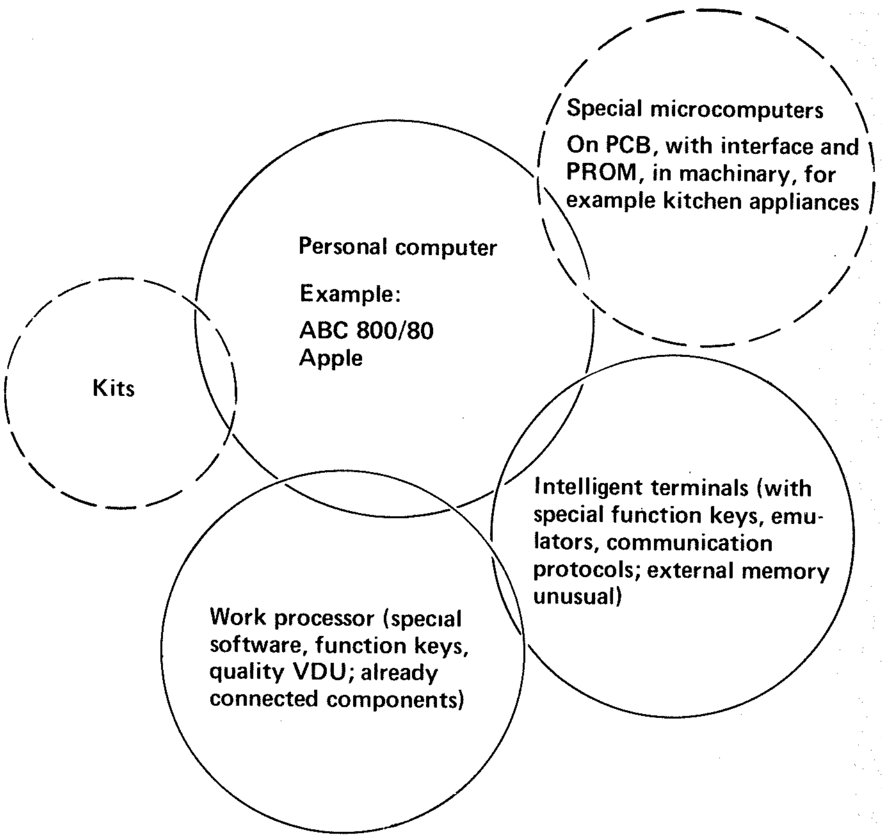
Besides the above-mentioned, other participants in this project are the Swedish Telecommunication Administration, the National Labor Market Board, the Swedish Board of Education, the Swedish Broadcasting Companies and the central organizations of different disabled groups.

COMPUTER DEVELOPMENT

A large number of personal computers, word processors and intelligent terminals already exist on the market.There are for example at the present over 40 American, over 5 Japanese and over 10 European distributors of personal computers. The word processor, intelligent terminal and personal computer seem to converge to the same type of equipment, a work place computer (see illustration 1). This market collision should be violent and have the effect, that many distributors are thrown out of the market.

The capacity of the components to these types of work place computers increases and prices decrease. Processors get longer word capacity, the internal and external memories' ability becomes greater and the in/output equipment range grows broader.

TYPES OF SMALL COMPUTERS



Personal computers, word processors and intelligent terminals will in the future be combined in the same work place computer

In Sweden there is at present about one personal computer to 400 inhabitants. Around 1985 it´s foreseen,that this figure will be one to 100 inhabitants. Around 1995 this figure could rise to parallel that of cars: one to each two inhabitants.

Within a few years almost everyone, working at an office, will be affected by this new technology in his daily working life.

Production series have a great impact on prices (see illustration 2). The Swedish market of handicap aids is much more limited as in most other countries. Therefore international cooperation is important.

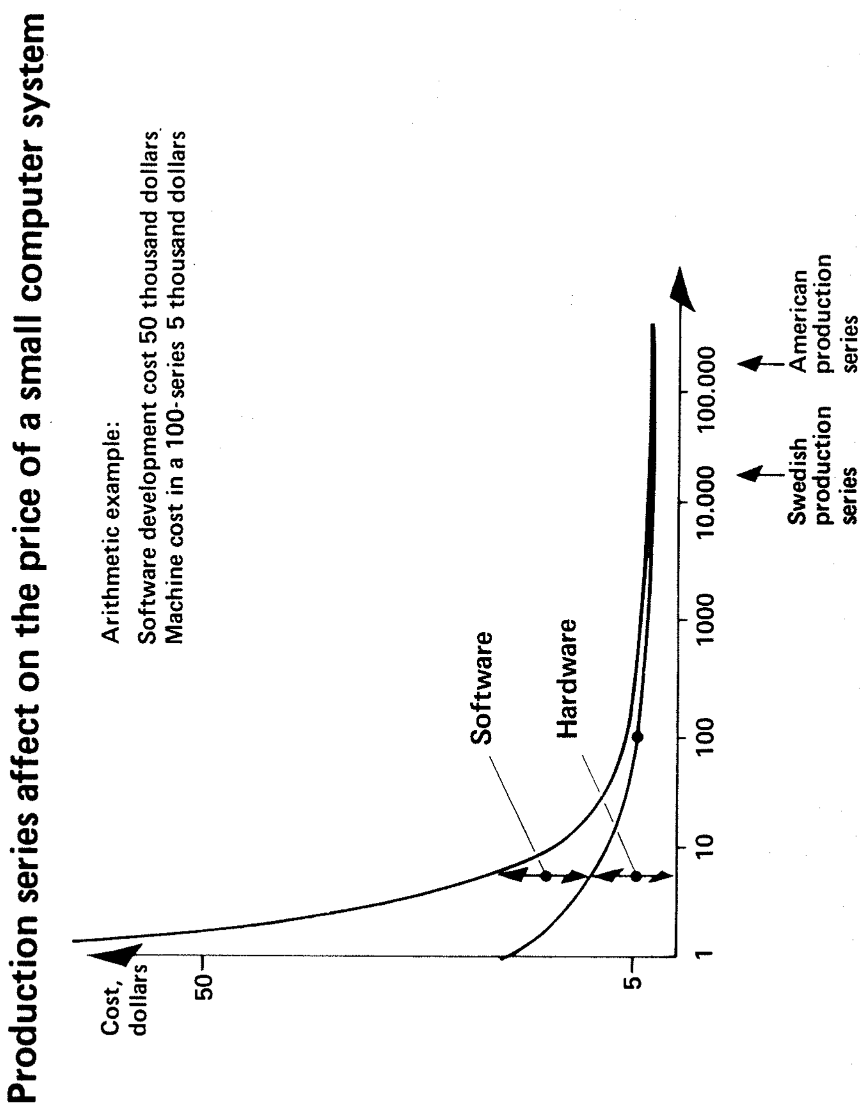
PROJECT METHODS

Within the project three office working units are constructed. One is located at the Telecommunication Administration and is for people with mobility disabilities. One is placed at the Swedish Association for the Promotion of Hearing, where many persons with hearing impairments are employed. The third is situated at the Institute for the Handicapped and is for the visually impaired. The knowledge gained from the three experimental work places will be used for the benefit of all disabled groups.

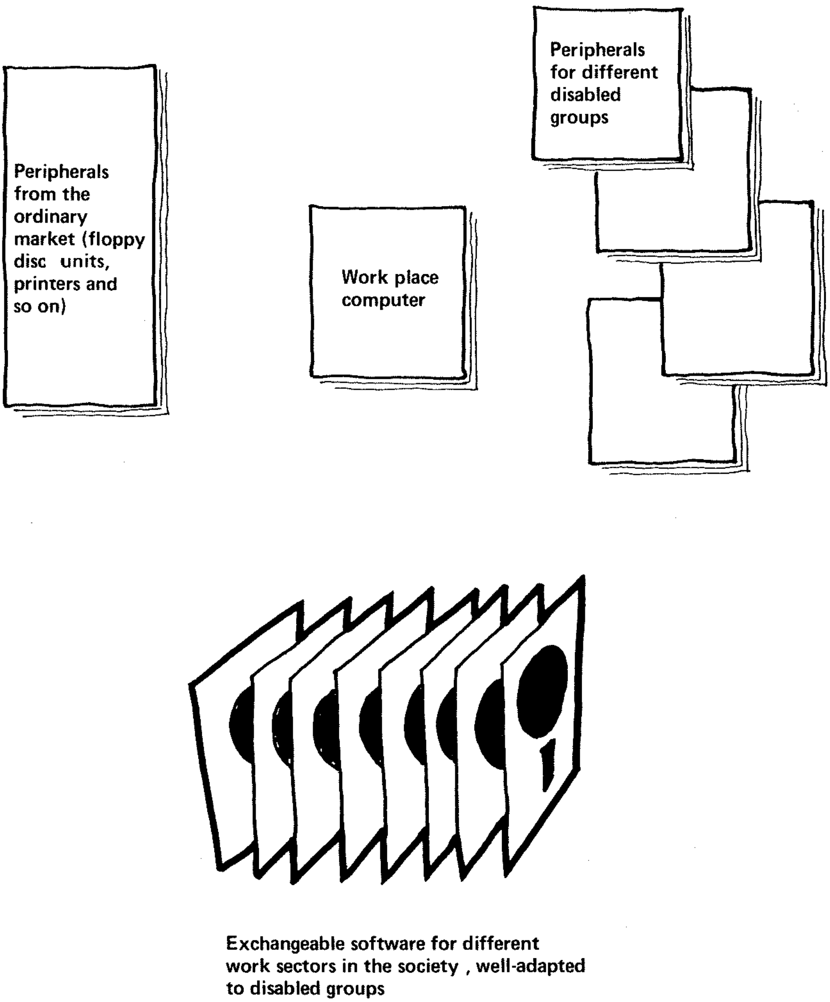
At the moment of this writing (october 1981), the installation of the hardware and software is underway at the Institute for the Handicapped and the Swedish Association for the Promotion of Hearing.

