REPORT OF THE PROCEEDINGS OF THE CONFERENCE

ON "NINE-DOT BRAILLE" - JUNE 19, 1964

HELEN KELLER ROOM

AMERICAN FOUNDATION FOR THE BLIND, INC.

NEW YORK CITY

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INTRODUCTION

Most people are aware, at least in a general way, that there exists a system of raised-dot writing which is read by the fingers of persons who do not see well enough to perceive the shapes of the letters of the Roman alphabet, and that this system was devised more than a century ago by Louis Braille, whose name it bears. Too often, the emotionality evoked by blindness obscures the most fascinating characteristic of Braille's invention. As the following illustration shows, it was designed and developed with mathematical precision and symmetry, for the inventor was an accomplished blind mathematician and teacher.

The June 1964 Conference on "Nine-Dot Braille" was a logical continuation of the century-long efforts of Braille and his successors to put the printed word, and all other written terminologies, within the reach and comprehension of those members of our literate society who are blind.

It is also a logical parallel that a number of those who participated at the Conference should be accomplished blind mathematicians and teachers in various institutions of higher learning, for the braille system has always been to a large extent a function of education. It is probable that modern science and technology made these participants more keenly aware of the magnitude of touch reading problems than were Braille and his immediate successors.

The complexities of the task before the Conference are perhaps best illustrated by the second item on the agenda, entitled "Readability of Nine-Dot-Cell Characters; Type Scale; Tactually Discriminable Space Difference Between Modifying Dots and Base Sign."

It was not the purpose of the Conference to seek specific answers to any of the problems of tactual legibility, but rather to identify all the problem areas concerning the expansion of Braille's six dot base cell into a nine-dot base cell, and reduce these and other tactile problems into researchable areas.

Mr. Strom's resume, which includes the reasons why he became interested in designing a "Nine-Dot Braille" code, and the agenda topic entitled "Need for 'Nine-Dot Braille'; Orthographic Efficiency and Space Saving," constitute an ample explanation as to why the

American Foundation for the Blind considered the subject of expanded braille codes so important as to have called the Conference presently being recorded, as well as a previous one which was also held at the Foundation on July 6, 1962.

The Conference proceedings have been arranged in topical rather than chronological order to give maximum relevancy to each of the participant's comments and recommendations, and in keeping with the topics listed on the agenda which have not, therefore, been repeated in this report. Nothing, however, has been changed, added, or deleted from the participant's statements.

A Working Paper (see Appendix A) was prepared and sent to the participants in advance of the Conference. It was intended merely to stimulate discussion. Subsequent to the Conference, Dr. Nemeth offered to supplement his remarks on the determination of the intrinsic ambiguity of six-dot and "Nine-Dot Braille" (see Appendix C).

The soundness of a philosophy of the presentation of written terminologies in tactile reading form, the logic and precision of the physical development of punctographic codes, the strict adherence to information theory in the assignment of meanings to the various characters of a code -- these and other aspects of code development are highly important; but code optimization will not be feasible until the necessary data on the tactile human sense have been gathered and organized by research specialists.

It was the hope of the Conference participants that extensive scientific investigations on touch reading would grow out of the Conference discussions. In the interval since the Conference, at least one major research study has been started. Dr. Emerson Foulke, of the University of Louisville, a participant in the Conference, has received a grant from the U.S. Office of Education for a project entitled, "The Development of an Expanded Punctographic Code for Tactual Communication."

The study, according to Dr. Foulke, is not being undertaken with the thought of replacing the present braille code, but to determine the advantages and disadvantages of an expanded code. Many of the Conference participants will serve in advisory capacities during the project.

The American Foundation for the Blind, which provided some financing of the project, is pleased that one research project is already underway and hopes that still others may be undertaken.

The Foundation wishes to express deepest appreciation to all of the participants for the diligence and vigor with which they addressed themselves toward fulfilling the purpose of the June 19, 1964 "Nine-Dot Braille" Conference.

M. Robert Barnett
Director

TABLE OF CONTENTS

List of Participants

Introduction — Pages i-iii

Opening Remarks (by Harold G. Roberts) — Page 1

Welcoming Remarks (by M. Robert Barnett Executive Director) — Pages 1-2

Resume on "Nine-Dot Braille" Code Development (by Robert Strom) — Page 3

AGENDA TOPICS

Readability of Mr. Strom's First Nine-Dot Proposal. — Page 9

Readability of Nine-Dot Cell Characters, Type Scale; Tactually Discriminable Space Difference Between Modifying Dots and Base Sign. — Page 11

Need for "Nine-Dot Braille": Orthographic Efficiency and Space Saving. — Page 34

Questions on Braille Code Design: Philosophy of Presentation of Information to the Braille Reader. — Page 50

Participants' Comments on the Duplication of "Nine-Dot Braille". — Page 61

Consensus of the Participants' on Structuring and Organizing an Effective Research Project on Six and "Nine-Dot Braille"; remarks concerning Funding. — Page 65

Consensus of the Participants' on the question of Publicity. — Page 88

APPENDIX A

"WORKING PAPER" - "Nine-Dot Braille" Conference

Submitted by: Carl T. Rodgers
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APPENDIX B

Report on "Nine-Dot Braille" Conference held at The American Foundation for the Blind, July 6, 1962

APPENDIX C

"The Mathematics of Six-Dot Braille and Expanded Punctographic Codes for Touch Reading and Writing".

Submitted by: Dr. Abraham Nemeth
Assistant Professor of Mathematics

Mr. Roberts: I am Hank Roberts. I am Director of the Foundation's Program Planning Department and I am going to be here with you most of the day. I have no technical knowledge of the subject that will be discussed here today, but I am extremely interested and, more than that, I'm very grateful, as all of us here are, for all of you coming here and participating in this discussion that, I am sure, will prove to be very helpful to many, many people.

Mr. Barrett: Every time we have any kind of a meeting in the Foundation, about all I do around here is come in and welcome groups of people. I have such a stock speech that the staff has heard it so much that I do sometimes try to change it, but it usually goes along the line that it is not up to me to welcome you in the sense of helping the Foundation as such. It is, rather for us to thank you for using our facilities from time to time to try to advance knowledge about services to blind persons or to advance or improve technical aid.

This particular subject is one that requires considerable genius, and I would say, brilliance. Evidently in this room there is probably almost all the knowledge there is in the United States of this particular subject. Apropos of braille, I remember a little verse that was once reprinted in the OUTLOOK and it went something like this:

Down in braille alley, down on my knees
Trying to find my stylus
Lord help me, please.

Can't you just get a vision of that little boy crawling around looking for the stylus.

I am also glad that this plan, this study, has been going on for some little while now, thanks to Bob Strom's initiative, and the extreme interest that was immediately shown by Miss Gruber and Carl Rodgers and John Dupress. The reason I am mentioning those two names in particular is that some of you may be aware that Miss Gruber and Mr. Dupress are no longer with the Foundation.

Beyond this, the only thing I can assure you as a group, is that the Foundation is prepared to pick up whatever your recommendations are. I notice on the agenda later in the day, the obvious questions of where do we go from here?

I'm strictly an amateur, but have had enough coaching from the Research Staff to know that if research is to be done right, it can be quite expensive and can take a lot of time and involve a lot of headaches and blood, sweat and tears. Insofar as I can help arrange the financing and the facilities for whatever the next step the group

recommends should be taken, you can certainly count on me and the Board of Trustees.

Mr. Roberts: .....Carl has worked very hard in planning this meeting for today and has really done an excellent job. I am sure you would all agree that it is with a great deal of pleasure that I turn the meeting over to you Carl.

Chairman Rodgers: Thank you very much for your very kind words, Mr. Roberts.

Before I introduce Robert Strom, who is going to give us his resume on his "Nine-Dot Braille" efforts, I would like to say just one thing if I may, pertaining to myself.

I have attempted to prepare a Working Paper on Research Areas. Know ye all, I am not a research man, and I do not labor under any hallucinations of being a research man or being acquainted with semantics, the jargon of research people, which simply means that as we go along with this discussion, if some other categories other than those which I have set down should be included or be taken in a different order, I certainly will be glad to do whatever seems most feasible to the group from the standpoint of a research discussion.

I would like now to introduce Mr. Robert Strom, who will summarize his efforts on "Nine-Dot Braille".

RESUME ON "NINE-DOT BRAILLE" CODE DEVELOPMENT (by Robert Strom)

Mr. Strom: Thank you, Mr. Rodgers.

I want to give you just a brief historical background as to how this system originally got started and what eventually brought me before the American Foundation for the Blind with a proposal of a "Nine-Dot Braille" system.

It all started in June of 1961, when Mr. Donald Barr, who was then director of Columbia University's "Science Honors Program", which was a classroom and laboratory program for pre-college students with unusual scientific aptitude, requested my assistance for a special task.

I was a computer programmer, and I was requested to give private instruction to Mr. John Covici, who at that time was a student in the Mathematics and Computers Section of the Science Honors Program. I was supposed to ascertain all the problems involved in a blind person's learning, writing, and applying the techniques of computer programmers so that my instructions could serve as a supplement to the standard lecture and laboratory program used in teaching John's classmates in the Mathematics and Computers Course. This lecture sequence was, for the most part, rather visually oriented.

For me and for the people at the Columbia Science Honors Program, this was an introduction to the problems and limitations of a blind person's learning a skill like computer programs. It was from this encounter with trying to teach a program that involved writing of technical symbols that the idea of improving the braille system, which eventually led to the "Nine-Dot Braille" proposal, was conceived.

Then in the course of instructing John, I familiarized myself with braille, with Standard English Braille, Grade Two and with the 1956 edition of Dr. Nemeth's Code for Braille Mathematics. I examined these codes carefully, trying to ascertain the logic behind the choices for the configurations. Many seemed at first sight strange.

I had the conception that any system of communication, whether it was verbal or written, should contain a certain amount of redundancy of information; that is, whenever two signs of distinct significance occur, they would be less likely to be confused if there is more than just one perceptual difference between the signs like, for example, in spoken English, the words "bat" and "pat", where only the voicing of the consonants serves as a cue for distinction, are more easily confused than "bat" and "cut", where there is a difference not only in consonant quality but also in the vowel.

Yet, in examining braille, there were many situations where the only other graphic separation between meanings was one of position with respect to blank cells such as the sign for "were" and the sign for the left parenthesis; that is dots 2, 3, 5, and 6, where the distinction of meaning is based upon position of the sign for "was" and the sign for "by" where the distinction is made on the basis of whether there is a space after the contraction. Or there were some characters where the only difference in perception between them was their vertical position within the cell. These seemed to be more perceptually confusing than situations where there were more distinctions between the contractions. However, the need for redundancy in this perceptual legibility problem and the need for space saving and time-saving contractions which speeded up reading often ran in opposition to each other and had to be balanced off.

When there are only 64 possible character configurations, there is a bad problem resulting from the fact that you do not have very many configurations to choose from. The result is that in literary braille, where we have a large amount of cueing from the context, what happens is that the orthographic redundancy is sacrificed for the sake of space saving contractions and, hence, we have a large number of situations where the same sign is used to mean different letters or characters, depending upon surrounding conditions.

In mathematical braille there is less cueing from the context. We, therefore, had to make more different contractions, and we ran into problems where there are multiple cell configurations five or six cells long to represent one symbol in mathematics. Also, one of the patterns that ran through both kinds of braille codes was that of three indicator dots followed by a six-dot base cell basically a nine-dot configuration in two cells.

So this was my first examination of the braille system that was used at the time I was teaching John. There were many problems with orthography as far as representing a lot of the information in the computer course and in the course in matrix alegbra, which is also being taught. These were mostly problems of orthographic inconvenience.

I decided to experiment with an extension of the braille system, that is, a way of expanding the number of possible one-cell configurations by a factor of eight. I felt that it was possible to both increase the number of possibilities for space saving contractions and also increase the number of different configurations and, hence, eliminate the overlap where we have different meanings assigned to these same configurations of dots.

What I did at that time was the following: I retained the sixty-four basic single characters of Grade Two braille and I also retained most of the formerly developed concepts of how to make contractions: whole-word contractions, part-word contractions, single-letter whole-word contractions, initial-letter and final-letter contractions, short-form words, and then I added dots 7, 8 and 9 to the right of the base cell. I transformed the contractions which consisted of dots 4, 5, 6, plus a cell, to a nine-dot contraction containing the same base cell plus the indicators in position 7, 8 and 9 of the same cell. For example, "ation" which was dots 6, 1-3-4-5, became dots 1-3-4-5-9.

On the basis of this and also on the basis of an elimination of all the situations where the same sign stands for two different configurations, I drafted a first tentative copy of both a literary and a mathematical braille system, more or less on my naive intuition at that time, and I then searched for organizational aid in supporting the construction of slates so that I could produce some "Nine-Dot Braille" in sufficient quantity for testing it.

There were many problems in looking for help before I came to the American Foundation. Part of the problem was a fear of a new system of braille that would just add to the long history of changes that have been made in braille and part to the prevalent conception that psychological experiments had proven that six dots were the largest number of dots that could fit into a single cell.

As to the second problem, I consulted Professor of Psychology Dr. Jerome Brunner of Harvard, and he explained that the experiment regarding threshold of immediate perception and the maximum number of single perceptual elements that could be perceived in a single glance did not apply to the limitation of the size of the braille cell. It merely meant that when subjects were presented with patterns of dots on a tachistoscope in the case of visual images or with an instantaneous glance and tactual images, there was a certain limit to the subject's ability to identify them as being composed of a certain number of dots. But this did not mean that a person could still not identify patterns composed of more dots. He illustrated with the example of Chinese, where some of the basic signs consist of more than nineteen strokes; yet people can read Chinese very quickly even though they may not be able to tell at a glance how many strokes are in the symbol that they read.

After some effort at locating help, I eventually came to the American Foundation and the very dedicated help of Mr. Rodgers, and he arranged a conference of specialists in July 1962 at which some of you who are here now attended. You can recall the recommendations that were made at that time, which included the following:

1. "Nine-Dot Braille" has potential for increasing the scope and flexibility of tactual reading. It may be said that it could become a successful general-purpose reading system. We must find out whether it can, by experimenting not with the present "Nine-Dot Braille" that was offered before the last Conference, but, rather, with a group of systems which share the "Nine-Dot Braille" concept. In short, we should not stick to that one tentative proposal of assignment of meanings that was presented at that particular conference.

2. "Nine-Dot Braille" has potential weaknesses which may aggravate the problems of tactual legibility. For example, bunched contractions should be avoided. However, it was not known whether the appearance of illegibility of these contractions was the fault of the contractions themselves, i.e., the dot configuration; whether they were the fault of the configurations combined with their meanings, whether it was the fault of the unevenness of the slates that had been produced in a hurry for that conference; or whether it was the fault of the spacing value, which was .080" used in that version of braille. There were many different reasons, and it was not necessarily the "Nine-Dot Braille" concept which was at fault. We did not know which.

3. "Nine-Dot Braille", whenever feasible, should continue the system and the pattern of Grade Two braille as much as possible so that people who are currently reading Grade Two braille do not have to make a violent transition to "Nine-Dot Braille" if the system is ever released. In particular, what was implied was that the "Nine-Dot Braille" cell should be considered as composed of two parts: a 3 x 2 submatrix of the cell, which is the basic six-dot cell, plus three indicator dots which would serve as a modifier to the six-dot sign that is inside the nine-dot cell. It was also implied that the pattern of initial-letter and final-letter contractions should be retained.

4. Indicator dots should be placed at the left and not at the right of the base-sign part of the cell, especially in mathematics where we had situations, when it was at the right, that a sub-2 looked like a 2-sub when read left to right.

To experiment with the spacing values, the Foundation created three different slates which we have here. The spacing values of these slates are .085", .090", and .095" between dots in a cell. Revisions to the "Nine-Dot Braille" system have been made since the time of the last conference. Sample material of literary amd mathematical braille codes were made on each of the slates. We have those. And the results were shown to Mr. Rodgers prior to this conference, and he immediately pointed out, after careful examination of the "Nine-Dot Braille"key and of the samples of material, that we had a problem in legibility again which may be a result of the problem in spacing.

Basically, it is the following: what would seem to be a logical division of the "Nine-Dot Braille" cell into modifier and base sign based upon the dot numbers may not always be psychologically separated into modifier and base sign according to the pattern that we have created. For example, remember that dots 7,8,9 are now on the left and dots 1,2,3,4,5,6 are now on the right. We had a contraction, dots 1-2-3-4-7-8 (dots 7-8 "p"). That would seem at first glance to be a good initial contraction based upon a "p" namely dot 7-8 p. However, when you actually read the contraction under your own finger, it turns out to look like an "er" sign with a dot trailing off at the right, and this would be a confusing perceptual cue because "er" does not have any phonetic resemblance to "p".

Of course, one might argue that you could still use it to represent, for example, a "per" sign. However, this would violate the pattern that we have set up, namely, that initial-letter contractions should always have the cue based upon the initial letter of the word, that is the "p". However, if we want to build a new contraction where this particular configuration is based upon the "er" sign, we would be violating the pattern that the indicator dot is on the left and not on the right. So we have a dilemma here.