Three different types of work place computers are tested, one at each working unit. Two are Swedish, one American. For this project the suppliers deliver most of the the equipment free of charge. The employers contribute with localities and personal support to the employees. The National Labour Market Board and the Municipal Labour Board are defraying the locality adaption costs and the special peripherals. The project is administrered by Teleplan.

An important philosophy within the project is its direction towards a module system (see illustration 3). This consists of work place computers, peripherals of standard types on the market, special equipments to circumvent the information handicaps and good-quality software components, that are modified to be used by the disabled. The most important demands, that are put on the module system from the disabled user´s point of view, are illustrated by table 4.


Production series affect on the price of a small computer system
Arithmetic example:
Software development cost 50 thousand dollars
Machine cost in a 100-series 5 thousand dollars
Cost, dollars
50
5
Software
Hardware
1
10
100
1000
10.000
100.000
Swedish production series
American production series

The planned module system



Important for the handicapped (in Sweden):

- Swedish keyboard
- Swedish text on VDU
- Supply of consultants for interface and program development
- Nation-wide sales and service network
- Swedish documentation on hardware and software
- Education material/training and support
- Easy to use equipment
- Easy to introduce software for new tasks
- Easy to adapt new peripherals
- Easy to upgrade to new computer generations
- Handicap organizations can easily influence system design
- Low price – many disabled groups are favored within limited possibilities

WORKING UNIT FOR MOBILITY DISABLED AT THE NATIONAL SWEDISH TELECOMMUNICATIONS ADMINISTRATION

The office working unit at the Telecommunication Administration uses at first a prototype for the Swedish teletex terminal (a word processor with communication capability over the common Swedish data network). The terminal is in itself easy to adapt to mobility disabled persons and could, for instance, be placed on a small table over a hospital bed.

With similar terminals one will be able to take education courses, do work for customers who geographically are far away, communicate with other terminal operators, search for information at large computer centers throughtout the world, write and send letters, participate in expert conferences or create music and graphical art, play chess, and so on.

In this case the aim is to test peripherals, that can enable even severely disabled to use terminals. Peripheral examples are speaker-command equipment with voice recognition and easily-handled mechanical tools to guide choices on the VDU.

WORKING UNIT FOR HEARING IMPAIRED PERSONS AT THE ASSOCIATION FOR THE HEARING IMPAIRED

Persons with impaired hearing could have great problems in using the telephone or grasping verbal speech, but have most often no difficulty in working with text and picture information at a data terminal. Possibly sound signals from the terminal to tell the user, that the computer has performed a desired task, should be changed into screen signals.

The activities at the office working unit are therefore aimed at developing the possibilities to communicate with text and picture information. Connections are made via thetelephone and data nets between hearing impaired persons, to people with normal hearing ability, and to computers. The research will also lay a ground for educational efforts to increase the opportunities on the expanding market of terminal work for the hearing impaired and the totally deaf.

The experiences are gained using an American equipment, the Apple computer (which is the third most sold computer in Sweden and well-fitted for work with picture information). One of the goals is also to learn from international experiences with computer equipment in the handicap field and apply that knowledge in Sweden.

WORKING UNIT FOR VISUALLY DISABLED AT THE SWEDISH INSTITUTE FOR THE HANDICAPPED

The Swedish Institute for the Handicapped bears the responsibility of following and adapting the technical development for disabled persons. The office working unit at the institute utilizes a Swedish work place computer, Luxors ABC 80/800. It dominates the Swedish market with about 12,000 computers sold. The market share is about 60 percent, in spite of hard competition. This computer well meets the demands illustrated in table 4.

A sight-impaired person can have great difficulty in grasping what is written on a VDU. Therefore attempts are being made to deliver the information via synthetic speech, Braille displays and printers. The working unit is also designed to be connected to a corresponding computer, used by a fellow worker with normal sight in a work team, by way of a local network.

The intention is to test different peripherals for sound and speech communication, Braille printing and text magnifying. The speech synthesizer is for instance the result of ten years' research work at the Department of Speech Communication at the Royal Institute of Technology in Stockholm. The goal is to create possibilities to install office working units for people with varying degrees of sight impairments and different needs of technical aids.

In the long run, the telecommunication development will create great opportunities to widen the area for the use of work place computers. Examples are shown in illustration 5. In table 6 some of the functions and equipment to be tested within the project for visually impaired people are listed.

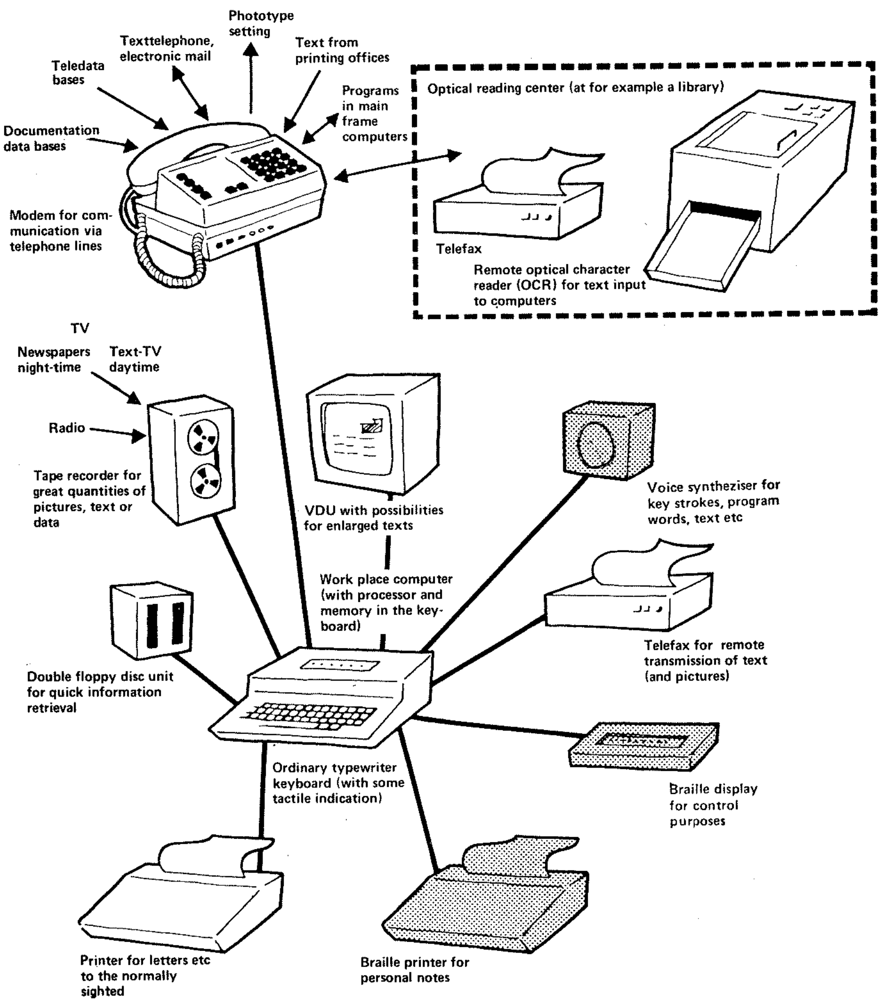
DECENTRALIZED WORK UNITS

Within the project we deem it of the greatest importance to bring the experiences to the handicapp organizations and others, who support the handicapped in the labour market. In spite of the fact that our work has not earlier been published, requests have come from many handicapped persons, places of work and institutions, who wish to participate in the project. Many visually impaired have an acute need of help. Almost a dozen working place adaptations for visually impaired throughout Sweden have therefore been tied to the project. The experiences are to be documented in project reports. In this way parallel work is avoided and the development of computer programs can be made better and cheaper.

Besides the working place at the Swedish Institute for the Handicapped, the following decentralized work units for visually impaired persons are included:

- Appointment making for patients at doctors' offices
- Research work, handling great text quantities at a university
- Translation work at the Foreign Office
- Secreterial work at handicap organizations
- The placement of order requests at an industry
- Warehouse routines at a small company
- Work at a clerical center of an insurance company
- Telephone service and secreterial work at an administration

Future work places for the visually impaired (example)



The following functions and equipment are planned to be tested in the project:

- Translation of documents with the help of optical character reading at a service bureau to floppy discs, which can be used in work place computers
- Development, adaptation and industry production of a text to speech converter (speech syntheziser) with possibilities to »speak» several languages
- Quick search of text material in the disc memory at the work place. Output on a Braille printer or a speech syntheziser
- Development of word processor program for visually disabled, where speech syntheziser and Braille display are coordinated
- Retrieval of text material from the printing offices and main frame computers for storing, elaborating, and printing
- Adaptation of a general register retrieval program for the visually disabled's needs and output media
- Information retrieval in remote data bases with local output as speech syntheziser, Braille display and Braille printing
- Development of terminal programs for communication with tele-conferencing and electronic message services
- Connection of the work place computer to multi user systems
- Establishment of teledata bases for handicapped groups and retrieval of teledata pictures
- VDU's with enlarged texts for the visually impaired
- Attempt to analyze the usability of different types of peripherals for the visually impaired, as for instance tactile VDU's (among others one of Swedish make), Braille tape recorders, Braille terminals, and Braille printers (two of Swedish make)
- Development of an interface for terminal communication with a paper printing Braille terminal
- Testing of portable Braille terminals with cassette memories for connection to different automatic printers and computers

COMMENTS

After a year´s work on this project we have come to the decided point of view, that the new technology holds revolutionary possibilities for visually impaired persons. The access to information, which perhaps is the largest problem for these people, can drastically be made easier by using the new information technology. This is equally true for other disabled groups, perhaps particularly for the mobility disabled.