The question that was raised is basically whether there is a natural psychological breakdown of a given cell into the parts, a six-dot and a three-dot subcell. Or is it just that the particular appearance to Mr. Rodgers may not be the same as the particular appearance of the cell to another blind person reading the system? We have to determine this fact.

The second problem is what to do about this. Should we relax the constraint about keeping within the same pattern precisely of Grade Two braille or should we modify the spacing values within the cell so that the "Nine-Dot Braille" is no longer a square cell but instead a cell where there is more spacing between the three dots at the left than between the six dots at the right in order to separate the characters more easily.

The problem is what kind of alternative solution with regard to overcoming the problem does this pose and how does this affect the future of "Nine-Dot Braille"? Basically this, combined with the problems of legibility, are among the things that I would like recommendations from this Conference today.

READABILITY OF MR. STROM'S FIRST "NINE-DOT" PROPOSAL

Mr. Ingham: Could I make a couple of points, having been at the last Conference? The first thing I would like to point out is that a resume of the suggestions of the last meeting as read here, I think, conveys a wrong impression. That is that these suggestions were by no means that firm. I think the only firm statements made were that "Nine-Dot Braille" could be read as it stood then, and that it should be researched as quickly as possible by a large number of people to see what could be done. I mean, we could not really tell at that time, in a one-day meeting, what these values and problems were; whether, for example, dots 7,8,9, should be placed on the left or right. This was not at all firm. I think this is slightly different. I wonder if Tom Benham has similar feelings.

Dr. Benham: As I remember it, we didn't come up with any specific recommendations about the aspect of it. It seemed to me as though we were talking about the possibility of getting the material in the hands of a lot of people so that it could get some widespread evaluation instead of just by us.

Mr. Ingham: The only unified impression we all had is that, as it stood then, we could definitely read it.

Chairman Rodgers: Mr. Liechty, as long as we seem to be reminiscing, would you care to offer any comments?

Mr. Liechty: It's my impression that there were no firm recommendations. I think I agree with these two gentlemen who have said that it appeared very legible. I was, I recall, amazed at how quickly you people, who read by touch, picked it up and followed Bob Strom's reading and prompted him at times when he hesitated a little bit. So it seemed quite legible as I observed the reading; also that it should definitely be tested by many more people.

Chairman Rodgers: Now I would like to give a little sequel to that, particularly with respect to the testing by many people.

It was, as I recall, the consensus toward the end of the conference that "Nine-Dot Braille" should not constitute a new system, at least insofar as literary braille was concerned. The point was made, I believe by Mr. George Meyers, that during the last forty years or so we extended the situation to include Moon type and other forms of raised lines; that blind people have been subjected so far to many, many changes which, from a purely pragmatic point of view, would involve a lot of interruption in the progress that has already been made with respect to the development of touch reading and that, therefore,

at least insofar as the literary braille is concerned, it should remain pretty much as it is now, with the possible exception of putting the modifying dots at the left and as part of the nine-dot cell. Thus the contraction for "mother" would not read "m" plus a middle dot but, rather, would read "m" preceded by a closeup dot which formerly, in a two-cell system, would have been dot 5.....

Mr. Ingham: Just a couple of more things. Bob, did your material at the last conference have the modifying dots? For example, in the case of "mother", was dot 5, which is traditional, following the sign then?

Mr. Strom: It was at the right originally.

Mr. Ingham: I think we rebelled against the idea.

Chairman Rodgers: Yes, they did definitely.

Mr. Ingham: As far as the random suggestion we made about the nine-dot system replacing the literary braille, you are right there. But as far as any other kind of braille, such as math braille, we felt that there were no holds barred and really we couldn't tell whether the dot should be on the right or the left. Or, indeed, whether the present way of writing was at all an efficient way in "Nine-Dot Braille".

Chairman Rodgers: Right; and, indeed, that would follow along the traditional development of braille anyway, because some of the time in mathematical braille the modifying dots are at the left and sometimes there is a modifying dot, or indicator, at the right of the base sign.

READABILITY OF NINE-DOT-CELL CHARACTERS, TYPE SCALE: TACTUALLY DISCRIMINABLE SPACE DIFFERENCE BETWEEN MODIFYING DOTS AND BASE SIGN.

Chairman Rodgers: The first thing I see on the agenda is "Readability of "Nine-Dot Cell Characters," and under that we have "Type Scale, Tactually Discriminable Space Difference of Modifying Dots," that is, between modifying dots and the base cell.

Dr. Nemeth, would you care to start the discussion?

Dr. Nemeth: For the sake of uniformity, I hope that we can get a standard way of talking about dimensions of braille, because trying to read different ideas that people have is very confusing.

There are essentially three dimensions. There is inter-dot, inter-cell, inter-line. Inter-dot means the spacing between the center of one dot and the center of an adjacent dot in the same cell. By inter-cell, I mean the spacing between the dot in one cell, and the corresponding dot in the other cell. Grade Two, this is about 0.250 of an inch. In various things that I have been reading, people have sometimes been talking something like 160 thousandths, and then I understand the spacing between the far side of one cell and the near side of the next cell. This is very confusing. We should stick to one nomenclature.

Inter-cell spacing is 250 thousandths of an inch standard, that's all. Inter-dot spacing is 90 thousandths of an inch, that's all. Inter-line spacing is 400 thousandths of an inch.

Covici: That's corresponding dots.

Dr. Nemeth: That's right. You should always use this nomenclature..

Chairman Rodgers: To satisfy Dr. Nemeth and anybody else who may disagree with that nomenclature in the Working Paper, I used both. In some instances, it may be necessary to use both for clarification. I personally prefer the corresponding dot system -- distance between corresponding dots of adjacent cells and adjacent lines.

Dr. Ashcroft: It isn't quite true that it is from the far side of one to the near side of the other. It's from center to center in the case of dots.

Dr. Nemeth: That's true.

Chairman Rodgers: Yes, it's from center to center in the case of the dot.

Dr. Nemeth: There's a fudge factor there, I agree.

Dr. Ashcroft: There's a good reason for that, I think, because of the base diameter of the dot.

Dr. Nemeth: There is also an intra-dot dimension that I did not mention. There are four dimensions of braille; intra-dot, inter-dot, inter-cell, and inter-line. Intra-dot means the base diameter and also height. But I think you see everything else can be inferred from this. There is no clarity gained by reverting to another system, because people are mentally oriented to one kind of set of dimensions, and can infer every other measurement from a standard set of dimensions, and I think that if you want to have universal understanding, you must stick to one set of specifications. That's the first thing.

The second point that I wish to make is this. When you prepare experimental material, I think it would be lethal to try to put all of the variables in at once. I notice that in the material of which there is only one copy, which you people studied at the last session, you have regular standard English braille where the inter-dot spacing is 90 thousandths and then you have a nine-dot braille where the inter-dot spacing is 80 thousandths. I don't know whether there's also a discrepancy between inter-cell and inter-line spacing.

Besides that, the standard braille has 189 contractions and short-form words, whereas "Nine-Dot Braille" has lots of other contractions. So this makes the comparison very difficult. No one knows what they are really comparing.

Chairman Rodgers: May I say a word as to that. In the first place, the first conference was not structured as a well organized research project. In the second, there was no nine-dot writing equipment other than the slate that Mr. Strom was successful in having constructed for him. That meant-----

Mr. Covici: That's not quite true.

Dr. Nemeth: That's not true. I could have sent you a nine-dot slate if you wanted it.

Mr. Covici: The New York Point slate is 3 x 3*

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*Editor's Comment: The New York Point System is two dots high. Theoretically there is no limit to the possible horizontal extension of New York Point characters; however, in practice no character extended horizontall beyond four dots.

Dr. Nemeth: Yes

Chairman Rodgers: That would do it, but it wasn't available to us.

Mr. Ingham: That's minor point anyway.

Chairman Rodgers: Then you have an assignment of going around and seeing if you can collect one.

Dr. Nemeth: My question is why not?

Chairman Rodgers: Your question has been noted, sir! There was no slate available period; other than the one which Mr. Strom had, which would have meant that he would have had to write the whole thing, the sample material and everything else; he would have had to peck it out on the one slate, and in order to save time so that the conference could take place at the assigned date, the standard braille, the regular braille material was written on a braillewriter and the purpose of the other material was simply to get a consensus as to whether it might be feasible to carry on from there with respect to research, and so on. We are not going to decide anything here at this meeting, gentlemen, as to which spacing variables and which set of comparisons is going to be the best. That comes at the end of the agenda, where you're going to have to think of setting up a well structured research project.

That is the reason for that. We agree with everything that Dr. Nemeth has to say and we hope that, as the research project gets underway, all of these universal norms will be adhered to and that a nomenclature will definitely be agreed upon. As it is now, there is no specific nomenclature agreed upon because if you read some records of investigations -- for example, those of the Commission on Uniform Type -- they give you those that Dr. Nemeth has proposed. But if you read other experiments and other records, it is a little different.

Dr. Nemeth: Let me make another point, the system of modifiers and full cell bodies -- I don't know what else to call them -- modifiers and cell bodies, is a very good system when it works for saving space. We have, from Mr. Rodgers' spacing values, the fact that a 40-cell line of standard braille will be reduced to approximately a 32 -- or a 33 -- cell line in "Nine-Dot Braille". Am I right about that, Carl?

Chairman Rodgers: It varies. I would prefer to use the cell totals per writing area. I think it was reduced, depending on the size of the type, from 1,000 to 725.

Mr. Covici: Incidentally, that was the lowest.

Chairman Rodgers: Yes. 725.

Dr. Nemeth: Yes, but that is if you have high density braille, you know, with small inter-dot spacing.

Mr. Covici: No. That was the worst.

Dr. Nemeth: I see.

Chairman Rodgers: That was .090" or to use your terminology of corresponding dots, .340".

Dr. Nemeth: I see. Anyway, the point is this, there is approximately a 20-to-25 per cent loss of numbers of cell per line or per page or per area, or what have you, in that neighborhood, in that order of magnitude. Let me confine myself to a set of contractions in the order of magnitude of 189, like in Standard English Braille. Let's keep that variable constant. Then this means that your nine-dot system will have to be overall -- not in the specific case, you understand, but overall -- approximately 33 per cent more efficient just to keep the space you already have without any gain on it. This means on the average that you will have to have approximately eight to nine dot-cell combinations per line just to break even with ordinary braille, because if you were to write ordinary text or anything like Bob had on the previous one, such as circuit statements or ordinary text where the contractions come at random, you don't get anywhere near the number of eight to nine cell-forms per line. You see, if you have 32 cells and you want to get up to 40, you need those.

If you have this system, it's very fine to have these long lists of contractions, but unless you get eight per line, you're not going to break even in space with your old-fashioned six-cell braille. This is the most important point to consider, I believe, even superseding space values and what have you, because if you're not going to break even with ordinary braille as far as spacing is concerned, you're not going to have any advantage. I wish you people would kick this around a little bit.

Mr. Ingham: I would like to, with respect to English braille.

Dr. Nemeth: All right. I would like to comment about mathematical braille. If you use the modifier-cell-body combination, you have at your disposal eight modifiers including the "empty" modifier which is no modifier at all. As you know, Ken, from being on the math committee with me, we have what, some 30-odd braille indicators?

Mr. Ingham: At least.

Dr. Nemeth: Some 30-odd indicators and we need them all. And the nine-dot cell is not going to help you. It is going to help you in this respect: First of all, one of the things we have in our math code is the possibility of performing five alphabets and within each alphabet we have the possibility of designing ordinary type, script type, bold face type, or italic type, which means for each letter you have 20 possibilities which is far outside the limits of your "Nine-Dot Braille" modifier product combination, you see. So the trouble is they are just as bad in mathematical braille as they are in regular braille.

Mr. Ingham: I just want to point out that there is an over-simplified way of looking at it. There are certain advantages which the "Nine-Dot Braille" might have in mathematics.

Chairman Rodgers: Do you want to get those on the record, please?

Mr. Ingham: I can't think of them all offhand.

Dr. Nemeth: You would have to have eight modifiers per line to make it advantageous, remember.

Mr. Strom: We have at least that.

Dr. Nemeth: In mathematics? No, you don't.

Chairman Rodgers: Would you care to delineate what those are? Remember that we're relating this right now to spacing of type scales; in other words, physical compactness and so on. Are you ready, Robert?

Mr. Strom: One point I wanted to make with respect to mathematics.

Chairman Rodgers: Because if you're not, I think somebody called me. Yes, Dr. Foulke. Go right ahead.

Dr. Foulke: I was a little bit surprised, I guess, to hear so much of the conversation related to literary braille. If I understand it correctly, the whole discussion of "Nine-Dot Braille" came up in connection with the need for a more elaborate symbology to express other languages, didn't it? Mathematics, computer?

Chairman Rodgers: Both.

Dr. Foulke: You see, this problem did not arise in any effort to solve any problem relating to literary braille.

Chairman Rodgers: Yes. Excuse me please. Let me tell you a little bit of the background.

At the first conference, Dr. Foulke, it was emphasized that since the literary braille readers would probably rebel at any new system or at what would seem to them psychologically a more complicated system because of nine dots instead of six, it was decided that if there was going to be a "Nine-Dot Braille" system, the stage of development would begin at the technical levels; in other words, mathematics, music -- the special code levels, shall we say. But at the same time the possibility of extending "Nine-Dot Braille" to the ordinary literary code was not excluded at all.

That is point number one. Point number two. When Mr. Strom presented the revised "Nine-Dot Braille" code that he had prepared it seemed, at least to me, that because of there being no space difference between modifying dots and the regular braille cell dots, what resulted was an entirely new configuration in a good many instances, and you will see that later on. Mr. Strom and I decided -- right, Mr. Strom, you can correct me on this -- that the same blending of modifying dot with regular base characters would also result in mathematical braille and, therefore, while we do believe that the developmental stage, so far as the structuring of a system is concerned, would begin at the special code levels, for practical purposes we took his literary key as an example because the type scale problems are going to be the same both for mathematical and literary braille. So we just took that one as an example. Do I make it a little clearer now?

Dr. Foulke: A little clearer except that I am not really sure that the spacing problems are the same. For instance, it may be that space economy is a more important factor in literary braille than in other codes. Space economy is, of course, important, I'm sure, in all of the codes, but it may be relatively more important in literary braille. This means that in the case of literary braille certain other arrangements might have to be made.

Mr. Ingham: Could I make a comment quite relevant to this? This is the fact that no mathematical text that I know of is strictly mathematics. Unless you're prepared to switch back and forth between two different types of writing, you're just going to have to be able to do all sorts of literary material in the nine-dot system. So I think it's a foregone conclusion that you have to consider it as literary material as well as mathematics.

Chairman Rodgers: I don't believe you can separate the two.

Dr. Nemeth: Unless you have one of these keys where they have nothing but theorem and proof and those are the only English words in there!

Dr. Nolan: Let me make a more general statement, Mr. Rodgers.

It seems to me that we are all here because there is a problem in communication; that the present system is not versatile enough to give us the degree of communication required, and that we want to consider a modification of the system, namely, going from six to nine dots as a possible way of increasing the versatility. The line of conversation to this point has been to give reasons why this won't work. We are just on the threshold of the whole business. I think that if we're interested in exploring increasing versatility of tactual communication, it's not going to do us any good to say it won't work for this reason, it won't work for that reason. We haven't even reached a point where we know whether the characters are legible. This is an elementary thing without even getting to the point where we use these symbols symbolically or we use the stimulus patterns symbolically. So to dwell on these very practical problems, which I admit are of great importance in the light of the very little information we have about the potential of "Nine-Dot Braille" - we haven't studied it all - I think is a little premature.

This is the thing that I confess I often find irritating, because when people advance new ideas and want to explore, there are always those around who say, "Well it won't work." This has been the history of science. There are always those people who sit around and say "No, that won't work," but people go ahead and explore anyway in spite of these, and I think that our conference ought to pursue it in the latter light rather than in the former.

Chairman Rodgers: Agreed.

Mr. Strom: I agree.

Mr. Covici: Yes. In the light of that, I think what should be done is to see what kind of system is readable and do a lot of research on all the variables and then see whether a book takes less space or whether it's easier to transcribe or whether it's easier to read, which is the main point.

Chairman Rodgers: If we have exhausted the topic of type scale as such, we can easily go on to another topic. Before we leave type scale, however, I would prefer to give each participant the opportunity to express his opinion with respect to the importance of spacing variables as regards "Nine-Dot Braille", because there is one very important factor here: How large should the type be in order, on the one

hand, to be meaningful to the reading finger, and on the other, how small may the type be in order at least to break out even with six-dot braille, be it literary or mathematical or both, from the standpoint of physical compactness?

I'm going to start over here at my left and let each one express his opinion on the specific point of needs for "Nine-Dot Braille" development with respect to spacing variables.

Bob.

Mr. Strom: Yes. The first point is in relation to what you said about getting "Nine-Dot Braille" to break even with respect to purely the matter of physical compactness. One thing that has to be agreed upon is that you cannot specify merely from knowledge of the formal measurements of your cell how "Nine-Dot Braille" is going to fare against Grade II braille with respect to comparison. It's always going to depend upon a large number of factors that are independent. I wish to mention that we had some discussion with respect to experimenting with a new kind of breakdown of the cell, i.e., having two different kinds of inter-dot measurements, that is, not have a square cell; have one kind of measurement for separation between indicator dots and base-sign dots and another kind of separation between the individual base-sign dots and consider these as two different spacing variables within the cell.