But the development doesn´t happen by itself. The visually impaired person must have access to special peripherals, which make it possible to use miner sight ability or transmit information into speech and braille. A good supply of such products is lacking today. We see here a great need of international coordination of efforts. With few exceptions a national market is too small for the manufacture of such peripherals on a rational basis. With increased cooperation these products can be both better and cheaper.

The same applies to software. As is shown in illustration 4, a good-quality computer program (with a development cost of for instance $50,000) can be attained at low prices ($50), if the number of users is 1000 or more.

Another important aspect is international standardization of Braille for computer output.

In Sweden we´ve noted, that without a national coordination of efforts many disabled persons run the risk of obtaining equipment, which can be difficult to use, limited in its possibilities to solve problems, or expensive to maintain. Distributors may suddenly disappear from the market. Hardware and software components in the system could be impossible to exchange for new products.

Such a chaotic situation leads at the same time to higher prices for those who pay.

Uses of Computers in Aiding the Disabled
J. Raviv (editor)
North-Holland Publishing Company

Services for the Visually Handicapped in Israel

Nathan Dickstein

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The Department of Services for the Blind is part of the Rehabilitation Services Administration of Israel's Ministry of Labour and Social Affairs. Most services provided by the Ministry for the visually handicapped are handled through the district supervisors and placement counsellors in conjunction with the local social service bureaus.

The Department of Services for the blind works with a variety of service agencies within the community to help the visually handicapped from birth through old age and to enable them to develop to their fullest capacity and to achieve the highest possible level of independence in all areas. Although a majority of the services are operated by volunteer agencies, a large part of the budget for the various services is funded by the Department of Services for the Blind.

Israel does not have a mandatory reporting of visual impairment to an appropriate Government agency. However, we do issue Certificates to legally blind people. These certificates are issued when a request for services through the Department of Services for the Blind is made. In this way, we are able to maintain a register of all those who have requested services, which may not cover all the legally blind in Israel, but covers a large majority. There are approximately 7,000 legally blind persons in Israel of all ages.

I would like to begin by describing our Services for children and then adults. One of our major services is the Home Teachers Division of the Migdalor Rehabilitation Center. This Service is available to all visually handicapped people from birth through old age. Practically all preschool children have had the use of this service at one time or another and therefore all these children are registered at one of the Ministry's District offices.

The Home Teachers Division has been serving the visually handicapped since 1959. In 1978, with the financial help of the American Joint Committee in Israel, a Professional Training Course under the auspices of the Haifa University was completed and there are presently 40 home teachers working throughout the country. The Home Teachers Division has served approximately 600 persons of all ages in the last year, of which about 110 were visually impaired children, ages birth through seven, out of the known total number of children. The Home Teachers work with the children in the following areas:

(1) Educational frameworks such as Child Care Centres and Kindergartens.
(2) Parental instruction
(3) Instruction of the child
(4) Special programmes such as the Summer Day Camp Programme in Jerusalem and Tel Aviv

There are four main child development centers in Israel:
(1) The Hanna Houshi Developmental Pediatrics Center at the Rothschild Hospital in Haifa
(2) The Institute for Child Development at the Tel Hashomer Hospital in Tel

Aviv
(3) The Jerusalem Center for Child and Family Developmental Rehabilitation in Jerusalem
(4) The Children's Unit of the Rehabilitation Center in Beer Sheba

The Centers have different programs to meet the different and individualized needs of the visually impaired children in each area. Each center has a multi-profession -al staff that includes a physician, a psychologist, a social worker, paramedical specialists, a kindergarten teacher as well as consultants on a part-time basis and work in close cooperation with the Home Teachers Unit.

Some of the Services at the Centers include:

(1) Diagnosis and Assessment
(2) Half day nursery school programs for sensory stimulation, education and treatment groups
(3) Group and individual counselling for parents
(4) Preparation for integration into a regular educational framework
(5) Special treatment programs such as music therapy, physical or occupational therapy, etc.
(6) Liason for community and other resources

The whole area of low vision is relatively new to us here in Israel. However, the Jerusalem Center for the Counselling and Visual Rehabilitation of children was established in October 1976 for the purpose of rehabilitating children with severely impaired sight, by means of optical aids and reeducation. It is the only center of its kind in Israel. It serves children up to the age of 16. The interdisciplinary staff is directed by Professor Nevratzky and includes two ophthalmologists, an optometrist, a clinical psychologist and a social worker. The center is part of the Jerusalem Institute for the Prevention of Blindness, headed by Professor Isaac Michaelson. The Center receives referrals from all over the country and has since its opening examined approximately 650 children. The work of the center can be divided into six broad areas:

(1) Examinations and Diagnosis
(2) Correction and Rehabilitation
(3) Follow-up and consultation with social service agencies and school authorities
(4) Teaching programs for professionals with interest in low vision
(5) Visual stimulation Program - a reeducation program using a closed circuit TV system for helping children to read text book material whose print is too small for their visual capabilities
(6) Genetic Counselling Services

Now I would like to describe some specific programs in various parts of the country which have been started to meet some of the special needs of the children. One program is at Jerusalem's Israel Museum youth wing, which offers afternoon classes in painting and plastic arts for children and youth. The ceramics class is run by a ceramics artist, Yael Cohen. Two years ago Yael proposed that the youth wing set up a ceramics class for blind and visually handicapped children. Her proposal was accepted and about 10 visually handicapped children have a class once a week. The primary aim is to provide the children with an enjoyable activity and with an opportunity for doing creative work. It gives the children a sense of independence and helps to develop their self confidence and their sense of touch.

Another program began in November 1980. A group of 14 blind children ages 4-6 years old began to function within the context of the special education program in physical education in the Tel Aviv area.

The aim of the program is to develop proper posture as well as adequate movement proficiency. The program includes the basics of dance and gymnastics. Large instruments are used to aid in the development of balance, self-image, orientation in terms of space and group integration.

The parents of young blind and partially sighted children with the encouragement of professionals in the field have recently organized a Parents Association. They began activities in the Jerusalem, Tel Aviv and Haifa areas, and then began to work on a national scale, founding the National Association ELIYA -- the association for the advancement of blind and partially sighted children.

The aims of the Association are as follows:

(1) To initiate, promote and coordinate activities for the integration, education and rehabilitation of blind and visually handicapped youth.
(2) To work for the establishment of rehabilitation centers, club houses, sports and social centers for blind and visually handicapped children and their families.

Although the national association is still in its infancy, the local associations have activated a number of projects for children.

In Jerusalem the parents have initiated an afternoon framework for children learning in an integrated school in the morning. This framework is called the "pupil's center" and it is supported by the Jewish Institute for the Blind where many activities take place. The center functions twice a week and 14 visually impaired children from all over Jerusalem ages from 6-11 are brought to the Jewish Institute where they break up into groups for the following activities:

(1) Home economics
(2) Handicrafts
(3) Physical education
(4) Toys and Games
(5) Help with their school work
(6) Orientation and mobility and A.D.L. lessons
(7) Reading exercises with closed circuit TV

Another activity organized by the parents in conjunction with the Home Teachers unit was a summer day camp program. Last summer one was held in Tel Aviv and Haifa as well as this summer. Jerusalem, too, had one with the help of the Jewish Institute, Home Teachers, and the staff of the Jerusalem Child Development Center.

Another interesting program which was started last summer and continued this summer is an educational day camp for blind children and youth to learn to use the optacon. The program was initiated by Dr. Yael Ben Dor of Safed who runs the program at the local community center. The program's goal is to provide intensive optacon training as well as practice in the use of other communication skills

The Central Library of the Blind in Netanya has 3,000 readers of all ages and provides services which include Braille books for children and adults as well as talking books in a variety of languages including English, Arabic and German, etc. These books include the classics, romances, school and university texts as well as excerpts from the daily newspapers in a weekly distributed form. The Library has special editions of religious and Jewish studies and catalogues. The Library also has combined Braille and print books especially designed for young children and their parents.

Keren Or Inc. in Jerusalem is a school for the multi-handicapped visually impaired child. It serves the trainable mentally retarded child and those children with a physical handicap in addition to the visual impairment. It has dormitory facilities for twenty children ages 4 through 18. There is a specialized program to meet the individual needs of each child and the school also provides counselling for parents.

The Ministry of Education, the Department of Special Education is involved in the education of about 380 blind and visually impaired children from the ages of 5 to the end of high school. This number includes all nationalities. About 65 of the children are totally blind, about 100 are with grave impairment and a great part of them are legally blind according to the Israeli definition of less than 10/200 feet or 3/60 meters, visual acuity. The rest have various degrees of impairment Until 23 years ago the Jerusalem Institute for the Blind was the only type of education for these children. In 1958, the present National Supervisor for Special Education of Visually Impaired Children, Mrs. Chana Kadmon and her colleague Mrs. Shoshana Gefen, started the first resource program in Ledugma Public School in Tel Aviv. Today the Jerusalem Institute serves more and more multi-handicapped blind children and is developing a pre-vocational high school.

The number of resource classes is now 12. Ten are in regular public schools. One in a school for the low retarded and 1 in a school for children with cerebral palsy The load for one resource class is 6-8 children. This year the Ministry hopes to open two or three more such classes. The resource classes function as follows: the children attend regular classes and receive special help by a resource teacher both in the regular classroom itself and in the special resource room according to the needs of the child in coordination with the regular classroom teacher. The Ministry also has seven itinerant teachers each serving between 5-8 children.

There are two main rehabilitation centers serving the blind in Israel.

1) The Migdal-Or rehabilitation center which has residential facilities in Kiryat Haim, Haifa.
2) The Beersheva Rehabilitation Center in Beersheva

Both Centers offer services to the visually and physically handicapped from the age of 15. The goal of the Centers is to bring the client to his optimal functioning and enable him to be integrated into productive employment and into regular social frameworks. Clients are referred to the Centers through the Rehabilitation Services of the Ministry, The National Insurance Institute, the Ministry of Defence, The Jewish Agency and other community health, welfare and educational services.

Some of the services available at the Centers are as follows:

1. Evaluation
2. Development of work habits
3. Vocational training
4. Completion of basic education
5. Activities of daily living
6. Orientation and mobility
7. Communication skills
8. Social skills
9. Counselling services
10. Work placement and follow-up

The home teachers division which we mentioned earlier with regard to children also serve adults in the community in the following areas.

1. Personal management
2. Home economics
3. Orientation and mobility
4. Communications
5. Leisure time skills

Details of our Rehabilitation Program in computer programming, I will leave to my colleague Mr. Ezra Shapir, Coordinator of the program, who is on the panel following this presentation.

Those high school students who are able to continue their academic studies at the university apply directly to the university of their choice. There are presently about 30 visually impaired students throughout the country who receive financial aid from the Services for the Blind, and who are helped afterwards by the Ministry's placement counsellors to find work upon graduation. There are approximately 400 Legally Blind people working in Israel. The majority have been placed in industry in a wide variety of settings, while the rest work in academic settings such as social workers, teachers, computer operators, and so forth.

I mentioned earlier the low vision clinic for children. There is also a low vision clinic for adults at the Vocational Rehabilitation Center in Jerusalem. The Clinic is operated with all the appropriate staff and aids. These include:

1) Ophthalmologist
2) Optometrist
3) Low vision specialist
4) Coordinator

The Clinic has the help of the social worker and psychologist of the staff of the rehabilitation center on a part time basis, as well as a home teacher when necessary. The clinic has a closed circuit television, a variety of magnifiers and other optical aids, including telescopic and microscopic glasses. The clinic is presently serving about 30 clients a month.

The elderly blind which makes up more than half of our legally blind population of course benefit from the overall services available, such as home teachers, and the low vision clinic. There are also many community centers for the aged that have social activities for the visually handicapped person. The Ministry also has many sheltered workshops and social clubs which are run in conjunction with volunteer agencies for the aged blind person which are open daily from 4-6 hours a day.

Material assistance for the legally blind in Israel is more or less similar to those benefits granted by other Western countries with some local nuances.

This has been a brief review of our services for the visually handicapped. We are always trying to improve our services and look for new ideas and programs to implement. I hope that your contribution today in the area of computers for the handicapped will help us develop further in this field.

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RESEARCH AND DEVELOPMENT IN THE NETHERLANDS ON TACTILE COMPUTER CONTROLLED EQUIPMENT FOR THE BLIND

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The needs of the blind and new technological possibilities have resulted in a growing interest of several institutes and research groups in development of special aids for the blind. In this paper a description is given of what is going on in The Netherlands in this field.
For a clear comprehension of this matter it will be indicated that this development is placed in a complex proces of innovation, provision of aids, evaluation and use of aids. A basic philosophy behind the Dutch set-up is that one should start with the needs of the handicapped person and try to meet those needs with the help of micro-electronics or computers; thus to start by looking for applications of micro-electronics and computers is not the correct approach to serve the disabled.

INNOVATION IN THE NETHERLANDS

A complete overview of the innovation proces on aids of the handicapped is given elsewhere (PZOG, 1980/81; Soede, Jonkers, 1981). Some of the main issues will be given here.
As in most developed countries there is a growing emphasis on innovation and especially the field of rehabilitation engineering seemed to have good possibilities. A research group "Project group Sensory and Organ Impaired" carried out a study in this field with the aim of describing the present bottlenecks in the innovation process, to recommend measures for aleviation of these bottlenecks and to search for actual innovation possibilities which should be beneficial to the handicapped, as well as to the industry.

This project group made an analysis of the situation on the basis of a seven element model: i.e.: 1- research, 2- development, 3- trade and industry, 4- provision (social security), 5- advise ((para-) medical staff), 6- assistance and 7- use of aids.
Some of the bottlenecks in the innovation process were as follows,

- The product flow and capital flow between these elements depends on the applicable social security rules, the type of the products and the social situation of the handicapped (employment and age).
- The market is controlled mainly by the social security organizations and funds. These organizations do not have a clear policy concerning new products. This means that new developments can only be done with the high risk that, nonetheless a new aid is not provided.
- The transfer of technology is difficult, but even more difficult is ensuring a good guidance and service organization.
- Very individual problems and subjective factors are the reason that market research is very difficult; small adaptation and variation in design can cause a considerable shift from one group of potential users to another.
- The needs of the potential users are very difficult to define due to the fact

that some possibilies are beyond the imagination of potential users while other product suggestions are only a small step in the direction of a far-off goal.

The innovation proces is summarized by figure 1

Environment of this system:

- social developments (criteria and values)
- economic developments
- political developments etc.

P = possibilities
S = supply
D = demand
N = need

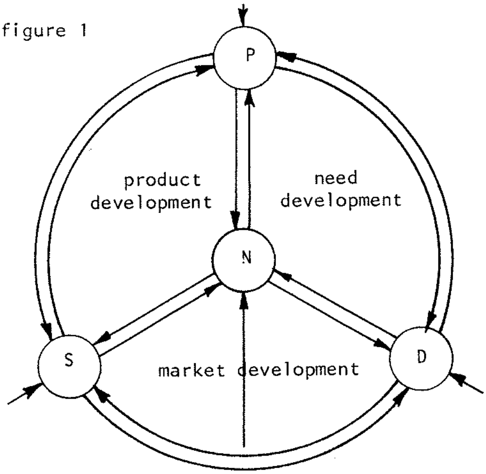

Figure 1
Interplay of factors in the innovation proces (PZOG, 1980)

The basic idea of this diagram is that, possibilities, supply, demand and needs are strongly related and constitute processes of needs development, product development and market development. These sub-processes have to run harmoniously and each mal functioning subprocess can mean a severe bottleneck as is seen with many products for the handicapped. The Dutch government will stimulate the innovation proces of aids of the handicapped and one of the designed innovation programs concerns tactile equipment for the blind. This stimulation will done according to criteria which have to prevent that again a bottleneck somewhere can inhibit the process. The last part of this paper will mention this in more detail.

NEED FOR NEW AIDS

The need for new aids for the blind does not only originate from the attempts to reduce the functional disability and handicap of the blind; this need is also based on the expectations that the rest of society will more and more use and rely on information systems and information handling.
It is estimated that up to 60% of employees are engaged in jobs with a strong accent on information handling. It is also expected that even in private life computerized information systems, like viewdata systems will play an important role. Thus, the development of new aids is also urgently required to prevent that the handicapped will increasingly fall behind. Also, developments in hardware and software of information systems can be a threat for the employment possibilities of the blind. An example is that at computer terminals, the human interface, the use of visual presentation of data and screen-oriented interactive programs increases, which is disadvantageous for the blind. Another example is that implementing a braille terminal parallel to other terminals is much more difficult and expensive if a computer system is based on video-transmission of data to the terminal screens. It might be possible that those problems will be very difficult to solve which means that computer professions will be made more unattainable. Therefore it is suggested that new possibilities of new tasks, new professions have to be explored with an emphasis on those possibilities dealing with information handling which can easily be performed with braille, coded information and which can be used in a sequential structure.

THE PRESENT MARKET OF COMPUTERIZED BRAILLE SYSTEMS

The present market offers a variety of braille equipment.
It is not necessary to give an overview of this equipment in the context of this paper; overviews are given by other papers and documentations. However, a number of remarks concerning present available systems can be made.
A first remark concerns the availability of information on quality and usefulness (consumer information in a broader context). Some reports present the personal experiences of users and in a very few cases data are available from field studies with a good experimental set-up. A severe lack of information exists on the usefulness and the effectiveness of braille systems and equipment in various professional situations. On the other hand, it is very difficult to do research in this field; comparative studies are difficult due to the fact that standardization is quite inadequate. A few more remarks should be made about the standardization problem.

In the hardware domain it is obvious that from the technical viewpoint electrical and mechanical standards should be used. Signal levels and standard codes are not always such that modules of one type can operate on a system of another type. As far as memory systems, cassettesystems are used: the cassettes cannot be interchanged. At the hardware level there is also a functional aspect related to the human factors and ergonomics of the system. Systems of the same type can also use (identical) control knobs in a standardized order as,for example, is almost the case with simple consumer cassette decks.

In the software domain it seems to be even worse. Computerized braille systems use a basic set of software functions/modules which takes care of the communication between the hardware elements. Furthermore, the translation of text into braille and vica versa is one of the standard modules. Standardization of these modules makes it easier to connect different types of braille systems. Apart from this basic set of software, which enables the user to operate the system on a simple functional level, other software functions can be added. This means that on a second level, application-oriented functions are implemented to be used in a specific professional environment; one can imagine text-editing procedures and special computer controlled functions of professional equipment.
At the third level software has to be developed for advanced and complex applications, exclusively for professional situations. The software itself can be adapted and programmed by the user. The application of complex input and output facilities like extended use of speech recognition and speech production, is an aspect on this level.
It will be clear that on level two and level three the function specifications need extensive research into the ergonomic problem. Lack of basic knowledge on the structural and definition aspects of these levels of communication makes it very difficult to execute the earlier mentioned research on usefulness of these categories of systems.