Chairman Rodgers: For what purpose?

Mr. Strom: For the purpose of making it easier for the finger to discriminate between what is to be the modifier within the cell and what is to be the base cell.

Chairman Rodgers: The base character?

Mr. Strom: Right. And this thing came up as a result of a number of perceptual confusions which should be noticed on the key that everybody has in front of him. Mr. Rodgers, do you happen to have an example of an easily locatable instance of this?

Chairman Rodgers: If you will give me a little time I will look for it.

Mr. Covici: I have one right here. The one for "her".

Mr. Ingham: Where is that?

Mr. Covici: It's on the second line, very near the bottom. It's the second column.

Mr. Strom: Yes.

Dr. Nemeth: I have it.

Mr. Strom: Right. Does everybody have that? Okay. The idea is that since I had the notion that a lot of personal pronouns had been contracted into one cell, "her" should also be contracted into one cell. I chose to try out dots 7-9 followed by a letter "h". Now the trouble with this is that it is probably going to look to a lot of you like a "z" with a dot trailing it.

Chairman Rodgers: Yes. I have here examples of characters like regular braille characters with a spare. Look for the 7-8 dot "e".

Dr. Nemeth: Where would that be? Is this in some order?

Chairman Rodgers: Yes. I would suggest that you look for the equivalent first, which is a little to the right, and that stands for the letters "ee".

Mr. Ingham: Where is that?

Dr. Nemeth: It's in column 2, the sixth entry down.

Mr. Strom: That's an "e" with the dots 7-8.

Dr. Nemeth: 7-8 followed by an "e" yes.

Mr. Strom: It probably looks like an "f" with something after it.

Dr. Nemeth: It does not. Let me make this comment, Carl, for once and for all.

Chairman Rodgers: Wait a minute. Let's examine a few of these. Now we have a stenotypist here, by the way, and every word that you are saying is being recorded. I would suggest that we can't get into an argument of what looks like what to individual "A" and what looks like what to individual "B" except perhaps to say that "X" number of individuals will take the 7-8 "e" as an "f" with a spare and "X-Y" individuals will take it as something else, but certainly you have no differentiation there between the modifier and the real "e" that it is intended to be.

Dr. Nemeth: May I say something?

Chairman Rodgers: Yes.

Dr. Nemeth: The comment is this: What Carl says is perfectly correct provided no one has preliminary instruction. But if you know that the structure of the cell is modifier plus body, then the interpretation of the "ee" combination as an "f" with a trailing dot is not an error, it's a blunder. It just can't be interpreted that way.

Mr. Ingham: I could make some points here which might be enlightening. We have at the lab a machine which can braille with a density of 8,000 dots per 10" squared and I was testing this question with this machine. I talked to Bob Strom a couple of weeks ago about it, and I suggested this very thing of making one column closer to the other. Then I went ahead and played around with this machine and thought a great deal about it and I decided that it would be extremely harmful to do it. The reason simply is that I could not discriminate when there were several in a row between that separation and, say, the separation that would occur between two cells. I got highly confused, and I think we really should make the difference not between columns but between cells. Make your cells distinctly apart, and I don't think you would have any problem.

Mr. Covici: Two points. First, three contractions, as Abe said, at first glance could look like anything you want. But if you know that they're supposed to represent a certain symbol, whether the modifying dot is before or after, or there is supposed to be a blank or whether it's so and so when you read it, you just have a table type thing and naturally it comes out. When you're going along reading, you don't say "Well, this is a modifier and this is a body." Only when you first lean it, do you think this way, and it may be nice to think of it that way as a mnemonic aid. Even though the cell used in the first "Nine-Dot Braille" conference was not so well spaced as the present one, it was quite legible and people were amazed, and I was too, when I first saw it. I think that the original cell spacing might be included in one of the research projects among many other variables but I'm not sure of its value. I think this "x" decimal of an inch may be equal to zero with very little loss in legibility or in anything else.

Chairman Rodgers: I'm going to turn the floor back to you folks, but first I would like you to look at some things that I could not find before and I have them labeled here. Samples of "Nine-Dot Braille" characters that seem to equal regular braille characters but, of course, they mean something else. Look at the sign for "ist".

Mr. Covici: It's on the first page on the right hand column.

Dr. Nemeth: I have it. It's in the middle of the third column. It's the fifteenth entry down.

Mr. Covici: I found it. Yes, indeed.

Mr. Ingham: It looks like an equal sign.

Dr. Nemeth: No. It's 7-8 followed by the "st" sign. Let me say this: Bob has been very consistent in making every one of his contractions three dots wide. Am I correct about this, Bob?

Mr. Strom: So far.

Dr. Nemeth: I mean I haven't been going down the list, but so far, they are.

Mr. Strom: The ones that are two dots wide are not contractions but, rather, regular letters of the alphabet.

Dr. Nemeth: That's right. So every contraction which is three dots wide is not subject to a misinterpretation of any kind, of the kind that you were talking about with the 7-8 "m" versus the thing moved over to the right.

Chairman Rodgers: The "st" sign.

Mr. Ingham: What is the matter with the sign?

Chairman Rodgers: This sign looks pretty much like a "gh" sign followed by the letter "a" to me.

Mr. Covici: Only when you first glance at it, but when you look at it--

Dr. Nemeth: Modifier-body tells me 7-8 "st".

Mr. Ingham: Bob, what you should do is give me or 10,000 other people a couple of weeks to read this. We can't tell. This is the worst kind of test.

Chairman Rodgers: Right. This is not a test; this is a discussion.

Mr. Ingham: But you can't gain any information. It's just faked.

Chairman Rodgers: This is a discussion and then these things should go on the record, because while it's true that right now we have a very erudite group of people here who would be perfectly capable of indulging in beautiful mental gymnastics in order to read, the fact is that other people around the Foundation to whom I've shown these things seem to have gotten the same reaction. So I just want to bring that out and put it on the record, and with that I turn the floor back to you gentlemen.

Mr. Ingham: If you're asking us on our particular level if we can read this, the answer is yes. If you're asking us in comparison with these other people, I think you are losing. I think this stuff should be going to thousands of people in test form.

Chairman Rodgers: It's a matter for research. I think we are all in agreement with that; right?

Mr. Covici: Yes. This is an open question and subject to review.

Dr. Nemeth: May I make the following suggestion, that when you have this thing tested, you do not say, "Well, here it is. Can you read it?" It should be preceded rather by a preliminary informational session where the potential reader will be told that "When you have a nine-dot configuration, you should regard the first three dots as modifier"--

Mr. Ingham: No.

Dr. Nemeth: Just a minute. Yes.

Mr. Ingham: Go ahead.

Dr. Nemeth: Of course. You should regard the first three dots as modifier and the rest of the thing as the body of the cell. This may make a difference. You have all seen the game where you ask people how to pronounce a word, you spell the word but you stop, you pause between the wrong group of letters and people pronounce it wrong, naturally. Or you have all seen this gestalt experiment where you have a picture of a vase. If you look at the vase intently it becomes the figure and the black silhouette becomes the ground, and so you see a vase. However, if you are told to look at the blacked-in material as the figure, then what you see is two silhouette faces looking at each other and what used to be the vase is nothing but the ground. What you see depends on the way you are told to look for something. This is essential.

Mr. Ingham: There is experimental work going on now at our lab on this type of thing. Pictures of different alphabets are being screened on the oscilloscope off the computer and people are looking at them. All sorts of things are going on, like letters upside down, word combinations put in different order, and what has come out immediately is the fact that by looking at the word as a whole you can buy a lot, by looking at the cells in sections, you lose. If you start thinking in terms of modifiers with this conglomeration of dots after them, then you are going to lose.

Dr. Nemeth: I agree.

Mr. Ingham: This is quite contrary to what you were saying.

Dr. Nemeth: I agree, but what I'm saying, for example, I tried an experiment here at the Foundation and it started out as follows: Someone wrote full braille for the first two lines. This was a coherent text, you understand. You write regular braille for the first two lines; then the next two lines was written with leaving dot three out of every third cell and then the lines thereafter were just leaving dot three and six out of every single cell. Now, you know, just by the context I was able to read this thing down and there was no dot three or dot six anywhere, but I was able to read several lines beyond where there was any semblance of braille, just from context and interpolation. What you say, Ken, is true. You should perceive something as a whole, but there comes a time when you have to make a deduction, and when you have to make a deduction then you have to know on what basis to make it. You have to cue yourself to keep going.

Mr. Ingham: Okay. Maybe at first in a training session.

Chairman Rodgers: I would like to insert a comment of my own with respect to the deductions that we may expect of the ordinary reader to have to make. After all, Dr. Nemeth, you are not an ordinary reader.

Dr. Nemeth: This was only an experiment. I don't read like that either, believe me!

Chairman Rodgers: Experimentally or in terms of speed, on the average, very few people read like Dr. Nemeth and other people I've known. I could mention them at random. Mr. A, who could read as fast as he could talk. I know Miss Y who could also read as

fast as she could talk, but that is not the average. So it boils down to the fact that you should not be expecting the reader to read through deductions rather than by cue, the perceptual cues actually on the page that he might utilize if he so wishes.

Chairman Rodgers: I've not heard from some of our participants who have done some very extensive research on tactual discrimination, on errors in oral reading of braille at the elementary grade levels, and so on, and I would like to get their reactions, particularly with respect to Dr. Nemeth's suggestions about how to orient the subjects to the type and purpose of the test they are to take.

Dr. Nemeth: They should learn to read in terms of one third plus two thirds instead of two thirds plus one third.

Chairman Rodgers: That should be explained to them beforehand.

Dr. Nemeth: To be told before, yes.

Chairman Rodgers: Before the test. I would like to get the reaction of Dr. Nolan and Dr. Ashcroft and those who have been sitting very quietly.

Dr. Nolan: I will cease to be quiet, on your request. First let me say I think we are about seven leagues in advance of the question of cells within dot spacing in the cell. This I think was the original question that was raised and we have gone a little bit afield. Actually I think there are two problems here. One is having a stimulus configuration with such spacing that people are able to identify all its elements when they encounter it. This is one problem.

Then there is another problem that has to do with symbolic use for these different stimulus patterns. With reference to the first, my guess is that using an increasing number of dots in the braille cell is going to cause us to make them further apart. This is particularly going to be the case with younger braille readers.

With reference to the problem of indicating the presence or absence of a modifying dot, that is, whether a dot 7, 8, or 9 is present, there is already a cue. If a cell configuration representing common usage is present, the space between it and the previous cell is going to be greater and regular-within-cell spacing will occur when you have the modifier present.

I wonder about using distance as a cue for the present modifier. We are working within a very small distance to start with and I wonder if people are going to be able to discriminate the small differences in distance that will be involved.

Chairman Rodgers: Do you want, Dr. Nolan, to go to the extent of saying that it is so highly probable that they would not, that it would not be worth experimenting for the purpose of determining whether "X" decimal spacing between modifier and base character would be discriminable?

Dr. Nolan: I think we are certainly going to have to study this. One of the problems, if distance appears to be a feasible cue, is the minimum distance that is discriminable to a majority of braille readers. This must be defined so that all people can use the system. There are other cues that one might use. Dot height is a possibility. That would present some problems for the writing devices that you employ. You may run into some problems there.

Dr. Nemeth: May I interrupt just for a point of information. How uniform is dot height from dot to dot in a production run book? Has anyone measured that?

Dr. Nolan: It's been measured. I can't give you the information. It's fairly uniform.

Dr. Ashcroft: It's on the order of ten thousandths of an inch, I would say. We had great difficulty, when we did the spacing variable study control, with dot height at 15 thousandths of an inch and we never did succeed really.

Dr. Benham: By the time someone has sat on it, why, it's not very useful anyway.

Chairman Rodgers: Thank you, Dr. Nolan. I think all these comments are very valuable and we want to keep them on the record. They will be very helpful in building up a set of recommendations to guide the research. The reason I stumbled there is because I have no idea what you folks are going to decide later on as to how to initiate at least some semblance of a structure for a research project that will come later. We are a little bit ahead of the game insofar as anticipating how much the reader should be expected to read by the actual stimuli which are presented to him and their clarity or lack of it, and how much by mental deduction or mental gymnastics, whichever you want to call it. I wonder if Dr. Ashcroft would have a comment on that just to get it on the record, because invariably that is going to come up later.

Dr. Ashcroft: Yes. I would like to make several comments.

First of all. I'm going back to the studies of spacing that we did. As you know, we varied the inter-dot, inter-cell and inter-line spacing and came up with 27 sets of specifications. It seems to me that it did not matter what you did very much in spacing; people could read it and we really had relatively short reading experiences for them and they accommodated rather quickly. Although Dr. Nolan alluded two considerations for younger readers and perhaps the necessity of some larger inter-dot spacing, if I heard him correctly, one of the things that came out of our dot spacing study was that with younger readers there was a slight tendency for them to read better with smaller inter-dot spacing.

Mr. Ingham: Really? Smaller?

Dr. Ashcroft: Yes.

Mr. Ingham: That's interesting. They could read better than adults? Is that what you are saying, with the smaller dots?

Mr. Strom: No. They could read better with larger dots.

Dr. Ashcroft: They could read better with smaller dots.

Dr. Nemeth: By smaller, you mean .085"?

Dr. Ashcroft: Yes. I think it was .085". It might have been as small as .080".

Chairman Rodgers: I think the tentative conclusion is that the inter-dot spacing they read best was .090", as in the case of the adults.

Dr. Ashcroft: Yes. It was between-cell spacing. I beg your pardon. That's right.

Chairman Rodgers: In other words, the distance between the end of one cell and the beginning of the adjoining cell was .123"?

Dr. Ashcroft: Yes, but I tend to agree with Dr. Nolan that this is far down the line and it seems to me the first thing to do is to get some "Nine-Dot Braille" out in this form and have it read widely and extensively. People can accommodate and learn very rapidly. From the error studies that I have done, I think that there are many errors that we don't need to be concerned about. People bring meaning to the context and the context is a crucial factor in errors and controlled difficulty level. This is extremely important for children. We can

cause any of us to make reading errors if we make the difficulty level high. If the difficulty level is appropriate to our reading ability we can keep errors to a minimum. I just don't think that this is anything to fear at this point. I would go ahead and get a lot of material and get it rather quickly. I think it will be read, and read with facility rather quickly.

Mr. Covici: Dr. Ashcroft, what was the degree of accommodation when the inter-dot spacing was reduced to .072"?

Dr. Ashcroft: There were some statistically significant differences, but they were small, and again I would emphasize that these people had a very brief time to accommodate, and I think that they would accommodate even better if given more time.

Mr. Ingham: That we could all read the first material at the last meeting is more than adequate proof of what you are saying.

Mr. Liechty: Yes.

Dr. Ashcroft: People can read anything if they just have the meaning to bring to it and have a little time to work at it.

Chairman Rodgers: All the figures on variable spacing which I presented in the "Working Paper" were only for the purpose of pointing out the tremendous number of possibilities that there are for varying these things, and I'm glad Dr. Ashcroft brought up the point about ability to accommodate to various spacing values, because if that is the case, with adequate experimentation it would seem to me that, should nine-dot-cell characters be proved desirable other than from the spacing values, "Nine-Dot Braille" might be very feasible from the standpoint of physical compactness.

Mr. Strom: Mr. Rodgers, I would like to put up a question before the Conference for their opinion.

Chairman Rodgers: With respect to type scale?

Mr. Strom: Right. With respect to the priority in research of investigations of spacing. The suggestion has been made that it may be the case that cells will have to be made not square but, instead, with two different kinds of spacing values within them in order to provide for necessary cueing relating to modifier versus dot.

Then there is the other opinion -- that it may not be necessary to change the spacing if the cell configurations are suitably endowed with meaning in such a way that the mind learns how quickly to adjust itself to identify the nine-dot characters as an entire symbol. Also, it may be that in faster reading, modifiers are not even thought of or that the concept of the modifier and the cell is not necessarily one that has to be adapted, but there may be some configurations which could be pure nine-dot configurations without the concept of modifier.

The question which hence arises is, should we first try to see how well we can get "Nine-Dot Braille" to be read within the scope of the spacing values? I would tend to think that, first, we should see what we can get within the scope of a square cell, adjusting the meanings approximately and seeing how well they can accommodate to the cueing the way the square cell is now.

Chairman Rodgers: Does anybody have any question about what Mr. Strom said? Is it clear to everybody?

Mr. Ingham: It's not clear to me in the sense that just before he made his point I thought the gentlemen, Dr. Ashcroft and the others, as well as myself, made the point that spacing between different columns was not only unnecessary but harmful and, therefore, that question I thought was left. I mean, in what I researched up at MIT, to use different column spacing is definitely harmful and I understood that the gentleman over here was saying that it didn't mean anything either: The small amount of spacing you could accomplish between columns would not buy the reader anything.

Chairman Rodgers: Was it Dr. Nolan?