SETUP OF A CONSULTANCY GROUP

The problems which are indicated in the previous paragraphs are partly related to the general process of aids provision i.e.: social security, risk capital at developments, research into the usefulness; other problems are directly related to braille systems problems.
Many of the problems became very clear when a laboratory model of a new braille lineprinter was finished. Although this printer used a revolutionary new construction it was impossible to find a company to produce it. Finally, when a company was found which was willing to take up the production it appeared that this small company could not take all the risks for the development of a production model, adapt software and hardware. To minimize the risk for this company* it was

*RESUS BV, Rehabilitation Support Systems, Rotterdam; in cooperation with Nepas, Enschede, The Netherlands decided to set up a consultancy group with representatives from the potential users (braille embossing firms, private users, schools), developers, industry and social-security organization. This consultancy group could arrange that by commitment of the future users, the company was able to start the production. Furthermore, this group tries, where possible, to integrate (standardization aspect) several developments and initiatives in the field of braille communication equipment. An example of this integration is that local braille making equipment which is designed for use by volunteers should be adapted such that cassette tapes can be used on other computerized equipment too. This consultany group (CTBS**) for communication technology for blind and visually impaired people has the following goals:

- Stimulate research, development, production, selection and proper use of communication equipment for the visual handicapped
- Improve the quantative and qualitative level of technical communication aids for the individuel visual handicapped and service organizations while the value of technological innovations for trade and industry is taken into account.
- Stimulate and organize information exchange on the subject of technical communication aids between all those who are involved in the field of the visual impaired.

This consultancy group was set-up spontaneously by braille equipment users and the companies as mentioned.
It now functions satisfactorily and the Dutch government plans to use this group to support the governmental innovation stimulation program on aids for the handicapped.

EXPECTED DEVELOPMENTS

An innovation stimulation program is under consideration.
Apart from the needs for such a program, as is described in a previous paragraph, it is also important to know that new legislation in the Netherlands is expected on employment for the disabled. This new law is prepared in order to enlarge employment possibilities by an obligation of reserving 5% of the jobs for the handicapped and also to take financial measures for the adaptation of the workplace. It is expected that actual implementation of this law will show a need for research and developments on this subject.
Therefore, the draft innovation stimulation program has emphasised the technical aids which are important for professional situations.
An important starting point in this innovation stimulation program is that considerable attention has to be given to dual handicapped persons, for example, visual and auditory impairment or speech impairment. This involves very small percentages of severely handicapped people. They are forgotten in most systematic research programs. A modular approach to the systems design might be helpful to offer more possibilities for adaptation to dual handicapped persons. As is seen in figure 2, the adapted interfaces should be easily interchangable for other types of interfaces. Again, this means that standardization is very necessary and will offer much more combinations, possibilities to adapt in rare situations.
The transmission elements have a special meaning in telecommunication applications which are becoming increasingly important.

This paper will be concluded with the presentation of preliminary programs on research and development for the blind and visual impaired and which are proposed to stimulate innovations in industry and in employment possibilities for the blind and visually impaired.
In the field of paperless braille display systems it is proposed to study the feasibility of a much more reliable and low cost braille line displays which might be extended to multiline or even page format displays.

**Dutch abbreviation for Communication Technology for the blind and visual impaired

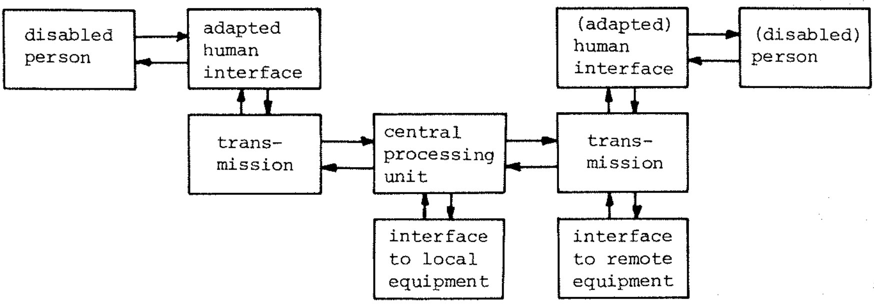

Figure 2
Elements in communication system

" Human factors research and market considerations have to be done in order to determine whether or not such page-size displays will be sufficiently useful. It is not known at this moment to what extent the early-blind and the late-blind can effectively use two-dimensional displayed information.
Almost the same problem arises with the use of a tactile graphics screen. A positive answer to this problem can, probably only be obtained by extensive practical experience. Graphical screens might be obtained with the same technique as the braille displays (mechanical, piezoelectric) but probably also with an electric texture effect.
A second line of research and development concerns low-cost and low-speed braille printers for individual use in a large variety of circumstances; basically it is an analogue of the electric typewriter. Such a printer mechanism can also be used in small and portable braille terminal systems offering the flexibility of such a system.
The third line concerns speech systems. The technological progress on speech systems is very substantial. However, until now, there are no Dutch language systems available. Having such a Dutch speaking system will now have a high priority.
After that, the applicability of speech systems for the blind must be studied. It is expected that quite a new type of human systems interaction has to be created. Psychological and sociological aspects will have an important role in these studies. Speech production and recognition have not yet reached a good "semantic level", therefore the applicability and usefulness of those systems might be disappointing. It is still necessary to explore the possibilities.

It is expected that this innovation stimulation program will be in full progress at the beginning of 1982. This program has to be seen as a first start.
When in progress, the program will be extended to new research and development lines. The spin-offof such a program can be considerable at some of the aspects. For instance, the developmentof a Dutch artificial language system is important and also basic research on communication aspects, human factors aspects will be useful for other applications.

CONCLUSION

One might conclude from this paper that innovation is a process confined to a strictly national level.
International cooperation is needed to obtain a sufficient large market to exchange information and to integrate or to put it into concord.
Summarizing the main issue of this paper, one can say that the development of aids for the handicapped should be backed up by support groups and consultancy groups.
It is our opinion that this is the only efficient way of obtaining high quality products which meet the user requirments.

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Uses of Computers in Aiding the Disabled
J. Raviv (editor)
North-Holland Publishing Company

COMPUTERS - A THREAT OR PROMISE FOR THE VISUALLY DISABLED?

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Computers, memories and terminals of various performances and capacity are already an integrated part of our daily life. The possibility to make use of such devices depends very much upon the ability of the user. Computers could be useful generally as tools in the modern society - or specifically as devices enabling visually disabled people to perform various tasks. In any case the design of the man-machine interface is critical, both for the retrieval and display of information.

INTRODUCTION

Computers have begun to influence our lives - if not already invaded it. We benefit from - or get troubled by - their presence when we go by aircrafts, when we place a telephone call, when we read our morning paper or get the latest weather forecast. There are a lot of examples of this kind - the hidden service - where we do not exactly know that a computer was involved. When we talk about computers and computers service, we perhaps think of more spectacular situations like processing information from satellites, enabling us to get pictures from remote planets. Or perhaps we think of more familiar situations like automatic price calculation when weighing vegetables in the super market. Or maybe the powerful information retrieval systems brought into our homes with broadcast/teletext or videotex. Or perhaps do we get in mind programmable mini calculators and wrist watches with synthetic speech display.

Whatever we think of, it is a relevant illustration of the impact of computers in our daily life. We all agree upon that it is important to decide in democratic order upon what computers are supposed to do - and not. It is as important that people with restricted preceptual ability could influence upon the way computers will serve - and display information. However, the benefit of computers must also be made available in the design and construction of aids especially designed to limit the handicapping consequences of a disability.

WHO ARE THE USERS?

Before we start to consider the use of computers, let us have a look at the consumer group. This group - potentially - is the group of visually disabled people. Not only the blind, consequently, but those who have such a poor vision that they get information handicapped in their daily lives - or need a specially designed device to manage in a situation where information is processed or displayed. The number of consumers depend upon how well the system is designed and how flexible it is. If, for instance, text on screens is displayed in good contrast, proper colours and with electronic magnification facilities a large part of the visually disabled population may benefit from it without any modification. The importance of care-fully designed man-machine interfaces is obvious also in systems especially designed for the visually disabled, like information retrieval systems for vocational purposes, mobility aids, devices for access to daily newspapers etc. The more well adapted and flexible a man-machine interface, the larger the consumer group and thus the benefit-cost ratio. This trivial statement does perhaps not seem so trivial if we recall, that a large majority of the visually disabled population is within the group of elderly. To many people in that group even a simple tape recorder may be difficult to cope with.

USES OF COMPUTERS FOR VISUALLY DISABLED PEOPLE

The usefulness of computers for the visually disabled has been demonstrated in a number of finished, ongoing and planned projects. Examples are computers in braille and graph production, communication systems, for vocational purposes, in reading machines, paperless braille recorders, mobility aids etc. Basically all those systems consist of an information collecting unit, an information processor and a display unit. As in many other cases the bottleneck seems to be the man-machine interface, i.e. the problem of finding a substitute for the visual information collecting system. Braille or graphes on paper have been used but require a complicated production system. Soft copy displays, like mechanical braille displays or the sophisticated Optacon display are mechanically delicate and expensive. Spoken output - especially synthetic speech - is attractive because it is adapted to the hearing channel. However, hearing has a comparatively low information capacity and the sequential display of information makes it necessary to use processors with good flexibility.

Properly designed display units are necessary in order to make computer based information systems like broadcast teletext and videotex available to the visually disabled poplulation. They are requested as outputs from watches, calculators and other ADL-aids. - Another example is the application in a Swedish research project, the aim of which is to make daily newspapers available to the visually disabled population. The digitally coded information is stored in a disc memory at the printing house and transmitted by radio to the individual user. At the receiver end the information is stored in another memory and retrieved with the aid of a micro computer. The bottleneck - again - is the display unit, which in this case will be a double mode display with soft copy braille as well as synthetic speech. The project is supposed to give much experience of how to cope with large amounts of information and display it in an optimal way.

CONCLUSION

Computers are already parts of our daily life. The society has obligations to people with a communication handicap; one is to make those powerful tools available as integrated parts of new aids to overcome or compensate for the handicap. Another is to see that information systems for common use will be made available with as few limitations as possible. - Whether computers will be a threat or promise for the future of the visually disabled depends on steps and measures taken now.

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The Computer Program for the Visually Handicapped in Israel

Ezra Shapir
Consultant, Instrumentation for the Blind
Ministry of Labour and Social Affairs
Jerusalem, Israel

My responsibility is the teaching of blind computer programming and the adaptation of instruments to perform as Braille computer terminals.

Since 1962, we have been working in Israel in the above mentioned field. At first we were teaching blind persons how to operate conventional IBM equipment in order to become IBM operators. We subsequently adapted ourselves to teaching the blind persons computer programming.

In the first stages of our work, we developed special accessories which assisted our center in teaching the blind persons the techniques of the machines involved. Then, we designed and produced a series of special instruments by which the blind operators could "read" the punched cards.

In the second stage of our development, we had to find a way to enable the blind operator to read computer output; therefore we wrote a special program in COBOL which used the dots of the 1403 printer's chain and produced adequate Braille output. This system has been functioning adequately up to now although it is a very smooth Braille and only those who have a very good sense of reading Braille can use it.

Since 1971, when we had to close the center because of lack of funds, we made an agreement with a college of technology in Jerusalem which has a department for the teaching of computer programming to regular students and which now also accepts two blind students each year in their regular classes.

Being aware of the modernization of the computer field, we are now trying hard to adapt the communications system between the blind and the computer which should compete with the monitor terminals. Therefore we now use the SAGEM terminals in the school and in a few cases in open market positions in which blind programmers are employed.

The fact is that we have now 24 blind programmers working in different places in Israel, and we also have four new blind graduates of which three have been accepted by new employers. Unfortunately, most of the computers in Israel are IBM ones, which do not recognize the communication protocol of the peripheral equipment which are still in use in the international blind market.

I am therefore calling all investigation centers throughout the world to join us in trying to solve this problem which causes a great deal of suffering to the blind and to those who are concerned with teaching and employing them in suitable jobs.

With thanks in advance.

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THE INFORMATION AGE: PLUGGING INTO A NEW ERA OF HOPE FOR THE BLIND

Guy Carbonneau

President, Triformation Systems, Inc.
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Stuart, Florida 33494

Thank you for this opportunity to speak to you about the great impact computer technology is having on blind people all over the world. A technology that is giving the blind a new understanding -- a new insight -- into their ability to reach goals that were once unthinkable.

Imagine, if you will, the blind being able to have two-way communication with a computer through audio synthesis. Think of the enormous potential for the blind person who can plug into a computer and communicate not in printed language but in Grade II braille.

The marvel of technology has put a new world at the blind person's fingertips. Not only in employment and education, but in a life-style that was once experienced only by the sighted.

In one amazing decade, our entire society has absorbed the impact of the computer revolution felt in the 70's and began adapting sophisticated technology to everyday living. We are taking a giant step into the Information Age.

The startling advances in computer technology well compress into decades what it took the Industrial Revolution two centuries to accomplish. By 1990, we will live in an "electronic community" in which virtually everything we need to conduct our daily lives can be done through a home computer programmed into vast knowledge banks of information.

The silicon chip has propelled the telephone and television screen into dynamic new roles in the way we live, work and play.

Such an enhanced lifestyle need not be limited to the sighted. The blind -- those who could benefit most from such an electronic community -- can now use a computer terminal to take full advantage of the dawning age of information.

This new technology for the blind is not something to be viewed in future tense. It is here today waiting to be implemented. By working with the scientific community and with people all over the world who share our common goal -- together, we can make what was once only dreams and inspiration for the blind a working reality.

Today, at Triformation Systems, we design and manufacture a complete line of terminals that are re-educating everyone in the way the blind can use their capabilities. Terminals that enable the blind to communicate with computers, not in printed language, but in raised-dot braille or through audio-synthesized speech. Terminals that, for the first time, allow the vision impaired person to plug into the

Information Age and reap the benefits of new technology.

One of our most exciting products is the Free Scan Speech Terminal. The FSST. It is a talking interactive computer with an unlimited vocabulary and can be programmed for almost any function having access to computerized data.

FSST accepts data as fast or slow as the user wants. Output rates range from 10 characters per second to a phenomenal 960 characters per second. And its response is all done through audible speech synthesis. This means that the thousands of blind individuals who don't read braille can now have ready access to the vast knowledge of the computer world.

The advanced technology of FSST enables the operator to call up "pages" of information and scan the material. It scans both horizontally and vertically, so its capacity is enormous. All this is done through audible speech and can reiterate data in either full words or single characters, depending on designated speeds.

With Videotex now a reality, the Information Age has arrived for the visually impaired person. An ever increasing number of banks are switching to video displays of personal banking statements. Combining FSST with a home Videotex hook-up can give the blind individual something that could never be experienced before in banking -- privacy. Now they can hear their banking statements without having someone read to them.

Electronic newspapers. Telephone directories. Yellow pages. Airline schedules. Home shopping services. Even video garage sales are only a small sampling of the exciting potential such technology has created for the blind individual.

Through the application of this same home technology, we have minimized limitations imposed by blindness. We have bridged the gap between the computer and the blind individual. Hundreds of new job opportunities are now opening for the blind.

In a working situation where sighted employees gain information from a visual display terminal, their blind co-workers can now have access to this information printed out on the LED-120.

We have developed the PBCE System which records typewritten key strokes on magnetic tape. To get a braille readout, simply play the cassette into the LED-120 and braille embossing begins. This sophisticated piece of technology can produce braille pages of information at an astounding 120 characters per second. It's quite versatile in that printouts can be produced from a computer, magnetic tape, a keyboard or almost any source of coded information.

With sophisticated computers playing an increasingly important role in the world's business and finance industries, the LED-120 opens doors that have been previously shut for the blind.

Now almost any field involving information processing is within reach of the visually handicapped. Work the stock market. Be an airline agent or computer programmer. The unlimited potential of the LED-120 working with the blind is determined only by one's imagination.

Until recently, another problem that blind people were faced with was the difficulty in obtaining reading materials. Translating print into braille was tedious and time consuming. With the development of our PED-30, a commercially used brailling device used in the publishing industry, braille plate productivity has increased by 1,000% compared to manually operated machines.

Interfacing the PED-30 and LED-120 with a computer allows a sighted typist to type the transcript onto the computer's visual display terminal. Words are automatically transferred into braille text. Information is stored on magnetic cassettes. It is then fed into the LED-120 and emerges as pages of braille. Editing and corrections are done and the PED-30 embosses the printing plates. The plates go on a conventional press and produce braille pages for virtually limitless publication of literature for the blind.

The FSST, LED-120, and PED-30 are only three examples of what we at Triformation Systems have developed for the blind to be able to benefit from today's technology. Who knows what tomorrow will bring?

We must be optimistic about the future of all handicapped people. With the coming of the Information Age and the marvelous advances in technology being achieved everyday, a new sophistication can be seen in how we live and how we think.

Looking back over the last decade, I see the great progress that has been made for the blind through the use of computers. I see the new attitudes of inspired hope and confidence being adopted by handicapped people all over the world.

Just as Louis Braille gave sightless people a new dimension in life -- a wealth of knowledge once limited to people who could see -- The Information Age as seen through a computer will bring a new dimension in helping the blind individual realize his fullest potential.

It is a source of great pride to me that Triformation Systems has played a significant part in the launching of this new era for the blind. Ladies and Gentlemen, I thank you.

PANEL DISCUSSION

E. Foulke -- Chairman
J.I. Lindström
H. Ohzu
E. Shapir
M. Soede
J.E. Sullivan

Uses of Computers in Aiding the Disabled
J. Raviv (editor)
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PANEL DISCUSSION

E. FOULKE, University of Louisville, Louisville, Kentucky:
I would like to point out that I have heard several calls here today in the meeting and also in several private conversations around the coffee pot for some kind of an effective international cooperation, and I would like to endorse that. We are, of course, in a time in which it is possible to do many things by technology, and people are of course going to try to solve their problems in this way. It is quite obvious from what we have heard today that we have many common interests, and we certainly ought to be able to make a common cause. But if we do not we will, of course, go our separate ways, and we may soon lose the opportunity to cooperate.

So if we are going to develop an effective mechanism for cooperation, let's do it now.

S. STAXLER, Telepan, Salona, Sweden:
I should like to complement with the question: How should we do it? How should we form that international cooperation? If nobody is ready to answer, I have hopes in Prof. Raviv who, with his excellent organization talent and with his good contacts with IFIP, could organize a working group that could go on with this international cooperation and standardization.

J. RAVIV, IBM Israel Scientific Center, Haifa:
I was going to say a few words about it in my concluding remarks, but now is as good an opportunity as any.

IFIP has technical groups, which are not really working groups, but they kind of oversee the whole work in the field. The working groups are made up of people who are technically interested in a specific area, and there the question arises - for instance, this Conference was on uses of computers for aiding the disabled, and it covered three areas.

Now, questions arise, and if we are going to make a working group, would it make sense to have a broad topic like this? Or should we have a working group for the visually disabled and a working group for the hearing impaired, etc? I think we cannot decide it here. It would be nice if some members of the panel or other people could make some comments on what topics they feel should be covered, and what a working group like this could accomplish. If you don't want to do it here, you could write to me. I am representing Israel in the General Assembly of IMIA and I am representing also the General Assembly of IFIP, and I'll be very happy to propose a working group of that sort.

Working groups meet about twice a year. They usually do discuss things like international cooperation, what standards should be set, and they try to fight for the standards. They publish books, and one of the things that they do is to organize working conferences. Now, because there wasn't a working group, I organized this working conference, but I don't know if there will be one in the future. Maybe this kind of working conferences could be organized every couple of years, or whatever the need would be.