Dr. Nolan: I commented on that. I wondered whether the variation in spacing that was possible would be such that you could get discriminable differences in spacing. I also wondered if it is really necessary to actually involve different spacing between modifiers and the others because, in the presence of no modifiers, the space between cells would be greater than in the presence of modifiers. This would be your cue, reduced space to start with.

Dr. Ashcroft: Vacant space.

Dr. Nolan: That's right, vacant space would be your cue. I'm getting back to the thing that Mr. Strom asked, is the initial thing to study discriminability within these patterns? How far must a dot be from one another in order for people to be able to recognize all of them present with whatever degree of accuracy is required? This, it would seem to me, is the initial step to be taken here. You can test this difference of the distances between cells and the usefulness of this as an indication of the presence or absence of modifiers and also the between-dot distances as it affects the ability of people to be able to recognize all the stimuli present within the cell.

Dr. Ashcroft: Some of these considerations were studied in connection with the spacing study that was done.

Dr. Nolan: There is some data on this already.

Dr. Ashcroft: We couldn't vary the inter-cell spacing very fat because dots 4-5-6 became part of a new cell with the next cell 1-2-3.

Dr. Nemeth: That's right. It has a coherence with what follows.

Dr. Foulke: I would like to comment upon something that I think Mr. Strom either said or intimated. This is that so far we have considered the possibility of "Nine-Dot Braille" as a kind of logical extension of the existing braille code, in which case we have been concerned with modifiers and how they might be used, and we have discussed the possibility of a rule of consistency regarding such modifiers which seems entirely reasonable. But there is, at least for the record, another possibility of considering the patterns that result from the use of a nine-dot cell as stimulus patterns in their own right, in which case we might be concerned with the individual's ability to make absolute identifications of these patterns without having to go through any kind of analytical process of interpreting a modifier plus a standard braille configuration. This could be done and this is another possibility which I think at least ought to receive some discussion.

Also I would like to make a couple of other comments on some of the other things that have been talked about. I agree emphatically with Dr. Nolan that much of what we are talking about is the kind of questions that can really only be answered by research. I think it is clear that the research can be done. I think it is obvious to everybody here that spacing variables -- within-cell spacing, between-

line spacing -- are all quite important. But beyond listing at least some of the infinite variety of possibilities that are available, the only resort is research to answer some of these questions. It also seems clear that if we are going to answer them, it's obviously going to require the training of some subjects in the use of codes that we might generate. We can't present them to people cold and expect them to give us any information about their utility.

Chairman Rodgers: Dr. Foulke, I think your statement of testing the reaction to a stimuli per se is an extremely important point with respect to the development of any orthographic system. I'm speaking not now as a research individual but as a mere ordinary average citizen, an ordinary reader. It may be true that we ought to read two-thirds by stimuli and one-third by deduction or vice-versa. But I would say that as far as I (and perhaps I speak for the average reader) am concerned, we want to have as much information available under our fingers as possible. I don't mean over-cueing or anything like that, but certainly the orthographic stimuli should be clear enough that we may avail ourselves of three-thirds of the whole set of stimuli if we desire, if the information is otherwise not clear to us. Also, I think we should do a little developing of codes in a more systematic way for the sake of the nine-dot cell concept per se and for the sake primarily, of course, of the reader.

Mr. Ingham: The point I just wanted to make, following Dr. Foulke's statement, was that I think the way to go about setting up those codes is to give a couple of people the assignment of writing codes, keep these questions in mind and submitting these codes, and one or two or perhaps all of them, should be chosen and distributed. I don't think these are jobs for a committee to even pass on in terms of right or wrong.

Dr. Nemeth: Every good research project starts with someone formulating a hypothesis. This subject is sufficiently complicated for us to formulate several hypotheses. I wonder if it would be useful for us to go around and ask people to formulate what their hypothesis is concerning several subjects in this area: First, the readability of "Nine-Dot Braille"; second, which space "Nine-Dot Braille" would occupy versus the space that six-dot braille now occupies; third, a hypothesis concerning a structure in which each "Nine-Dot Braille" character has its own meaning versus the structure in which each "Nine-Dot Braille" character is a two-component symbol of modifier followed by principal character. I think these are the principal aspects.

I think we already have the consensus accepted that the precise decimal amount of spacing between dots and space, between cells, and between lines, is easily adjustable too, and that the only important factor is dot spacing within cells, and I avoid the word "inter".

Mr. Ingham: I think we disagree there. It is the other way around.

Dr. Nemeth: Isn't that what Dr. Nolan said?

Mr. Covici: No. The other way around.

Dr. Nemeth: The spacing between cells was not so important as the spacing within cells.

Mr. Covici: No.

Dr. Nemeth: Dr. Nolan, would you edify us?

Dr. Nolan: I don't think I said any of those things! I said that the problem was one of legibility of the stimulus pattern and that this depends on the space between dots in the cells. This is the principal question. Then you get into the question of what is the cue to show whether the meaning to be attached to the stimulus pattern is that of the old six-dot cell or the modified six-dot cell. In this, spacing had been suggested as the cue, one idea being that the dot 7, 8, and, 9 should be spaced further to the left than dots 1, 2, and 3 are from 4, 5, and 6. And I also suggested that perhaps the absence of a stimulus, that is the distance between cells, could serve as effectively as a cue.

Dr. Nemeth: Yes.

Dr. Nolan: But the elementary problem is one of legibility of the stimulus pattern.

Dr. Nemeth: That's right.

Dr. Nolan: Can you report what you have been exposed to?

Mr. Ingham: I think this is the point.

Dr. Nolan: Then you get into the problem of codes. What meaning do you attribute to these patterns?

Dr. Nemeth: I suggested four hypotheses. Is it useful for people to formulate sort of a first guess as to what --

Mr. Ingham: The only comment I had about your hypotheses was, Abe, at least two of them had already been answered and I thought the third one had been agreed upon. The first one, for example, readability, had been answered no. Everybody agreed at the last conference and people agree here that it can be read.

Dr. Nemeth: This is not a hypothesis. Hieroglyphics can be read too.

Mr. Ingham: So you make up a code and then you determine this.

Dr. Nemeth: No. In other words, when I say "readability", I have in mind what Dr. Nolan has in mind, tactual discriminability. By that I mean readability. Can you identify one nine-dot character from another nine-dot character?

Mr. Strom: What constitutes identifying a character?

Dr. Nemeth: By naming the dot numbers.

Mr. Covici: No, maybe not.

Mr. Strom: I have a feeling that that is not the best way--

Mr. Covici: I'm not sure. It's not clear to me that naming of dot numbers is too significant. It may be that at the beginning naming the dot numbers is helpful. But, I really don't know.

Dr. Nemeth: May I clarify that?

Chairman Rodgers: Excuse me. I would just make a comment here and then I will turn it back to you and pretty soon we will have to summarize this whole thing because time is getting short. You see, this is the valuable purpose of a "committee". We are not even sure how to go about these things. So the most we can do is to identify some of the areas of research.

Dr. Nemeth: You see, here's what I want to get. I want to get into the heart of the matter. I want somebody to make a statement. I don't care whether it's true or false, but a statement as to what we think will be the result in certain areas of this thing. You can discuss it forever, and you're not getting close to this idea. But before you can do research, you have to state a hypothesis. Maybe it will be borne out, maybe it won't, that I don't know. That's the purpose of research. But you also do research this way. Someone

makes a statement at the beginning of a problem that as a result of this kind of an experiment something will be the case. Then you do the experiment. Then from the experiment you say, "Well, I was right", or "No, I was wrong". But you have to begin with a statement.

Dr. Nolan: I would like to comment. The problem with expressing hypotheses at this point is that your hypotheses must be phrased in terms of the actualities of the research situation. This involves resources, people, apparatus, and so on. How these things will come into being is unknown to us at present.

I would like to suggest that if we were to only achieve an outline of the questions to be studied and these could be broken down in a variety of ways and hypotheses developed relative to them, relative to testing, this might be a realistic goal. In addition, we do not know who is going to do this research, and for us to impose upon this unknown party or parties a format may be a little bit premature.

NEED FOR "NINE-DOT BRAILLE": ORTHOGRAPHIC EFFICIENCY AND SPACE SAVING.

Dr. Foulke: I think it is obvious that if research of the sort that we have been talking about is done, it will be expensive and difficult to accomplish and I think it's further obvious that the efforts of those who have struggled for standardization are going to have to be considered. In view of these obstacles, I would like to hear a persuasive argument for the need of another code.

I think that one can make such an argument, but I wonder if we ought not to say a little bit more about just how necessary this is.

Chairman Rodgers: I think your point is well taken, and although we had a very concise history of the efforts of developing a nine-dot braille code, perhaps the need for such a code has not been clearly explained. I would also say that in this connection we should also hear arguments as to why there is no need for "Nine-Dot Braille". Since Mr. Strom and Mr. Covici are the protagonists of a nine-dot system, I think it is only logical to start with Mr. Strom.

Mr. Strom: Thank you. The first thing that I wish to mention is that the need is not specifically for a "Nine-Dot Braille", but rather the need is for an improvement of some sort over the existing six-dot braille system, of which "Nine-Dot Braille" has been the current suggestion.

Mr. Liechty: May I inject one question. Are you speaking of literary and scientific braille or just science, math?

Mr. Strom: I'm speaking of both. Although the original impetus came from the need for technical braille, I think that the application is to both. As was mentioned somewhere earlier, if you are going to have a new kind of system for technical braille such as mathematical braille, this will automatically have to be incorporated for literary braille, merely because there is no such thing as a text which contains only mathematics in it, and it is completely unfeasible to have a mathematical text where the mathematics is in "Nine-Dot Braille" and the explanations between equations are in the six-dot braille. This would be completely out of the question with regard to printing or writing or any other kind of printing.

Dr. Ashcroft: Could I ask a question? I don't know how relevant it is. Is what you have just said predicated on the idea that six-dot braille has been exploited to its fullest extent now?

Mr. Strom: No, I don't think that six-dot braille has been exploited to its fullest extent. What I do find is that there are certain problems with six-dot braille which require one of two different solutions to be made, merely on the fact that you have only a six-dot cell and, therefore, 64 configurations open to you.

Mr. Ingham: Could I ask a question? This is perhaps the point really of what was going on at the moment. This is something Abe brought up and also something that could be answered or should have been answered rather quickly: What is the actual saving, in terms of cells and so forth, that "Nine-Dot Braille" would make in, say, the code as you have written it here? Admittedly it has to be approximate, but, for example, in comparison with braille to English text, the actual saving is what, 26 per cent with the use--

Mr. Covici: I would imagine it is about that.

Mr. Ingham: With the use of contractions and six-dot braille you can save 26 per cent. How about the case of "Nine-Dot Braille"? Is it the same or can it be significantly better?

Mr. Covici: In the first sample I recall the actual space taken up with the same thing written in Grade Two and the same thing written in "Nine-Dot Braille" was 25 per cent less in the "Nine-Dot Braille" in the original first sample.

Mr. Strom: You have those plastic sheets in front of you. One of the things that has to be taken into consideration is that the tentative "Nine-Dot Braille" doesn't have all the contractions I wished for. I recall that for mathematics the improvement was somewhat in the order of 40 per cent for "Nine-Dot Braille" as opposed to the 1956 Edition of the Nemeth Code, which is not the same as they have now.

Mr. Ingham: I don't think there's any improvement on that score.

Mr. Strom: One of the problems with the current braille is that it is difficult to expand the scope of the configurations without going into multiple cells, and when you go into multiple cells you not only go into increased space but you also go into a new type of reading, a new way of reading one symbol, namely as a composite of a bunch of different individual cells. And that applies for the most part to technical braille.

The other thing noticed is that it is possible to increase, with a "Nine-Dot Braille" system, the contracting power of a literary braille and it is also potentially possible to eliminate some of the perceptual difficulties that result from the fact that within six-dot braille you have, on occasion, signs that are difficult to distinguish from one another which require more context cueing to discriminate between them. I'm thinking in particular of the lower signs; I'm thinking of the situations where the same sign stands for three or four different things depending upon positions. Sometimes where the meanings are particularly unrelated to each other, like when there is a contraction for "was" or "by". I'm also concerned with the fact that the so-called signs, like the italics sign, the composition signs combined with the punctuation symbols often provide a very large number of cells just for the process of indicating what kind of character is going on, and "Nine-Dot Braille" could put, for example, a double capital sign into one cell and double italics signs in one cell and reduce space along those lines.

The original "Nine-Dot Braille" had a proposal to eliminate such extraneous things as the numbers, or such potentially possible extraneous things, as the number sign, which added one cell every time you wanted to use a number and also required re-duplication of the letters "a" to "j" as the numbers. With "Nine-Dot Braille" the contractions of six-dot braille can be put into a smaller space. Presumably there is more compactness of presentation on the braille page. Contractions which previously had half of an empty cell in them, such as dots 4, 5, 6 followed by a letter, could now be represented in one cell without this additional space, so we have increased the number of contractions; we have more compact representation; we have reduced the number of ambiguities of other graphic representation, and we have the facility for making braille capable of expanding to the needs of the new symbols that have to be created in special fields - mathematics, music, and dictionary writing. We have the composition signs made more compact.

Chairman Rodgers: I think you made mention of all those already and we have enough material. Mr. Covici, do you wish to add anything?

Mr. Covici: Yes, I wish to add the following. We have to get around the six-dot barrier, and there are a number of ways to do this. There is a need for some improvement over the old system and a nine-dot system is the thing which should be researched very thoroughly. Then, if this proves sufficiently worthwhile it should be suggested to the braille authority, and so forth, as a new standard.

Chairman Rodgers: All right.

Dr. Foulke: First of all, Mr. Strom, I gather that in the case of a math symbology, we're not primarily concerned with space saving, are we?

Mr. Strom: No. In any system we are concerned with ease of reading.

Mr. Ingham: Compactness.

Mr. Strom: We're concerned with compactness insofar as it helps the blind person put more books on his shelf. We're concerned with compactness in that the finger has less space to traverse in reading material and, therefore, makes it possible to be done in less time. John has mentioned here that multiple-cell mathematical representations are extremely hard to read.

Dr. Foulke: This is what I'm trying to get at. The problem that arose, then, is that with the braille code it was either impossible, or else unacceptably clumsy, to express the mathematical language that you had to express in the braille code.

Mr. Covici: That's right.

Mr. Strom: That's right.

Dr. Foulke: Then this is a case that you are attempting to make, isn't it?

Mr. Strom: In the case of mathematics, yes.

Dr. Foulke: That in order to accomplish the job, in order to communicate what you needed to communicate, there had to be a larger supply of symbols available.

Mr. Strom: That's right.

Mr. Covici: Yes.

Dr. Foulke: I wonder if Dr. Nemeth would comment upon that?

Dr. Nemeth: Yes, I would love to. I would like nothing better. First I would like to make a few *a priori* judgements as to the space saving. I think that if the nine-dot system were used, even using the contractions that Mr. Strom has now, the amount of space occupied would be from 15 to 20 per cent greater than the amount now required for literary braille.

Mr. Strom: Okay. Next a priori judgment!

Dr. Nemeth: Let me say why. There are 189 contractions in braille. Short form words consitute, I believe, 76.

Chairman Rodgers: Yes.

Dr. Nemeth: Carl, do you know offhand how many initial-letter and final-letter contractions there are?

Chairman Rodgers: No, not offhand.*

Mr. Ingham: 180 something.

Dr. Nemeth: No, no. Initial-letter contractions and final-letter contractions only, something in the order of 86 out of 189, "ity", "ation", and so on. The alphabetic contractions would result in no space saving. The one-cell part-word signs would result in no space saving. The only characters which would save space would be the initial-letter contractions and the final-letter contractions.

Mr. Strom: Plus any new---

Dr. Nemeth: That's right. Plus any new contractions which you care to add. I would judge that if you were to use no new contractions but just Grade II braille, and use the nine-dot cell to represent it, you would get something in the order of magnitude of about 25 per cent expansion. But because you added additional contractions in your code, the expansion will not be quite as great. It will be, however, about 15 to 20 per cent expansion in number of linear feet that your hand has to travel to get the information. That's what I mean.

Mr. Strom: Wait a minute. There was a 25 per cent expansion in the size of the "Nine-Dot Braille" cell that resulted from the mere extra dots.

Dr. Nemeth: That's right.

Mr. Strom: However, you're not counting even the fact that these 39 initial and final-letter contractions save one cell in addition to the composition.

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*In six-dot Grade II braille, initial and final-letter contractions are two-celled contractions. There are 33 intial-letter contractions and 14 final-letter contractions, a total of 47 two-celled contractions. There are 67 one-celled contractions and 76 short-form words, for a total of 189 contractions and short-form words (abbreviated words).

Dr. Nemeth: That's right. Let me say what I wanted to say before but which Carl didn't let me say. I was saying that on a nine-dot line you would have 32 cells approximately, maybe 33, which means you would have to have an average of seven or eight initial-letter or final-letter contractions per line just to break even. For example, take the first two lines of, say, the Preamble of the Constitution: "We, the people of the United States, in order to form a more perfect Union, establish justice," -- there isn't a single initial or final-letter contraction in that statement.

Mr. Strom: You know this?

Dr. Nemeth: I was looking through it as I was reciting it. "When in the course of human events, it becomes necessary for one people"-- there's the "one" to dissolve the political bonds which have connected them with another "-- there's still just the one initial-letter contraction, "and to assume among the powers of the earth, the separate and equal station". There's the "ation". There's the second one, and so on.* You see, you have to have eight per line to bring up--

Mr. Ingham: May I interrupt?

Dr. Nemeth: Let me finish my comment. I will talk long but then I will keep quiet longer! In other words, as I say, unless you get the eight initial or final-letter contractions per line, you can't hope even to break even.

Mr. Strom: Or new contractions.

Dr. Nemeth: All right, or new contractions.

Let me tell you my experience with Grade Three. Grade Three braille, just a brief summary for those of you who do not know, is divided into seven lines of braille. The seventh line consists of the modifiers, but the other six lines of braille are the non-modifiers. In Grade Three braille you do this: You put a 4, a 4-5, a 4-5-6, a 5 and a 4-6; in other words, five possible modifiers in front of each of the six lines of braille. That constitutes 56 characters in the six lines of braille, and when you multiply this by four, this gets you 224 initial letter contractions in Grade Three.

In addition to this, there are prefixes and suffixes.

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*The word "among" in braille contains the final-letter contractions for "ong".

There are contractions for "pre" and "pro", and "ate" and "ite", and "bly", and things of this kind, which are part-word contractions, which are also of this variety, modifier plus principle character.

I regard myself as a fairly competent braille reader and I read material in Grade Three. Grade Three is very highly contracted. It has about five or six hundred contractions overall, and you have to read that system mostly by deduction. What you are essentially doing is a very rapid mental table look-up, because many of the contractions do not follow normal mnemonic devices. Only 26 of the characters are letters. The point is, contractions like the "and" contraction, a certain position turns it into "anyone", "anybody", "anything". And the "of" contractions of "off", "office", "official" and so on. In other words, what you are doing when you are reading it is engaging in a continuous mental table look-up operation.

I don't know what the optimum number of symbols is for ease of learning, and this is a matter for research, of course. But there comes a time when if you condense the information too much -- to the point where you have to do this consecutive table look-up -- you're going to lose efficiency of recognition. You are going to gain a lot of space. You would think that since Grade Three is so highly contracted it would affect the space saving of a proportionate amount over Grade Two braille, but there is a very rapid low of diminishing returns involved. For example, in Grade Two braille, I think empirical evidence leads to the fact that the Grade Two braille effects a saving of about 20 per cent in space over what you would have if you used simple Grade One braille.

Mr. Ingham: 26.

Dr. Nemeth: 26 per cent

Mr. Ingham: Yes.

Dr. Nemeth: In other words, you didn't save that much. Now, if you go to Grade Three by doubling the number of contractions, you add only a few more percentage points in the saving ratio. In other words, to effect an additional 20 per cent of saving you would have to add maybe 2,000 more contractions.

Mr. Ingham: There is a good counter argument, but I'll save it until you're finished.

Dr. Nemeth: Let me finish this. Anyway, this is the thing. There's a lot of diminishing returns involved here, so that what you gained in space in Grade Three, you lose in speed of reading.

Now, there's also this: There's no question that the modern six-dot braille symbol is highly inefficient, and there is a need for another system. But I think that a revolution in the braille system that would effect a saving, over Grade Two of only 10 per cent is not worth the revolution. If you could do it by an order of magnitude of something like making the distance one half of what it is, that's worthwhile saving. But just to get a 10 per cent discount at the cost of such a revolution, I don't know.

There's another thing. Let me come to mathematics now. In mathematics the problem of putting tables into braille would be almost hopeless in a nine-dot system, for the following reason. It's almost hopeless already when you have 40 cells available, but when you have only 32 columns wide to accommodate some tables, you're in all kinds of difficulty. You see, you can't put two digits in a single cell, can you, Bob?

Mr. Strom: No.

Dr. Nemeth: Then you are constricting yourself to a 32-column or 33-column page, whereas 40 or 42 cells is hardly adequate now. Second of all, I suspect -- and I'm making another guess -- in mathematics at the level of algebra, in other words --

Mr. Strom: A saving of space over what?

Dr. Nemeth: Line for line. In other words, every time you write a formula in six-dot braille and write on in "Nine-Dot Braille", if you can get one on a line, you can get the other one on the line most of the time. In other words, in mathematics there won't be an amplification. If you are dealing with a special field of mathematics like vector analysis, where letters are modified by being written in bold-faced type, then for that kind of mathematics there will be a saving in the nine-dot system over the six-dot system by a small percentage. There I would judge it might save 5 or 10 per cent, but nothing like 20 per cent or 25 per cent at the numbers that I heard mentioned. I would imagine this is the case.

Mr. Covici: We measured with the mathematics--

Dr. Nemeth: What do you mean, you measured? How can you measure it?

Mr. Covici: With the mathematics that you have there for the 1962 Conference plus the space taken up by the Nemeth Code, I mean as far as linear feet of braille was concerned--

Dr. Nemeth: Wait a while. You see, you are being unfair. You must not measure a code book. You've got to take a mathematics--

Mr. Ingham: He did it. He took text material and he found it to be a 40 per cent saving on your code, that is "Principia".

Dr. Nemeth: I don't know what kind of symbols are in "Principia".

Mr. Ingham: It doesn't matter. He did it.

Dr. Nemeth: All right, it doesn't matter. I would say that in certain branches of mathematics there would be a saving. In no case would the nine-dot system take more space than the six-dot system in mathematics as it will in English braille except for table writing. I don't know what you can do about that. But, as I say, the nine-dot system will be a saving over the six-dot system in mathematics.

I don't know how you solve this--the problem in mathematics is not just the proliferation of numbers of symbols. In mathematics, you have essentially a two-dimensional notation. Fractions are written above a line and below a line. Superscripts and subscripts are written obliquely above and obliquely below. Modifiers are written directly above and directly below the symbols with which they are concerned. In braille you have, for all practical purposes, only a one-dimensional method of representation, and the problem stems more from the need to do one-dimensional representation than it does from the lack of number of characters. Ken will recognize what I am saying.

Mr. Ingham: I have lots of comments on your arguments when you've finished. I'll bring them up then.

Dr. Nemeth: I know you have. Now, for example, my fraction indicators are necessary only because I'm going from two dimensions to one dimension. In superscripts and subscripts, indicators are necessary only because I have to go from two dimensions to one dimension. My alphabet modifiers and my type modifiers, on the other hand, are necessary because of symbol proliferation.

Mr. Ingham: The problem is, Abe, you bring up so many points so that when I get back to reply, I can't remember them all!

Dr. Nemeth: Anyway, the point that I want to make is that there will be a variation in saving mathematics by nine dots over six dots, depending on the system used, and the saving will be only in the mathematical portion of the material, which far outweighs the formulae portion.

Dr. Foulke: Dr. Nemeth, let me ask you a very specific question.

Dr. Nemeth: I have, for all intents and purposes, finished.

Dr. Foulke: As far as space saving is concerned, it seems to me that again this doesn't have to be our primary requirement. If a nine-dot mathematics code will do a job for us that the six-dot code will not do, we can afford the paper.

Dr. Nemeth: Yes.

Dr. Foulke: But what I would like you to answer specifically then is, will it do a job that the Nemeth Code will not do or will it do it significantly better?

Dr. Nemeth: I don't think it will do a job that the Nemeth Code will not do, because it will also be based on a system of modifiers just like the Nemeth Code now is.

Mr. Ingham: The real catch to his question is the second part: Will it do it? Will it do it better?

Dr. Nemeth: That I don't know, whether it will do it better or not.

Dr. Foulke: This, it seems to me, is what we need to know.

Dr. Nemeth: Better from what point of view?

Mr. Covici: The reader's. I'm not concerned with the transcribers.

Mr. Ingham: Can we hold the answer to the second part of the question until I have my points made?

Dr. Nemeth: Wait a while. Dr. Foulke has asked me a question.

Mr. Ingham: I know, but I'm just saying that it would be better if we could hold it.

Dr. Nemeth: Go ahead. I would like to answer it later.

Mr. Ingham: Yes. I want you to remember it because this is one of my points also. The first comment is, all of your arguments, Abe, are based upon the fact that the code in its best form is based upon the six-dot system.

Dr. Nemeth: Which code?

Mr. Ingham: The nine-dot codes. This need not be the case. Just take, for example, your question of algebra and literary braille, things like that, where you said the savings would be equal or less than the six-dot braille savings over, say, Grade One, okay?

Dr. Nemeth: I don't know. I don't follow you; I'm sorry.

Mr. Ingham: You said that in the literary material you are going to lose with the nine-dot system.

Dr. Nemeth: Yes.

Mr. Ingham: In elementary material in mathematics you're going to maybe break even.

Dr. Nemeth: Yes, you're going to break even.

Mr. Ingham: Now, I disagree with you on those points for the simple reason that there are situations which could be devised, with a proper choice of symbols, where we would save fantastically. Take, for example, your chart problem. Suppose your cells, as they often are, included numbers with signs in front of them, plus and minus, letters which were capitalized.

Dr. Nemeth: No.

Mr. Ingham: Just a minute. Let me finish.

Dr. Nemeth: You're not realistic at all.

Mr. Ingham: I am so. You can have tables with lots of numbers and signs in front of the tables. Secondly, you can have tables, particularly in programing where your letters are all capitals. All IBM manuals are typed with capital letters. When the transcriber gets it, she's going to type capital. Now, Mr. Strom can devise a system where his nine-dot cells include those symbols which in your system take up a total of four columns.

Dr. Nemeth: I agree with you for your capital signs, but I don't agree with you for your plus and minus. There's no way of incorporating a sign for a number with the number in the same cell.

Mr. Ingham: I don't agree with that. I don't see why Mr. Strom can't use a group of four dots, say, in the nine-dot cell and use an extra dot to indicate a minus sign in the absence of a dot plus a sign, for example.

Chairman Rodgers: I'm a little confused here and I want a little clarification for myself. Mr. Strom, have you provided in your revised code of mathematics for the incorporation of signs of operation with the number itself?

Mr. Strom: No, not in the current system.

Chairman Rodgers: Do you think it would be feasible to combine a sign of operation with the number to which it refers?*

Mr. Strom: It could be, if I were convinced that it would be advantageous to do so. I don't know whether it is.

Chairman Rodgers: You don't know?

Mr. Ingham: This is the question, but it could be done.

Dr. Nemeth: Ken, do you realize that there are just now the two possibilities? You have to provide for the possibility of an unsigned number, a number with a plus sign, a number with a minus sign, etc.

Mr. Ingham: Go ahead. You still have nine dots to do that.

Dr. Nemeth: I know, but I have these numbers without--

Mr. Ingham: Let me just make one point.

Dr. Nemeth: Let me answer to this one point. Unsigned numbers, numbers with a plus sign, numbers with a minus sign, numbers which are preceded by plus or minus, and numbers minus or plus. All of these possibilities exist.

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*In Literary Braille there are special symbols that represent accented letters in foreign languages, thus combining letter and accent into one braille cell. See "English Braille American Edition 1959, Revised 1962" - inkprint pages 22-24

Mr. Covici: Would the eight cells in the table make a difference? There are often a lot of tables where they put lines between the numbers, and they put crazy lines down the page, and they do all kinds of tricks.

Dr. Nemeth: Let me ask you this: How would you do a simple table of logarithms: -- no signs, just digit after digit? Ten columns, five digits per entry with a column of "n" on the left, you know, and across the top? What's involved?

Mr. Ingham: So you use two pages. The thing is this: I agree with Dr. Foulke that in essence you may lose in certain situations such as you're pointing out in a table of just pure numbers, unsigned. Okay, fine. The question is, how would it do with the rest of the code? I think the point that Mr. Strom made with me over the phone is that he looked up in the American Physical Society's booklet, or whatever it was, a list of some 500-odd standard symbols which they recognized that all print books use, for example, in articles in their journals. With his system he could account for every one of them with a single cell.

Mr. Covici: It may not always be possible.

Mr. Ingham: This may not be always true, but the tendency is such that you can do this.

Another thing as far as your code goes. There are situations in your exponent problem which is really one of the most important points in transcribing math, or other sciences, where these level indicators can be either included in the same cell or can be given a separate cell of their own, while you use two or three cells in between modifiers. I think all of this discussion is a little bit irrelevant due to the fact that you will have to admit that a code has to be devised, which can bring these things out much better than what we have before us here. We really can't say categorically how much it will save and how much it won't since we don't really know (1) how many of the signs can be read without ambiguity, and (2) whether Mr. Strom can devise a code with, say, the logic your code has which, will be superior to it. I don't think we can give an answer. This is useless stuff; that you will end up, say, on an equal basis with alegbra and you will lose with literary braille. I think that there are possibilities where you can save quite a bit.

Mr. Covici: And we did save 40 per cent in the one case.

Dr. Nemeth: John, could I ask you a question. What kind of symbols were there?

Mr. Covici: You have the thing there to look at.

Mr. Ingham: There was everything in it; all sorts of weird assumptions, and so forth.

Dr. Nemeth: I don't see it.

Chairman Rodgers: Go toward the part of mathematics.

Mr. Strom: I wish I had the key for the braille that was used two years ago, which is completely different.

Chairman Rodgers: Yes, it is, and this is why I didn't feel it was worth distributing.

Mr. Strom: This is the six-dot braille?

Dr. Nemeth: The six-dot braille. The small sheets are the six-dot braille. Where am I to look?

Mr. Strom: I better point it out for you.

Mr. Ingham: I just have one more point to make in order to finish my statement. The point is that 40 per cent was saved over your code with this kind of material.

Mr. Covici: In linear feet of braille. Thirty-six or thirty-seven per cent; I don't remember.

Mr. Strom: I can't recall the figure.

Mr. Covici: It was around there.

Mr. Strom: I don't want to commit myself.

Chairman Rodgers: If I may interject here, we could go back and forth with the 40 per cent or no 40 per cent for the rest of the afternoon. We don't have the tabulations; we don't have the necessary material step by step, and a conference like this would not be competent to judge whether a statement of that kind is correct at its face value and we would have to take it at its face value.

Mr. Ingham: This is part of my statement. There's only one thing I would like to say. As far as Abe said, he brought up the case of Grade Three braille, and the saving it made, and so forth and so on,

and I would suggest that much of the problem, as he pointed out with Grade Three braille, was that it involved the attempt on the blind reader's part to coalesce two or three cells or say, two cells, and I think you would win over a system using 500 or more contractions, as with Grade Three, if they were grouped in a one-cell configuration and you looked at it as a complete cell, not as you insist on doing, Abe, as a cell with a modifier.

Dr. Nemeth: Then you're doing this table look-up that I'm talking about.

Mr. Ingham: No, you're not doing any table look-up at all. You're designing a code which, as you learn it, will be just like the simple Grade One braille is now.

Dr. Nemeth: Only 512 instead of 26 letters.

Mr. Ingham: So what?

Mr. Covici: When you read it--

Mr. Ingham: There's nothing mnemonic in Grade Two braille as far as I can see.

Dr. Nemeth: There are a lot of things which are not mnemonic. I don't know where the breakdown begins.

Mr. Ingham: The point is there's no reason why dots 1-2-4 for example, should be "f" in mnemonics. There's no good reason for it. Once you have assigned a characteristic group of symbols to a word or a part word, there's your mnemonics. It's when you start going into more bits of information like two cells or more that you continue to have to look up.

Dr. Nemeth: What is mnemonic is that "b" stands for "but", and not for "cow", that "f" stands for "from" and not some other letter. What you say is correct. These contractions in the code that Bob has are fairly mnemonic, whereas Grade Three wasn't, but this can be the case only if you stick to the modifier plus principal character.

Chairman Rodgers: I think we will have to terminate this portion of the discussion. The main point which should have been established by now, which originated in Dr. Foulke's question was, is there a need for a "Nine-Dot Braille" system? Correct, Dr. Foulke?

Dr. Foulke: Yes.

Chairman Rodgers: I think enough has been said to enable the participants as a whole to judge for themselves and form a consensus as to whether there is or there isn't such a need.

Dr. Nemeth spoke of the law of diminishing returns with respect to space-saving efforts. What I was concerned about, that Dr. Nemeth didn't mention, and again this is just for the record on behalf of the average reader, is that the more contractions you put into a system the more you increase the need for braille rules. Braille rules up to a point can be tolerated by the average person so long as they don't become too numerous. Let's suppose that we have a contraction for "ide" which does not exist in Grade Two braille. Does it or doesn't it?

Dr. Nemeth: No, not in Grade Two.

Chairman Rodgers: Okay, it does not. In Grade Three it does.

Dr. Nemeth: In Grade Three there is a "de" and you can leave out the "i".

Chairman Rodgers: Suppose there's a clearly defined contraction, the "ide" contraction for "chloride", "confide". That's fine, but when you come to a word like "confidence"---

Dr. Nemeth: "Mideast"!

Chairman Rodgers: "Mideast", I wonder what's going to happen to what Mr. Strom has described as the morphology of English words?