Now, the ingredients that are needed for a working group to function well are dedicated people who like to meet and discuss pertinent matters, who like to work - you know, work for the cause, because the worst thing is to elect some people to a working group and then they don't show up for meetings, and the working group is there only by title.

So I think if there would be a good number of people, and I don't think it has to be large - something like ten or fifteen people or more, who are willing to put in some time and thought - that would be the right beginning. I don't think there would be any problem in convincing IFIP that a working group of this sort should be formed and would function. So please either make some comments now or write to me on this matter. Thank you.

M. SOEDE: TNO Central Organization, The Netherlands:
I raised the problem of standardization, but I am rather pessimistic about international cooperation. I know that a working group in this field is already existing but I think it is mainly at a scientific level, i.e. on the level of research engineers. It's a good start to begin with but there should also be something similar on the level of the manufacturers and the users, not apart from each other but in correlation with what is being done on the scientific level. I think you cannot do one thing and leave the other things alone.

E. FOULKE:
I've heard John Gill express the opinion several times that the interests or needs of people with low vision are likely to be overlooked. I wonder, John, if you have anything to say about that?

J. GILL, Warwick Research Unit for the Blind, Coventry, England:
One of the reasons obviously for interest in low vision is that they make up a huge percentage of the visually handicapped population. For Britain, with a definition of registered blind which is quite a lot narrower than the American definition, only 3.4% of the blind in Britain are in fact totally blind. About 85% of registered blind have some degree of useful residual vision, and this obviously varies depending on the visual defect.

There is interest in relation to computers in that an increasing number of people are having to use visual display units, which currently tend to be not all that clear. Very few of them are what could be called "large print" in the conventional way.

There is also the area at the other extreme, which is using a computer to economically produce large print. For instance, one project in England now uses laser printers for producing large print bank statements, which have turned out to be enormously popular. So there does seem to be unmet demand in that area which can be met economically by use of computer technology.

E. FOULKE:
Also several people have talked about problems involved in translation. It is obvious that people who are doing this work have a good deal of common ground and a good many individual problems too. I wonder if anyone has any remarks to make about the possibility and fruitfulness of cooperation in that regard?

A. BEN-DOR, Telesensory Systems, Inc., Palo Alto, California:
I'll say a word on the side of the manufacturers. In making a machine for the blind community, it's a very hard task. You have to make a machine of high reliability. The market is very diversified and relatively small, and therefore, you are running into big expenses. So, a manufacturer has a share of problems relating to manufacturing problems, quality problems, technical problems, etc. And I am not trying to shy away from the problems.

However, the problem of translation, of a lack of standard of the Braille system, is a problem in which the manufacturer has a very great deal of difficulty, and I think these difficulties can be solved relatively easily. I was listening today to the lecture of Joe Sullivan, and I know that John Gill has got also a Grade 2 translation system; there are a variety of them, and each one has a variety of dollars in the range of tens of thousands of dollars to ten dollars. And everybody claims a degree of accuracy to a percentage of some sort of a known standard which is non-existing. And it is very hard to even attempt to solve the problem.

This is a problem that should not exist. This is computer aiding for the disabled by computers with very exact minds, and computers do whatever they are told to do. If the definition of the Braille language is fuzzy, then I don't believe there is any scientist who can make exactly a Braille Grade 2 translator. This is a problem that we have been confronted with.

The problems of computer Braille translators are in making it user-defined. We are very proud of finding a solution that can be adaptable to different languages, but our lives would be much easier if there would be an international agreement on the subject, so that we would not have to postulate on basic solutions. Basically what happens is that the blind community suffers in the end. The device is much more complicated and much more expensive, and these are the problems you can help to solve if you really pay attention to that. If there is anybody in the blind organizations or the academic environment who can set up a committee to really look into that, I think everybody would thank you for that.

H. WERNER, University of Bonn, Germany:
It is certainly good to hear all this optimism, but particularly with respect to the last remark I'm afraid I have to caution down a bit the situation because really most of us who are discussing problems of the blind are sighted people. I have been working with the blind for years, and at least suggest that if we try to make any change, any proposals to the blind, quite a number of blind consultants should be involved.

I think that, if I understand the last remark correctly, you hint that it would be much simpler if, for instance, Braille could be slightly adjusted.. We really need only very small changes in order to make Braille more easily accessible for computer handling, let's say. But I know that it is extremely difficult to get the blind community to accept some change, and I think we have to understand this. The blind person has organized his world so that he knows how to orient himself, how to find his way around; this is not only in his environment, where he is living, but also I think it is the same about the way he writes things. He wants to get it written for him, sent to him. So you must not underestimate the barriers that exist in this field.

Maybe we have some blind here who could comment on this, but I am aware of the situation in the United States. I learned this about twenty years ago, when I still had great optimism and I thought change would be easy. I mean, we have achieved a bit in Germany, but the steps were very small, and it needed the power of a newspaper which was periodically given to the blind to demonstrate typical difficulties for the computer and the resulting errors. Those things which are difficult to learn for the computer are difficult for schoolchildren also, remarkably enough. But in spite of this they would insist that, if possible, nothing should be changed in Braille.

So really I think we have to accept essentially the fact as it is given, and it takes lots of psychological work if you really want to change something. It is not a matter of months, but engaging in problems of the blind is usually a matter of years.

J.I. LINDSTROM, Swedish Federation of the Visually Handicapped, Stockholm, Sweden:
Mr. Chairman, I would like to agree with Mr. Soede first. I have some years of experience in the field of developing aids for disabled people and also international work, and I say that it is very difficult task. However, I think we must try, and I think the suggestion put up by Sten Staxler is really interesting, and I think we should do something about it.

However, I would just like to remind you that there is an organization of visually disabled people in the world, the World Council for the Welfare of the Blind. I guess that they have some committee studying questions relating to Braille standardization and also that they are considering problems of computerized Braille.

Now, I guess that Sten Staxler considered also other problems, but he can answer that question himself. Anyhow, I guess that there could be cooperation between a group mentioned here today and the organizations of the disabled in the world. Thank you.

L.J. LEIFER, Stanford University, Stanford, California:
It's a bit late in the meeting to bring this up but it is something that I find bothers me. I come from the research community. I'm not particularly familiar with the needs of the visually handicapped community, but I hear very little attention to the future in the big sense of the future. I hear a concern with translating Braille, with changing habits that are twenty years old, but I don't hear what should come after Braille. Somehow Braille, to my perception, doesn't look like the final answer, and many of the devices in front of us don't look like ultimate answers, but I've heard no one, including the disabled, talk about what they want the future to look like ten to twenty years from now. Can I provoke any response to that point?

S. STAXLER:
We have talked about Braille but, as some of the speakers have mentioned earlier, I think there are quite a lot of other things to do. We look upon this problem from the point of view of the work place computer, as we presented it. We see the modularity both in the hardware components and the software components, and we see the very fast exchange of generations, of machinery here; and we see the need to conserve the investments in the software. As we get the impression, the software investors will be the big ones in the future, and it is very important that the software can be conserved from generation to generation.

So I think this is a very big field actually for standardization. My impression is that, even if we form such international cooperation, which there is a very strong need for, it hasn't the possibility to do so much, but it is still a very good step in the right direction. So I strongly recommend that we use the offer from Prof. Raviv to form a committee; and when that has started to roll, I think it could be possible to build separate groups for the hearing impaired, for the visually impaired, for mobility disabilities, and so on, and to make contributions with different manufacturers and so on.

I think that, if we have the first platform to stand on, we have the possibility to form the future in advance for the disabled groups, and not being after many years as we have seen in the past.

M. SOEDE:
I would like to make a comment on both questions. I think that we should go into standardization and we should also realize, as one of the speakers said, that we shouldn't step too far ahead. So standardization of what is now available on the market is worthwhile, and what is coming next has to be developed; the development process is long, and it adds probably new confusion to what we have.

But I am convinced that what we have on the market is worthwhile to improve with respect to the aspects of economics, different applications and more applications. I think that further development with available technology can be done in the sense that in different working situations, different private situations, you can use this technology. If you use it then you have to make it better. You have to do research into usefulness; you have to make better standards; you have to aim for a modular system to meet individual needs. And, taking into account what our Chairman said in his talk about applying different modules for an individual situation, you need a standard system to connect all these modules of hardware and modules of software together.

E. FOULKE:
I would like to make a couple of comments and first respond to several remarks. Prof. Werner's discussion of changing the code - it seems to me that here the rule is simple enough. That is, it is permissible to change the code if changing it will improve the readability of Braille, and not change it just to make life easier for programmers.

On the other hand, I see no objection to making changes that would make life easier for programmers if it has no effect on readability.

Now Dr. Leifer's remark: You were wondering about the future. We seem to be talking about Braille, but you are dubious about its ultimate viability. Well, I think that people who know how to read Braille well regard it as a very good system indeed. Now, it has some obvious problems, but it also has some obvious advantages. It preserves many of the advantages of the print code because, like the print code, it is spatially displayed; the information it presents is spatially distributed, and this makes available to the Braille reader much of the search capability, much of the selective reading, re-reading, retracing, and so forth that is enjoyed by the print reader.

However, as I said, it does have disadvantages as well, and administratively it is probably irritating. After all, it is expensive, it is cumbersome, cumbersome to distribute and to store, and there are probably administrators all over the world who would be perhaps a little pleased to discover that it is going out of style.

And this brings up the next point that I would like to raise. You know, all over the world we have the movement toward mainstreaming and toward educating blind children in public schools; and there are, of course, many advantages to be realized by doing this, but there may also be some disadvantages. And one of the disadvantages, I suspect, is that Braille is in many places not being taught as well as it used to be taught, simply because resource teachers who have to spend time with many students, and often over a very broad area, simply do not have the time to do the teaching that is required in order to make Braille readers competent Braille readers.