Dr. Nolan: It seems to me again we are way ahead of ourselves. We're talking about codes and the degree to which they will save space. I think the purpose of us being here is not to decide these issues and not to decide whether or not we will adopt "Nine-Dot Braille". but to decide how it might be studied. And all these things are a little premature, I believe. They are taking us far afield from our goal. They are pertinent problems but they are problems that are going to be an integral part of the study. The codes that we originate are certainly going to result from consideration of these problems that have arisen here. But this is for the future. We don't have the codes jelled now. In fact, there can be several codes. So wouldn't it be more to our purpose to get back to it?

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QUESTIONS ON BRAILLE CODE DESIGN; PHILOSOPHY OF PRESENTATION OF INFORMATION TO THE BRAILLE READER.

Dr. Nemeth: First of all, let me put in a plug for modifiers on the left as being consistent with everything we know about information theory. Those of you who know my math code know that one of its salient features is to give the reader information in advance of what's going on instead of afterward. So we have the fraction indicators to tell you that a fraction is about to happen, and we have a modifying indicator to tell you what the precise nature of the modification might be until later. So we always have to have the information first.

In fact, even in literary braille the people who devised the Spanish language have an advantage over us. They put the question mark in front of the sentence to let you know that it's going to be a question; this is a superior way of conveying information. If you put modifiers on the end, then you have no readiness for the modification at all and you are likely to read it in its bald form before you realize that it should have been modified. That's the first thing.

Now---

Chairman Rodgers: Before we go into the second thing, may I interrupt you there for a second. You do have modifying dots at the right to close up a situation.

Dr. Nemeth: To show the termination. They are not modifiers. This is to put a limit on it. In other words, it tells you when a modification is ended.

Chairman Rodgers: Right.

Dr. Nemeth: But this is just so that you could now sort of clear your readiness for the next thing.

Chairman Rodgers: Good enough.

Dr. Nemeth: But the important thing is to know when modification begins. This is salient. This is paramount. It is important also to know when it ends, but more important to know when it begins..... In addition, Bob was making a comment about 8-9 followed by a "p". I suspect that the psychological confusion-------

Chairman Rodgers: 7-8?

Dr. Nemeth: Yes, 7-8. I suspect that the confusion by which it was read as "er" followed by a trailing dot 4 was more the result of lack of familiarity with the system than anything else, because if one is used to a pattern of modifiers plus 4-5, modifier plus 4-5, modifier plus 4-5, one will have a mental set to read the 4-5 by itself and not to initially try to associate the other three dots with that.

Mr. Ingham: You see, this is one of the reasons I brought up the question of the last meeting, and the impression is again in those notes, I don't think that was a question that came up in the last meeting at all. In other words, we found that it was readable; there were no questions as to whether signs were confused with something else. I think this is an intellectual question that has been raised rather than a natural practical situation which arose at the last meeting.

Mr. Covici: When the dots are on the right in some cases, it may not be a question of a mental set to read modifier plus body. The person may still read that more like a "p". Also I think that in questions of telling you what's going to happen, whether it's on the left or on the right, whether the modifier should come first to tell you what's happening, I'm not sure whether the time lag is really of too much significance; this would have to be researched. I could see that in a fraction, you would want to know when it actually begins. That's a whole level space, but whether you have it on the left or on the right in the cell, it is not a great distance in space. There's not a very great difference in time. I've seen material from the last conference. You read a sub-2, say. You read "a" and you read the sub-2 or most times sub-one.

Dr. Nemeth: That's a right modifier.

Mr. Covici: Yes, that's right, but the information doesn't come too late.

Dr. Nemeth: No.

Mr. Ingham: I think Abe's point was well taken. He was pointing out that, for example, in the case of literary braille, dot 5 "m" tells you that the "m" is modified rather than "m" followed by a dot 5. You don't really read that as a full thing or at least you haven't where it included two cells for the combination. It may be different with the one-cell case; I don't know.

Mr. Covici: Another point about Dr. Nemeth's system; in general systems of mathematics and of literary braille, there can be at least two different orientations, (a) the writer, as the person doing it; and (b) the reader. Dr. Nemeth's code is oriented definitely towards ease of writing by the transcriber. It's very easy to write and somewhat difficult to read.

One symbol may be strung out over a large area. This impairs legibility of braille in mathematics notation. The "Nine-Dot Braille" notation would be more compact. Dr. Nemeth's system is perfectly computerized. In other words, it would take only a machine-type operation. But on the other hand, it makes it somewhat harder to read, and I think as far as time is concerned, which is what we really want to save in the reading, the point of saving space is to decrease the time; I think it has to be definitely oriented toward the reader and I think it must be stressed. I don't think it can be overstated.

Mr. Strom: I think it is very important to mention that if you're going to work on designing a system that is in the interests of the reader rather than the transcriber (which has to be always kept in mind first) we should hesitate when we say we're developing a new code for mathematics to mention whether it's absolutely necessary to have 10 to 15 indicators. Basically, as I understand it, the present mathematics code gives a good deal of information on how the imprint shape of the characters may have looked, which may or may not be important when you consider it in the light of merely being able to read the material more easily. It may be that cueing other than that based upon the shape of the imprint character is better for developing mathematical symbols.

Dr. Nemeth: May I make a comment about that. There is so much science around now in mathematics that no transcriber can be expected to have a comprehension of everything he's asked to transcribe. Consequently, unless the transcriber can transcribe what he sees, the likelihood is you get no transcription whatever. In other words, the ideal thing would be if someone could convey to you the meaning of the thing instead of the contour of the thing. But it's just not possible. There are no transcribers that you can get who will understand algebra, atomic physics, statistics, and what have you. Therefore, the only safe way to do is to convey notations instead of significance, and let the blind person read the significance out of the notation. I'm firmly convinced of this.

Mr. Ingham: We're not arguing the Nemeth Code.

Dr. Nemeth: No. We're arguing the philosophy of presentation. For example, let me go to the English braille and I'll tell you some of the things that arise in my mind where this factor has been neglected. One of the rules of the English braille system says that you should put abbreviations in front of the number sign instead of after the number sign. If you want to write "50 feet" you write "ft #50". This conveys the meaning perfectly well, but you know that a blind person grows up with a misconception of what that imprint it. He's likely to do the very same thing on a typewriter and get a grade for using bad grammar from his teacher who doesn't know what the rules of braille are. In other words, writing "ft #50" is the kind of thing that I call a braillism. It conveys the meaning perfectly well but it does so at the expense of the blind person's full comprehension of what the standard situation is in inkprint.

Another thing: A rule of braille says that a transcriber should translate Roman numerals into Arabic numerals even in references and so on. So if you want to write II Samuel (Roman numerals), you don't write the Roman numeral II but you write the Arabic 2. It has come to the point where I have to have a file card available for my reference as to what the proper way is for writing a reference, because if I were to use the rule of English braille, I would be accused of being an illiterate professor. No one writes references like this in print. And I very often have to use the typewriter. You see, the blind person's life doesn't begin and end with braille. The information has got to come to him from something which has previously been written and often he has to convey information in written form. So he has to be aware of both of these, as to what normal print practice is if he is not to labor under a misconception as to what is right and what is wrong. The case in point is that I have to keep a reference card as to what the right way is to put a reference in a footnote because the way you do it in braille is just wrong. You just don't do it that way. This is the point.

Mr. Covici: Fine. This is a good point, but is it so bad? I mean can a person remember that it's done differently in print?

Dr. Nemeth: He never gets a chance to find out.

(Dr. Nemeth and Dr. Foulke then proposed some ways and means of determining the intrinsic degree of ambiguity of certain six and nine-dot braille characters relative to code design which were discussed as follows.)

Dr. Nemeth: I haven't done this, but this is a perfectly mathematically feasible thing to do. Let's go to the six-dot braille cell and let's imagine that we have before us a sheet of paper of infinite density so that it is high and wide and we put braille characters on it. Some of them are truly unambiguous; for example, the "y" or the "sh" sign or the full cell, but there are certain other cells which have certain degrees of ambiguity. For example, the letter "a", if it were present or by itself, you might say has six degrees of ambiguity because if it were present all by itself you could not tell which of the six dots it was. The letter "b", you might say has four degrees of ambiguity because it could be 1-2, it could be 2-3, it could be 4-5, or it could be 5-6. Similarly, you can assign an uncertain factor to each one of the 64 braille characters. The space is a perfectly certain character, because if there is nothing on the paper at all, then evidently a space has been printed. The only question is where!

You can do this and you can sort of weight the amount of uncertainty that there is in standard braille by multiplying each one of the characters by the uncertainty factor which you have associated with it, and then you can divide the result by 64 to see how much uncertainty there is.

You can do a similar process with a "Nine-Dot Braille" cell. You see, when you read braille the uncertainty comes out because of contiguity. Things are next to other braille characters or out of context. For example, a dropped "h" can be either a question mark or an opening quotation mark, depending upon whether it is at the end or the beginning of a word with which it is associated.

Mr. Covici: That's a six-dot.

Dr. Nemeth: That's right. The point it--

Mr. Strom: Only one side has one meaning.

Mr. Ingham: Dr. Foulke's suggestion is that we are talking about other codes and all of these points should be kept in mind in designing one.

Dr. Nemeth: That's right. But what I'm saying is, this is a way of assessing mathematically the intrinsic uncertainty of ordinary braille versus the intrinsic uncertainty of "Nine-Dot Braille". Does everybody understand what I'm talking about?

Mr. Strom: I understand.

Mr. Covici: It may be overweighed, overridden by a lot of other things, you know.

Dr. Nemeth: This may be true, but I'm talking about intrinsic uncertainty.

Dr. Foulke: This can be determined.

Chairman Rodgers: Hold it. We're getting into cross conversation here.

Mr. Roberts: Both Mr. Strom and Dr. Foulke wanted to react.

Chairman Rodgers: I think Dr. Foulke spoke ahead of Mr. Strom.

Dr. Foulke: I think this could quite easily be done. If I were going to conduct research of this sort, for instance, I think one of the things that I would quite likely do would be to give people sequences of symbols to read and to cast their results in a confusion matrix to determine such things as stimulus ambiguity. The procedures for doing this are quite well known.

Dr. Nemeth: Yes.

Dr. Foulke: I think I would go ahead and make the standard information analysis.

Chairman Rodgers: I think Mr. Strom spoke next, or tried to.

Mr. Strom: Yes. One thing that has to be mentioned. I understand what Dr. Nemeth had to say, this numerical measure of intrinsic potential for confusion is a function of number of dots alone. Is that it?

Dr. Nemeth: No. For example, suppose you decide to have nine dots around the circumference of a circle instead of ranged in a square. Then the nine dots in the circle would be the same as the number of nine dots in the square. So it wouldn't be a function of the number alone.

Mr. Strom: I'm sorry. That's right. But it is a function that's independent of the assignment of symbolic meanings?

Dr. Nemeth: That's right. I have no intention here of finding out what meanings you assign to the letters. It's just a measure of what I call the intrinsic ambiguity of the system - that's all.

Mr. Strom: Right. Although a more interesting measure, I would think, would be to take six-dot braille characters and observe with respect to each six-dot braille shape or configuration how many different meanings are assigned in that system to that particular configuration, such as--

Dr. Nemeth: Take the letter "n". What do you mean now?

Mr. Strom: Take the letter "n". It has two meanings. It means the letter "n" and the whole word "not".

Dr. Nemeth: "not" and that's all.

Mr. Strom: Okay.

Chairman Rodgers: Take the dropped "d". I think it has four meanings.

Dr. Nemeth: I know it has several. I think this is true.

Mr. Strom: Then what you do is you weigh these up and you divide by 64.

Dr. Nemeth: Not by 64.

Mr. Strom: I'm sorry. By the total number of meanings that there are.

Dr. Nemeth: No, no. You see when you do this you're measuring what we call contextual uncertainty and then you have to make a statistical analysis of the frequency with which, say, the period occurs, the frequency with which the "dis" occurs, the frequency with which "dd" occurs in the English language you know, from large samples, and you have to weight this. With this kind of a frequency distribution it would not be fair to say that, for example, the accent mark occurs as frequently as the letter "e" and use it as weighting the things equally, you see.

Mr. Strom: Yes.

Dr. Nemeth: You have to make a distribution of the frequency of occurrence.

Mr. Strom: You are right, and I think this distribution should be made and the results of this study would be a little more significant and would be a measure of the so-called intrinsic ambiguity in "Nine-Dot Braille", which is effectively presupposing that because the nine-dot cell is bigger, it's possible for the letter "g", for example, to have one, two, three, four different possible positions. This will, therefore, tend to increase the ambiguity coefficient.

Dr. Nemeth: On the other hand, there are so many characters which are fully wide and fully long, more so than in the six-dot braille, that the factor will have the effect of decreasing it.

(The discussion on braille-code design then centered on the possibility of exploiting the full potential of "Nine-Dot Braille", the development of experimental codes and the possibility of restricting the use of "Nine-Dot Braille" to special technical codes only).

Dr. Ashcroft: I don't know if this is relevant or not, but it seems to me that some of the kinds of statistical computations around which questions have been raised today could be attacked right away, such as the amount of space and the comparative space-saving features of Mr. Strom's system, and that could proceed right away, and then I think we could map a strategy, at least a tentative one, right here for attacking some of the experimental work for a tryout of some nine dot systems.

Chairman Rodgers: Of nine dot cell characters; is that it?

Dr. Ashcroft: Yes.

Mr. Strom: This would be contingent on developing a code.

Mr. Ingham: I don't know how you do that unless you're assuming this code.

Dr. Ashcroft: Let's assume this code for some tentative answers that we haven't had today.

Mr. Strom: Okay.

Mr. Ingham: Haven't you gotten that already, any of this? I mean your figure of 40 per cent on the math and things like that?

Mr. Strom: I have not made exact measurements. First of all, this code and the code of two years ago are different. Furthermore, I don't really consider either of them representative of the full potentialities of "Nine-Dot Braille". I think these codes both represent an extreme construction of the possibilities of "Nine-Dot Braille", namely that they have been harnessed to certain ideas which are part of the six-dot concept, namely, the concept that every contraction must be an initial or final-letter contraction and must contain a base cell and a modifier in a certain way.*

Also this code has been based upon a principle that anything in six-dot braille like punctuation marks, and so on, should not be modified unless we are sure that there is something wrong with it. So I don't think these two codes are representative, and although I would be perfectly willing to have various kinds of tests regarding spacing, and so on, set up with these, I would put in an element of caution and say that this particular code would not be truly representative of what "Nine-Dot Braille" really could be if we gave a little bit freer rein in designing a code.

Chairman Rodgers: All right.

Mr. Liechty: A question that's been bothering me, Carl, that I would like an answer to: I don't know whether it's the right place or not to ask, but I'm going to do so anyhow.

What bothers me is that it is naive, possible to ask: Could not a technical code be devised on the basis of a nine-dot cell, that would fit in mechanically as a unit with the standard six-dot cell, so that you could write a mathematics text using the narrative, the words in literary braille, making use of the standard literary braille and simply insert in the line, when the occasion occurs, the technical sign based on the nine-dot cell? That would permit interpointing of dots on both sides of the paper because your spacing would be standard and uniform.

Mr. Ingham: Could I ask for clarification. What do you mean? Do you mean that, for example, within an equation where you had, for example, "x" equals "y" square, that "x" would be standard six-dot?

Mr. Liechty: Yes.

Mr. Ingham: The equals and others would be nine-dot?

"This is an incorrect description of six-dot Grade Two braille design, since there are sixty-seven one-celled contractions, consisting of base cell alone, while there are forty-seven two-celled contractions consisting of base sign preceded by modifiers.

Mr. Liechty: Right. That's what I would think, but I don't know.

Mr. Strom: Let's consider something a little more realistic; namely, where a line of a formula is all in mathematical braille, considering that there is an "x" for mathematical braille also.

Mr. Ingham: The reason I brought that up, then, is that if you're going to go with a nine-dot system for your equations and formulae, and we're not going to say that the existing English code is the correct code for "Nine-Dot Braille", then I don't know how you could represent your letters and things like that, and numbers, in the two different systems and expect people to be able to read them or want to read them.

Mr. Liechty: This is my question. I don't know with codes. So I don't know how to answer. Carl, may I make one more comment and I think this is the most important comment that I have to make all day: I'm not so sanguine to think that within our lifetime, or in the next two or three generations, a basic change from the six-dot to a nine-dot braille cell is going to be achieved, if it is going to have to apply to literary braille.

Dr. Scott: Mr. Rodgers, I wonder if we could ask Mr. Liechty for clarification of that. Why isn't it likely to happen?

Mr. Liechty: In my opinion, and this is only an opinion, there are enough contractions for the average blind reader to learn and use now. Anymore will defeat any further reading in braille for the vast majority of people, and this is why I first asked the question whether or not we can make a distinction and use a new basic cell for only technical purposes. You will not get John Jones of Podunk, Iowa, to drop his six-dot cell and go to a nine-dot cell and learn a new system of braille.

Mr. Ingham: I think you are probably quite right in the case of John Jones, but if you ask me or anyone else in the scientific fields or music, I might say to you I would be willing to know two different codes, six-dot and nine-dot.

Mr. Liechty: I'm sure you're right. My interest in "Nine-Dot Braille" has been on the basis that this will serve a special people, an especially selected group of people. It will serve technical, scientific, mathematical purposes but not for literary braille, for novels. To read a novel in another system of braille will not be achieved.

Mr. Covici: Would it be worth it to you if it increased the speed, say, by a third? I'm just throwing out a figure of a third.

Mr. Ingham: I don't think it's a question of that John. I think it actually will happen, but he's right, it will take two or three generations for the average guy reading literary braille to move over, but so what?

Mr. Liechty: In that period of time you would have a duplication of systems and libraries, and confusion.

Mr. Ingham: No duplication of the scientific libraries.

Mr. Liechty: No, but in the literary world.

Mr. Ingham: Yes. This may be worth it in the long run. You may find that some such code turns out to be really worthwhile and to have a distinct advantage, so that it may take over the literary branch.

Mr. Liechty: I think here then there is a very proper place for research to find out whether one can determine what is the top limit of the number of contractions that will be assimilated by the reader, the blind reader.

Dr. Nolan: I think the value goes beyond that. Maybe nine dot isn't the answer, but by studying "Nine-Dot Braille" maybe we can learn more about tactual reading and devise some other system that may solve our problem.

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PARTICIPANTS' COMMENTS ON THE DUPLICATION OF "NINE-DOT BRAILLE"

Chairman Rodgers: Does anyone have any question relevant to the other proposed items of discussion?

Mr. Covici: I have one question in respect to small and large quantity duplication.

Chairman Rodgers: I think you are referring to the point of determining whether small and large quantity duplication would be feasible with respect to "Nine-Dot Braille". By small quantity duplication I meant such things as braille writers, braille slates, and so on. The reason I brought that up, (see Appendix A Working Paper), is that I think you will recall, Mr. Liechty, at the last conference, some people were concerned with that aspect.

Mr. Liechty: Yes.

Chairman Rodgers: Certainly, duplication of "Nine-Dot Braille" should be studied in terms of the big IBM computers. But we should also include the study of duplication by the conventional methods of stereotyping equipment, braille writers, and braille slates.

Mr. Liechty: That's an ordinary mechanical problem.

Mr. Covici: I think that research on duplication should be done along with research on code development.

Mr. Liechty: Still, Carl, you would have the mechanical adaptation to make of the embossing machine.

Mr. Covici: Yes, adaptation of duplication techniques and code development should proceed concurrently.

Chairman Rodgers: That's a mechanical and engineering problem and it certainly should be considered.

Mr. Strom: Mr. Ingham, would you know anything about the possibility of getting machinery produced so that we could get more of this material made? I mean I'm thinking of the problem that at the moment I have a two-line slate. I was wondering whether we could recommend that we look into the possibilities of getting a machine to do this?

Mr. Ingham: There is a possibility in this sense that if you could design a program which would produce the "Nine-Dot Braille" following your rules from a typist through, say, the IBM machines, it's very possible that the new MIT high speed brailler could be adapted. I'm not sure how the keying works, but it probably could be adapted to produce a heavy-weight paper sample which could then be thermoformed. The cost there simply would be the cost of the thermoform.

Mr. Strom: I would like to set up an arrangement whereby this could be done.

Dr. Nemeth: Do you want all the same material distributed or do you want lots of different kinds of material distributed? If you want fifty pages of the same material, it's not unreasonable to ask somebody to punch this out on a slate. Don't laugh. Volunteers do this all the time. They transcribe volumes at a time. If you want to do fifty pages of work, you can do it. I mean somebody could punch it out in fifteen hours of gross time. Then you could thermoform it and that could solve the whole problem.

Mr. Ingham: I know we're all mechanically oriented, but I think this is a simple solution.

Mr. Strom: Yes, but there would be errors. For example, I made 22 pages of material for this conference which never were thermoformed because of the reading difficulties that we encountered, but Mr. Rodgers and I looked over it, and there were many erasures that had to be made.

Mr. Ingham: You have to have an expert transcriber. These are available.

Dr. Benham: May I make a point, please. At Haverford I built a machine a few years ago that is like the Perkins braille transcriber, the big thing, except that it's solenoid operated. It's relatively crude. I made it for the purpose of making legends on diagrams and things of that sort. It writes on zinc plates. I think for maybe four or five hundred dollars an extra row of holes could be added to it to make it nine-dot. Then you could write on a metal plate with it.

Dr. Nemeth: What about the escapement on it between cell and cell? You would have to vary it, you know; you would have to make it bigger.

Dr. Benham: You can make a new rack for that. That's all it is, just a rack.

Dr. Nemeth: All right.

Chairman Rodgers: Excuse me. I think we have become too involved in the point of mechanical reproduction. I would like to ask Dr. Nolan-- I know no one can commit anybody to anything --but, Dr. Nolan, do you think the American Printing House for the Blind might be in a position to help with the reproduction of text materials?

Dr. Nolan: That would depend on several things: One, what we make them from. Are you talking about vacuum forming? We can vacuum form all the stuff you want. If you're talking about building machines to make "Nine-Dot Braille", this is a costly enterprise and there might be some questions attached to it.

Mr. Ingham: Can I offer another suggestion. There's another machine we have in the lab which is what we call a picture brailler which loads the heavy-weight braille sheets on a rotating drum and can emboss a 90" x 90" array of dots from recorder or from a computer or from what have you. I'm sure that, for this kind of density, we could adapt it with a simple program again to do a master for thermoforming of this type of material. After all, there are plenty of graduate students and senior thesis students who could do such a program and set up such a thing.

Mr. Strom: Given a description of the machine, I could write the program.

Mr. Ingham: Fine. I mean this is a simple solution.

Dr. Ashcroft: It seems that multilith-multigraph approach might be very easily a solution.

Mr. Covici: There's actually a machine into which you put a paper tape, and it will make something.

Mr. Strom: It will operate a tool. Anything that involves programming. I don't know that particular machine.

Mr. Ingham: I was thinking of the flexowriters and machines of that sort.

Mr. Strom: They have machines to control the operation of the tools from a program.

Mr. Ingham: Yes.

Mr. Strom: So that you could, for example, if you wanted to make a nine-dot slate with a certain specification of dot spacing, you could set these specifications up on a paper tape and the paper tape would control the operation of the drill. That could make a slate. Again, before I could work with this, I would have to do things like learning the machine language for that machine paper tape.

Mr. Ingham: There are minor things.

Mr. Covici: Yes. I just mentioned it.

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CONSENSUS OF THE PARTICIPANTS ON STRUCTURING AND ORGANIZING AN EFFECTIVE RESEARCH PROJECT ON SIX AND "NINE-DOT BRAILLE"; REMARKS CONCERNING FUNDING.

Co-ordinator's note: At various times during the Conference, the participants posed questions with respect to the role the Foundation might be prepared to play in carrying out the participants' recommendations for research on six and "Nine-Dot Braille".

In the interest of conciseness Mr. Roberts' replies have been consolidated as follows:

Mr. Roberts: Certainly the Foundation is very much interested in furthering any efforts that will result in improved systems of reading for blind people, and I think principally what I would like to see come out of this is your advice really as to how we can further this mutual objective.....If there is a role that we have to play and can play that would be useful, why, as Mr. Barnett said, we certainly would use our resources to the best of our ability to play that role, and it is hoped, effectively. If this is to be done alone by the Foundation, if it is to be done by others outside of the Foundation, if this is to be done collaboratively, we have no predetermination on this at this point. We are really looking for your advice and guidance.

I should now like to pose a question: What apparatus is there in this field for launching any kind of organized system of research that can be identified as a valid proposal here? I should add (and this is what I implied before in a more direct response to one question that was asked) we have no plans for carrying out research in this area at this point; we have none whatsoever. It may be that we will and it may be that we won't. I think we want your advice about this. Let us assume that we identify and agree on areas of research that are sound and valid. The question I think needs to be thrown out to the floor as to what the auspices of this should be; what the possible resources are to undertake this research. We don't know the answer to this now....If any proposals come out of the deliberations here that would seem to indicate a need for this organization--and it does not necessarily have to be the case--using its resources (dollars, equipment, staff) to carry out the proposals, we certainly would consider this very sympathetically.

If I just may make this one other comment. I think this has been implied in my remarks; maybe I ought to state it more directly. That is, that we have quite frankly no sense of paramount interest or concern or responsibility in this whole subject that we are talking about. I think it has been perhaps a long time since this organization, itself, has conducted research in this area, if it had at all in the past. I don't even know that.....At this point, I should add, we have no plan to ask any particular individual or group to undertake research. It hasn't as yet really been agreed to or identified in a formal sense.

Chairman Rodgers: Now, I think we are ready to attack the strategy; in other words, to determine what method of attack we're going to use to develop a well structured long-range research project. I think it was Dr. Ashcroft that used the word "strategy", did you not? And for that reason I would like to start the discussion by asking Dr. Ashcroft for his ideas on strategy.

Dr. Ashcroft: It seems to me that we need some kind of a place to start, whether it's with Mr. Strom's present version of nine-dot or some modification of it and to get samples of that out for reading, and to include at that time some of the options that come up to get these trial readers to feed back options that they see developing for, say, the assignment of meaning to symbols or introducing more system to the assignment of meanings. Then to test some of those options in research and feed the answers back into a revision of the original version and then we would be ready, it seems to me, for a fairly extensive trial, experimental trial of the system.

Mr. Strom: Who would operate this? I mean how would such a test procedure be organized?

Dr. Ashcroft: I think the possibility is limitless there. I think if you could just get information out about the problem and the idea, that you will have competent people respond to the challenge, and I think funds can be obtained to do it, however they would plan to do it.

Dr. Foulke: If we can tell them what to do, they will do it.

Dr. Nolan: I would not phrase it exactly that way!

Chairman Rodgers: All right. Dr. Nolan.

Dr. Nolan: I think with the thought I have given to it, what I might do would be to start out on this legibility thing. I'm so concerned over this. I think Mr. Ingham differs. Maybe some of the others of you do. Let me tell you why I'm concerned.

In order to get the sensation of touch, the surface of your skin has to be, for want of a better term, dented. There has to be a dent made in it. With our regular six-dot cell there's enough space on either side of the cell so that the skin can droop down, if you will pardon the use of another non-scientific term, and we can get this dent.

When we go to a nine-dot cell using the same inter-dot spacing with three dots in a row, the closeness of these is not going to allow for an indentation to be made by the center dot and this is going to be lost to many readers.

Dr. Benham: Is that any more true in a horizontal row than in a vertical row, which we now have?

Dr. Nolan: I don't know. It ought not to be, but you see what we're running into. We're not actually just talking about rows; we're going to have rather gross patterns, are we not? We could have nine dots or we could have eight dots in many figures or even seven dots. The point of this is until we're sure of the legibility of these things, to start researching codes may give us problems because our problem may not be with the code, it may be with the legibility of the configurations.

Dr. Ashcroft: We have tentative evidence of the legibility already.

Mr. Ingham: Yes I think so.

Dr. Nolan: What do you mean, tentative evidence?

Mr. Ingham: We can read it.

Dr. Nolan: The very reason that you're here is because you're at a higher level of achievement than many of the people who are going to be using this thing.

We need to determine legibility for the full range of ability found among braille readers.

Dr. Foulke: I don't think we have any kind of evidence of legibility that we would be willing to act on, do we?

Chairman Rodgers: I think it was Dr. Ashcroft, or was it Mr. Ingham, who mentioned that we have tentative evidence.

Dr. Ashcroft: I did.

Chairman Rodgers: I would like to hear it Dr. Ashcroft. Will you put it on the record.

Dr. Ashcroft: One of the earliest comments I heard at this conference was that even the crude material that you had last time, which had spacing problems in it and other problems, was read by people here.

Mr. Ingham: I think this is probably derived from my comments. I mean I'm no protagonist for "Nine-Dot Braille"; I'm willing to go either way. I still think we should do research.

Dr. Ashcroft: I think there are two approaches to the problem of legibility. One is a gross one where you just provide people some stuff and let them see if they can read it, or the analytic one that Dr. Nolan is suggesting, and I would certainly go to the gross one before the analytical one.

Dr. Foulke: I don't think I would. If I were going to start researching this problem, I would conduct, I think, an initial study to try to determine or learn something about the legibility of all of the characters that were possible in this system, and I think I would probably want to set up at least some kind of tentative criteria for symbol legibility, and on the basis of this then attempt to formulate some kind of code.

Dr. Ashcroft: Then you will have to do the legibility studies on symbols in isolation and you won't know the answers to whether it can be read or not.

Dr. Nolan: Wait a minute now. Let's just go a bit further. I think a check on legibility should certainly be made. This doesn't mean that everything has to stop while this is being done. It may be that the initial efforts on legibility will show that this is really an unnecessary problem. It may be that we will see that we really have legibility problems and if this is the case, then it's rather reckless at the moment to get involved in codes until we solve this problem.

Mr. Covici: What do you mean by legibility, counting how many dots there are or recognizing the difference?

Dr. Nolan: There might be a very elementary way. You might discriminate different patterns or you might just report the stimuli present. There are several approaches that you might use.

Chairman Rodgers: Just a moment. I wonder whether the two phases, the legibility phase and the stimulus phase, can be investigated concurrently.

Dr. Nolan: What I think I would do if I had this problem to solve, I would work on legibility. I would start exploratory work with the code Mr. Strom has devised. This would be a trial and error process--actually trying to accumulate sources of error in the code. While I was doing this also I would be refining the code on a logical basis and also working into these special areas where special codes need to be developed. Then at the same time, or a little later, I would just for the heck of it develop a whole new literary code and study this to see how we might alter the degree to which we can communicate in tactual form.

Dr. Ashcroft: By new literary code you mean six-dot or nine-dot?

Dr. Nolan: Nine-dot.

Dr. Ashcroft: How would you differentiate what we've been talking about from literary code?

Dr. Nolan: The present setup is to use the old literary code as the base and modify it, isn't it?

Mr. Ingham: That's right.

Chairman Rodgers: Yes.

Dr. Nolan: We know, on the basis of our experience with the present literary code, something about soft spots in it. For example, frequency of occurrence of letters, etc., are not reflected in the present code. I would develop a new literary code on the basis of what we know about information theory, what we know about the problems we have found in your present literary code, and so on. Remember, we're researching, we're studying, we're not saying that we're going to adopt any of these things, that any of them will ever come into practice. But where are we now? Here we've had this problem for years. We have "trialed-and-errored" it through. No one has ever extensively explored beyond the present system; what has occurred has been more a fight and a power struggle than an exploration. Here we have an opportunity to take off in several directions at the horizon. What's over it, we don't know. Let's look and see!

Dr. Benham: It seems to me that there are few enough people reading braille as it is, and the harder we make it to read the fewer there will be. I don't know what the percentage drop in reading was when it went from Grade One to One-and-a-half and then when it went from One-and-a-half to Two, but I'll bet it drops every time there's an increase in the complexity of it. So I think that Dr. Nolan's suggestion of finding out the legibility of the system, nine-dot system or any other system, is extremely important because, yes, we can read this.

I agree that at the first conference we had, I could read the "Nine-Dot Braille" that I was presented with and, in fact, I believe I even wrote a little of it on the slates. Sure, I could do it. But it was a contest; it was a game. I was vying with my fellow man trying to be as clever as he was and he was trying to be cleverer than I was, and as a result we were stimulated sufficiently to manage to struggle thought it. But I imagine I'm the poorest braille reader here today. Because I can read braille only when it's absolutely necessary that I read it, like for instance, the Working Paper that we were presented with. I read through those pages, but it was a struggle. I don't know why this is so; I wish I did. But I really get frustrated trying to read braille. I don't know why it is. It's obviously some psychological thing in my background some place, but that happens to me.

I can struggle through mathematics and physics and engineering and science of all kinds of that nature because it's a slow, tedious process reading it anyhow. So it doesn't bother me. But to pick up

braille and read it as a novel, I just wouldn't think of it. I couldn't. I can't even read the braille technical press (and I'm interested in what's in there), partly because there is so much redundancy in it. In your working paper, for instance, I nearly through the thing out the window when I got to the last couple of pages and you repeated and repeated and repeated in each line. Why you couldn't have said it at the top of the page and then given the salient features of what it was you were doing, but every paragraph is just like every other paragraph except there was one number difference in it. And I had to read through the whole thing just to find that different number, and I was afraid to skip it for fear you might have slipped something in on me.

Chairman Rodgers: You're now talking about the format of the braille; is that it?

Dr. Benham: No. I'm just talking about the fact that it's hard for me to read; it's slow, tedious, and I read it only when I have to and, of course, I have to, and I have to quite a lot. But I don't do it for fun. And the Grade Two contractions throw me every once in a while. I'm trying to read along and I come to some cockeyed looking this. I can't make out whether it's capital "St" or "each" or some other combination of dots. I'm not being very coherent, but then I'm not intending to be.

The point that I'm trying to make is that I think that when we go to something that is harder to read than what we already have, we'd better be sure that it's going to be acceptable to, I would say, at least as many people as now find Grade Two acceptable, because we're going to lose people on the way. Another interesting comment that I have often though of is: I wonder whether blind people are poor readers because they never see words spelled. Everything you read in braille is a contraction of some sort as the "m" for "more", but you never see "more" spelled out. We're going to get the system so contracted that its going to get even worse in the literary area if we're not careful. I think I told you at the beginning that there was a great deal of redundancy, because I agree with a great deal of what's been said. I was only trying to emphasize a few points. For literary braille, I'm not sure that we want to make the thing more contracted than it is, more difficult to learn, and more difficult for some people at least to read. We ought to try to make it easier to read, not harder.