Well, of course, when this happens then incompetent Braille readers do not express much of a demand for Braille, and because they don't, it helps to prove the point that it is no longer wanted very much. And so we may find ourselves in the situation in which we have a self-fulfilling prophesy.

Now if this analysis is correct, and you may want to dispute me, but if it IS correct it seems to me that, instead of looking for some way to get rid of Braille, what we need to do is to look for some way to save it and to turn the situation around.

D. PALMER, Kingston, Jamaica:
I am a social worker. I'm blind. I'm not involved with the technology of producing Braille on any level, but I think the future of Braille is really a timely question; it is important. The last speaker brought up some important points, and I'm wondering about the future of Braille, because in Jamaica we have not been blessed with the technology of computers. People, blind people, young people and old too, seem to be moving away from Braille. One of the main reasons is that it is cumbersome, but then, that is my opinion. There are there many good Braille readers. The problem might be in the method of teaching, but I know that a lot of people are becoming disenchanted with it.

For example, I work, but I hardly use Braille. As a social worker, I make jottings, I use a tape recorder and a typewriter, and so on. Even students studying, just to move around they find easier with a tape recorder or something. They use Braille in a very limited way. And I am wondering now if this is not the time to really take a serious look at Braille. Should we continue this onward trend? The point is that people are moving away in Jamaica, and we seem to be more satisfied with the spoken word. Like cassettes, which everybody is using. I think it is important now to look at the future of Braille and future aids, to see what direction we must take.

H. WERNER:
Just a short comment. Let me come back, for example, to the newspaper that was mentioned. It was already pointed out, I think by Dr. Foulke, that there is one difference between written and taped material - since Braille or printed material is distributed spatially, you have a random access. If you get a newspaper which

is taped, as you say, for a length of I don't know how many minutes, then you cannc just quickly go over it, and say: "This is the article I would like to read". Maybe it can be reorganized. You have to have a real table of contents. Hopefully it allows you to choose what you are looking for by reading the heading. If not, you just miss these articles because they have not very good chosen titles.

So, I think, there is one point: Braille is useful if you need random access and, for instance, if you have to use books. Now, Braille doesn't mean that it has to be printed on paper. I envision, for instance, that ink print books nowadays are printed by means of computer and ink print. That is, the book will be available on a computer accessible medium.

So, just as a sighted person might have magnetic tapes to play music, for instance, I think the blind person might have a tape recorder and the random access medium enables him to pick out from books or from documents what he is interested in. This concerns, for instance, the scientists. A lawyer has to look up certain paragraphs in the law. Some chemists may have to look up some formula in a table. And in this work I would expect that you have still to have some medium for writter documentation. These things will hardly be spoken. And I think if you summarize these arguments, a medium to store the information cheaply, digital cassettes or something similar might be a means for the future, together with some device to represent the information you need in a small space - this I think is what we have, and what we will probably have for quite a while. To me this is still kind of Braille.

S. STAXLER:
It is a very interesting discussion about the media to get information to handicapped people. It is interesting too to listen to the Jamaica views here. In the experimental work in Sweden we worked on text information of floppy discs and on Winchester discs, and, you know it is possible there to pack the information in very small room. For instance, if you take a book, whether you put the floppy discs, say 25 of them or something like that, you can store as much information in that type of book as you can in, say, ten equally big normal books. And at the same time you have the possibility to search for the information very fast. You could go through, say, ten pages in one second, or something, to look for the page number, for the heading of a special piece in the text, for special words in the text or something. You could look for the information very fast on the floppy discs and on the Winchester discs. So it is possible to store the information, to look into it very fast and to display it, maybe, by speech synthesizers.

As we heard from Mr. Lindstrom, the speech synthesizer doesn't speak very well today, but it consists of integrated circuits and the integrated circuits, when they are mass produced, become very cheap and more and more competent. I think we have to take these developments in observation too for the future, and in such a conference - that is, a working group that we are talking about - we could further this discussion still more, and try to both help the Braille printing to live, and at the same time take the opportunities to use the modern technology in an efficier way for the handicapped society.

L.J. LEIFER:
I want to make a point of clarification. I'm not in any way against Braille, nor am I in any way for Braille. I'm trying to understand the issues of communication for the disabled, be they blind, physically impaired or deaf. And I think there must be some underlying structures and problems. I come to such a meeting to look for inspiration so that I can go home and formulate research to solve problems tha delivers a product five to fifteen years from now.

That is the sense in which I ask: Is there something beyond Braille? Is there something beyond hearing aids? Is there something beyond steel manipulators? That was the sense of my question.

V. WOLF, Tel Aviv, Israel:
I am an Israeli blind student, and I wanted to say that I don't understand much

about technology or computer systems. But I am an eager reader of Braille, and I think Braille is neglected in favour of cassettes and talking books. For me, for example, talking books or speech systems are only a partial solution and absolutely not the ideal solution. And I would really like to see something like a system which will enable me to know more, to have more books and reading material available, so that the situation will not be as desperate as it is now.

Personally, I am eager to read and know more, and the present systems do not really enable me to reach much of the material that exists. Thank you.

R.S. TYLER, University Hospitals, Iowa City, Iowa:
I just want to support the Swedish gentleman's argument that the limitations in arbitrary search for text in a speech system as opposed to a Braille type system is probably not a valid argument for future developments, given the possibility of speech synthesis. And certainly I think the software developments of data management systems and in-depth searching are quite well developed, and research should go towards this sort of speech synthesis aided text searching devices. I don't see that that should interfere with people who are good Braille readers, but certainly would provide an enormous alternative for those people who are not Braille readers.

M. TRUQUET, Universite Paul Sabatier, Toulouse, France:
I should like to answer the student, because I received a letter from a student which said: "I received a talking book. It was so nice that I should like to read this book. Can you transcribe this book?" And I transcribed the book and he said: "There were so many nice passages that I can read again and again. By the cassette it is not possible".

N. DICKSTEIN, Ministry of Labor and Social Affairs, Jerusalem, Israel:
I just want to make a comment. To put it in its proper perspective, we are talking about two groups of people. One group is those born blind who start learning Braille in school from childhood on, I would say almost like Vered, who knows Braille very well. We've seen the statistics from Mr. Anbary's slide. I am talking about Israel, but I am sure these are international statistics. You are talking about half the population becoming blind from fifty, fifty-five, sixty and up; so, when you speak of a given number of blind in any country, you are talking about 50% of 60% of those who have sight until that age, and this group beginning to learn Braille at that age is very slow, if anything at all. You are using these various electronic devices to help them adjust to their visual disability without the aid of Braille, and here you are talking about a group of 50% or more of all the blind population.

M. SOEDE:
Just a comment, a short comment. This discussion fits perfectly in what I showed in the needed development process, interaction between what is on the market, what are the possibilities and what are the needs. Without needs, we don't have to talk any more. And another remark: It is not "Braille or not Braille". I think the question is Braille in what situation.

S. BECKER, Sweden Institute for the Handicapped, Bromma, Sweden:
Perhaps my remarks come a little bit late, but I'm afraid Mr. Chairman's observing eyes didn't observe me earlier. Just a few remarks about Braille here. I quite agree with our Mr. Chairman here that the readability of Braille must be the criterion for an optional change of the code; that's quite right. And care should be taken that the programmers may not be the criterion - that is quite correct. But I am quite convinced that a drastic change of a Braille code will just lead to much increased, much better readability; it will lead to a situation where a possible group of Braille readers will rapidly increase, and the amount of Braille will also increase. As has been pointed out by several speakers, what clever programmers we have, what clever computers we have, but there are problems that the computerized Braille translation cannot solve.

So I think, let's throw away all these Grade 2 systems, and let us change the Braille code on an international level, so that it more conforms with the normal ink print way of writing, and as much as possible also conforms with normal layout of printing, and so on. This will make it much easier to learn; it would make it much easier to read, and especially it would make it easier for those people who have difficulty with Braille.

I think we have spoken a lot about the clever Braille reader here. This is an important group, but it is very very small. A big group of Braille readers, and all these coming potential Braille readers - they are old people, most of them, and I think they will never cope with a sophisticated Grade 2 system.

On the other hand, I must underline that we have a great need for a very good shorthand note-taking system, on a national basis of course. Let's call it something like the Grade 3 system or whatever you want to call it. That's really what we need, but I think we do not need a Grade 2 system. That is something we ought to throw away to give us the possibility to have more output from the computers, more Braille output, more amounts of Braille and more Braille readers. Thank you.

S. ROSEN, University College, London:
Dr. Leifer seems to have stirred up a hornet's nest here about the advantages of Braille or not, and if I may interpret his remarks, I don't think that is what he was trying to get at. Mr. Sullivan mentioned earlier that yesterday's talk about deafness focused on the possibilities of getting the deaf to use their hearing sensation from residual auditory function or the residual neural representation they have.

Now, as far as the future for blindness, there is work currently going on - not to pretend that this is about to be applied in many people, but there is work being done on cortical electrical stimulation to give visual sensation to the totally blind. I think these are the kinds of things that he was trying to bring forward.

Again, this might not be ready to go immediately, but if we look at, say, the history of the cochlear implant, the first cochlear implant was only done just about twenty-five years ago - the first actual experiment on a patient. It has taken about twenty-five to thirty years to get to the point where more than 10 or 15 patients were being treated. Now these numbers are moving into the hundreds, and it may well be a similar situation. So if we look forward twenty, twenty-five or thirty years, there may be actually the possibility of giving some actual vision, especially if we are talking about symbol systems like letters and Braille and things like that, through biological interventions.