I find also that the "Nine-Dot Braille" that I've seen so far is too spread out. For instance, when you take the material that you presented us with today, the code, and you look at the nine-dot version of it and then look at what it means, like "pro" or whatever the letters are, those letters look like they were sitting in the middle of the desert.

Mr. Covici: You mean the six-dot braille.

Dr. Benham: Yes. But obviously you're going to have to spell some things out. You're not going to have everything abbreviated, I hope. So there will be occasions where you want to follow one letter with another. What is it going to look like when you do that? Is it going to be spread out? Now, I've been inconsistent because in some cases I say you're getting it too compact, and in some cases I say you're getting it too spread out. I think it boils down to the fact that I believe the present braille spacing in the six-dot code is about the optimum spacing for easy reading. To get it much closer, you have to study it too much except for the exceptional braille readers, and if it's too spread out it gets difficult to read and you can get lost in it. This is one of the things that I dislike about the Nemeth Code. It's too spread out on the page as far as I'm concerned. Of course, I was brought up on a different one, so my opinion is really not important, but for me it's too spread out in many cases. I want to find out what the legibility of a new system is, before we go very far in trying to decide what kind of a code it ought to be and what kind of abbreviations there ought to be.

Dr. Ashcroft: I was much in accord with what Dr. Nolan said about carrying on legibility studies, but I think some kind of actual reading study, some kind of a nine-dot code, should go parallel with it.

Dr. Nolan: Yes.

Mr. Ingham: I agree.

Mr. Covici: Yes.

Dr. Ashcroft: I think this is in line with what Dr. Benham has just said, too.

Chairman Rodgers: Yes, I think so, and perhaps the two studies could go on concurrently, but I would like to comment in particular about what Dr. Benham has said with respect to reading difficulties. I think that in the study of legibility, one thing we have to be very careful about is not just whether the finger can discriminate, but how readily? In other words, there is a difference between mere discrimination and getting by, and genuine reading; and that is, I think, what we're concerned with.

Mr. Covici: It would take training.

Chairman Rodgers: Yes, it would take training. In other words, one should be able to discriminate without too much study of the thing, you see. That's the point I think that should be very carefully taken into account in any study of legibility. Maybe I misused the words "degree of discriminability". I should perhaps have said "discriminating without too much studying of what you have before you".

Mr. Strom: Then, Mr. Rodgers, would you say that the experiment should go along the lines of a point where we spend several months training a certain number of subjects to become proficient with "Nine-Dot Braille", and then make measurements with respect to how quickly they pick them up?

Chairman Rodgers: Yes. I just tried to throw that in about ready discrimination insofar as helping the study is concerned. But as to what specifically to do, that's a matter of structuring and that is what we're here for, to collect your opinions as research specialists. That should be up to you to decide and if anyone would care to comment on Mr. Strom's suggestion--

Mr. Ingham: What was the suggestion again?

Mr. Strom: That among the tasks that we consider would be one in which subjects would be trained for a few months to learn the code and develop proficiency in adapting to its peculiarities, and then train them on being able to read straight text of the material and see how easily they are able to.

Mr. Ingham: Which code are you talking about?

Mr. Strom: Either the current "Nine-Dot Braille" code or one of a few modifications thereof. I think the point mentioned about two "Nine-Dot Brailles", namely, one like the one here and another one that we invent on the basis of six-dot braille but, rather, on the basis of information theory, optimization of whatever factors we figure will make it more psychologically readable. I think we should try, perhaps, working with both of these, but the important thing is that we have got to get some kind of tests made with some code. The more codes we get tested, perhaps the better off we are.

Mr. Ingham: What Dr. Nolan was saying requires that you people go into lots of practice. If you're going to use a new one, you have to have lots of practice, of course.

Mr. Strom: Then we have to first of all get people in our project who are specializing in teaching braille. I mean among the people who would carry out a research program will be specialists in education, people who are familiar with the specific problems involved

in teaching of braille and who would be able to adapt this to "Nine-Dot Braille" so that if we have a research group, one of the members of the group would include a specialist in education.

Dr. Scott: Have you, Mr. Strom, at the present time, developed any code which exploits to its maximum the potential "Nine-Dot Braille"?

Mr. Strom: No. I haven't.

Dr. Scott: Would this be a relatively simple thing to do or would it be time consuming?

Mr. Strom: It would be relatively easy to invent a code that broke away from the six-dot braille and gave more flexibility. What would not be relatively easy would be to optimize certain details within this.

Mr. Ingham: You actually could, particularly if you could take advantage of, say, the lists of the 400 more frequent words in English text, and so on and so forth, which the English braille could do.

Mr. Strom: Yes, but also what I have to take into consideration are the 512 nine-dot configurations and some kind of measure of the degree of appropriateness of these contractions. So you have a whole bunch of lists of common words or word parts and then you have a list of 512 dot configurations. We have to somehow isolate a property of these orthographic configurations which we can relate to a rule for assigning proper meanings to them.

Dr. Foulke: This you can probably do on the basis of linguistic information, for instance, construct a code taking into account such things as sequential dependencies, orthographic conventions, things of this sort, but in addition to that, before constructing a complete rational code, it seems to me that you would have to know something more about the stimulus alphabet itself and we're back to legibility again.

Mr. Strom: That's right.

Mr. Covici: Can't you do both things at once?

Mr. Strom: The problem is I could write a tentative code but I could not write easily an optimum tentative code. What would have to happen is first an intuitive code and then give it a legibility test; train subjects to read it, assess their reactions, and get

verbal questionnaires from them, get statistics on speed and, in short, get quantitative and qualitative data on this. Then have the specialized studies regarding problems of individual characters independent of meaning, as somebody suggested. Then we have these two studies. These have to be correlated.

Then there has to be a feedback mechanism where the code is revised and put through the same tests, so that you are always using information that you are gaining about psychological properties, legibility of characters relative to the meanings you assign to them, and you have to use this information and put it in the context of a whole system which you then have to put to the tests. The tests will take a long time. Every time you have a new code you have to get some new subjects and train them for several months on this. Presumably these tests would have to be made--you would have to get a whole group of blind subjects.

Mr. Covici: Maybe we could have the subjects optimize the code by these tests, maybe change it a little bit and make it better and then eventually we can get enough legibility studies through and then maybe eventually we will have one code. Then we will try it on a whole group of people and get your statistics back.

Chairman Rodgers: It seems to me that that is a statement that the research specialists would have to approve; that is, in terms of established norms of research procedures. Whether it would be a sound one would be up to the research specialists to determine. Would any one of you care to comment on Mr. Covici's remarks?

Mr. Ingham: I think it's haphazard. That's no way to go about doing it. Could I interject a hopeful note as far as one of the things that was brought up. One of the hardest things I had to do was to find how many people do read braille. If anybody has a concrete figure, I have, and this is somewhere between 30,000 and 40,000 who are reading braille at the present time; this number is constantly increasing and has never declined actually.

Dr. Nemeth: What constitutes reading braille? What material do you use?

Mr. Ingham: I don't mean just using it for notes; reading books. For example, more concrete figures in that line would be 4,000 people subscribe to the braille book listing. Somewhere between 5,000 and 6,000 read the Reader's Digest, and things like that. These are just figures, though, in case you're interested. So the figure is increasing. This will be an extremely useful thing to have if it will work.

Chairman Rodgers: Let us now get back to the structuring of the project. Dr. Benham, I think, has given us his views. Dr. Foulke, did you have anything to add to the structuring of the project?

Dr. Foulke: No, I don't think I have anything to add. I think I could summarize what I would do if I were going to research.

Chairman Rodgers: All right, do you want to give us your summary.

Dr. Foulke: I think I would start out with a legibility study in an effort to learn something about the legibility of the dot combinations that are possible with the nine-dot system.

I think I would attempt, on a gross basis, just to learn something about how people would respond to a system such as the one that is presently before us; that is, the attempt to teach it to some people and get some impression about how well it did appear to work, and then I think, probably at the same time, I would attempt to construct a brand new code on the most rational basis possible, using all of the combinations that are available within a nine-dot system on the basis of an analysis of the language, redundancy, of sequential dependencies, things of this sort and what was learned about legibility or ambiguity of the elements in the stimulus alphabet. Also I would give some consideration, I guess, in the assignment of elements in the stimulus alphabet to elements in the response alphabet.

I would give some attention to the matter of stimulus-response compatibility. I think that this would be the kind of research program, then, that I would undertake if I were going to do it.

Chairman Rodgers: Thank you. Mr. Ingham.

Mr. Ingham: As far as the projects go, I think what has been said just about summarizes what I would like to say, except that I would reinforce the comment about a gross survey, about, for example, having the present code used to do maybe fifty pages or a hundred and distribute it to a reasonably large number of people with questionnaires, carefully designed to elicit comments on both characters and context and understanding. I would do this as soon as possible.

Chairman Rodgers: Mr. Liechty, would you care to summarize your comments?

Mr. Liechty: The notes that I've taken, I think I've already touched on them. I think I will pass up and save the time. Thank you.

Chairman Rodgers: Dr. Nemeth, what would you suggest with respect to research procedure?

Dr. Nemeth: I would suggest that we should undertake several directions of investigation: One, produce just ordinary English braille with no additional contractions but just the contractions of English braille in the nine-dot cell form, and allow people to accustom themselves to reading just that. You realize that they will thereby only need initial and final-letter contractions in this form of the research. They will not have to learn anything new essentially but just to acclimate themselves to the change of the spacing, and to find out what kind of acceptance or what kind of troubles you get there.

Two, I would make a statistical analysis of the frequency of occurrence of words in order to determine what kind of codes would be most suitable for them. I think that a one-to-one assignment of 512 nine-dot sub-sets to the 512 most frequently occurring letters or groups of letters would just be fatal. I don't think you would get anywhere.

Mr. Strom: I agree. It has to be different.

Dr. Nemeth: So this is the second thing. Then I would suggest that the thing to do is to bring the code that you eventually devise gradually to bear, produce material maybe a volume long, and on the first two pages you do nothing but Grade Two, and then you add three contractions of the code you devise on the next two pages, and then you add three more contractions, and so on, because learning the code and reading the thing all at once is going to get you an unrealistic response.

Mr. Covici: What if some of the contractions are different? I mean you want to keep all the Grade Two contractions in everything we did?

Dr. Nemeth: No. For example, the contraction for "in"--Bob made it three dots wide to avoid the other troubles. The contraction for "can", he also made three dots wide for the same purpose.

Mr. Strom: So that it could be a part-word sign, that you could use it in the middle of a word without its looking like a letter.

Dr. Nemeth: I see. I thought it was for orientation. In other words, you would not wonder whether it was "a" followed by dot 1, or whether it was "a" followed by dot 4.

Mr. Strom: It serves both purposes.

Dr. Nemeth: Anyway, there are relatively few changes. The "it" is another change which can be used as a part-word sign. In other words, you could introduce all of Grade Two plus those contractions of Grade Two, which are changed and then add brand new ones as you go. I'm afraid that while it will be interesting to make the kind of experiment that Dr. Nolan suggested; namely, the ease of perceiving meaningless dot configurations, I don't think it does begin to tell the story of readability.

Mr. Covici: We do not know.

Dr. Nemeth: That's all I have to say.

Chairman Rodgers: Thank you.

Dr. Nolan: I can only say I disagree!

Dr. Nemeth: Okay.

Dr. Nolan: I have already given my comments on the way I think the research should proceed.

Chairman Rodgers: Yes.

Dr. Nolan: I don't think I have anything more to add.

Chairman Rodgers: You don't have anything else?

Dr. Nolan: Only to say that I disagree with my friend, Dr. Nemeth.

Chairman Rodgers: I was just going to interject a short comment which may be a redundancy. As I see it, readability is to a large extent a highly refined form of discriminability, so that when we're studying degrees of discriminability for the purpose of relating it to legibility, we have to bear that in mind very carefully.

Dr. Nolan: That's right. I would go along with that, but legibility is a basic ingredient.

Chairman Rodgers: That's it.

Mr. Strom: It's one factor among many.

Chairman Rodgers: Dr. Scott?

Dr. Scott: I want to make two brief comments, but I want to preface them by saying that I know nothing about braille and so my comments are to be taken with that in view.

One is that I have the feeling we don't really have a great deal of research on the six-dot braille cell and this is one of the difficulties we have had here, because as questions come up about "Nine-Dot Braille" it becomes apparent that we don't even know the answers about six-dot braille, and I think it would be a mistake if the research strategy were to study only "Nine-Dot Braille", because at the end of it we would only know whether or not it was a feasible system and if it weren't a feasible system, we would have gone through a lot of trouble to determine this. It seems to me a much more realistic thing to clue in the basic problems about which we have no data at the present time which are applicable not only to the six-dot but to the "Nine-Dot Braille", as well. In other words, we ought to be studying both systems or at least our research ought to be phrased so that it's applicable to both systems.

The second thing is that there is a analogous experience which the field of education has recently gone through and I imagine that we might learn something from this experience, because there has been an attempt to introduce a new system of reading involving various contractions and this is being experimented with by the public school systems*

I don't think we will learn anything in terms of how to set up a new system of raised-dot reading, but we might learn something about how you go about instituting it or about what kind of problems you meet in doing so, or, if it were decided to use "Nine-Dot Braille", I'm sure that the experience of these people trying to institute a new system of reading would be very valuable, and also how they went about researching it, which would be a very valuable thing in terms of setting up strategies here.

Chairman Rodgers: With respect to that research, of course, I think it could be very helpful to us in obtaining all the reports on the methods and results thereof. So we're very happy to have that comment.

Now Mr. Strom.

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*(See NEA Journal, "Value of ITA", September 1964 - Pages 20 to 22).

Mr. Strom: I go along with the proposals of all the people who have mentioned most of the things to be considered already. The very fact that we have disagreements in matters of details with regard to research strategy, implies that we somehow have to set up a structure of a small group of research assistants who are going to plan this, and it is somehow going to finally come to a conclusion regarding different ways of going about the problems and actually putting them into execution.

The group has to be small but diversified enough so that it contains representatives from the fields of psychology, education, braille, mathematics, and whatever other specific categories are necessary, and who are familiar with matters regarding machinery and with matters regarding testing methods and educational methods. Further, this group has to be run sort of semi-independently and, therefore, we somehow have to recommend that a small sub-committee, say the braille legibility committee, the braille legibility testing or something like that, be set up as a result of this conference to ascertain what kind of equipment and research is necessary and to plan this program and then perhaps solicit funds from the American Foundation for the Blind for carrying this out.

Some small group would need to give basic direction for the research efforts, and I think now is the time to decide how we're going to go about getting such a group.

Mr. Covici: The first thing I would do in a research project is to review all the literature that's around and find out how valuable it is. I don't think anybody has mentioned this but I think it should be done, even though I don't know how much there is.

Secondly, I would set up an autonomous research group. In other words, I agree substantially with Robert's statement, but I must emphasize that it should not be too closely linked, it should not have too many administrators on it. It should be research people in different fields who could do a little work independently of the group as well as with the group, and so forth. I would set up studies; I would develop a code; actually develop the material, have people read it, and I would also do some legibility studies on the meaning of the combinations just so that some interest might come out of it. I would do some information theory, and so forth, to develop a code and in general to do what he said, but

I really must emphasize that we've got to get something out and have people read it. What good is it if they don't?

Chairman Rodgers: If no one else has any comment--and the time is getting a little short--I should like to get to the final phase of the Conference; namely, the organizational aspect of the structure. I thoroughly agree that it would be most unfortunate if no action were to result from this second Conference, because this is the very reason we called a second Conference on "Nine-Dot Braille". I, therefore, am open to suggestions as to what steps should be taken to organize the nucleus. I personally feel that this is a highly competent group, and think you all could make valuable contributions, if you were to organize yourselves into a research nucleus from which the whole project would stem and develop. By "whole project" I mean the research contents which are now on record.

You may disagree with that proposal and we will make the rounds again in the regular alphabetical order. Dr. Ashcroft, what do you think about this nucleus idea and about this group of participants constituting it?

Dr. Ashcroft: I think that this group might constitute an advisory committee. They might be very helpful, but I think ultimately the work will have to be done by individuals, and I would like to see this group or some group that is constituted for this purpose of being an advisory committee publicize the work widely and attempt to get the individuals interested who need to be. And then facilitate the writing of proposals by the individuals for funding by private agencies like the Foundation, although I'm sure that there are also federal funds that could be solicited through grant proposals to carry on the work. But it seems to me that ultimately the work has to reside in the hands of individuals to get it accomplished.

Chairman Rodgers: All right. Dr. Benham.

Dr. Benham: Whom did you put down on that nucleus?

Chairman Rodgers: All the participants who are research specialists.

Dr. Benham: Then I have no other comment.

Chairman Rodgers: Dr. Foulke, do you have anything to suggest or add to or modify?

Dr. Foulke: If we are to set up an advisory committee, I'm sure we'll all be happy to advise anybody we could get to take it. I don't know if this is the way in which we are to serve as a consequence of this meeting today, I'm really uncertain about what our next step would be. If we were to serve as the group who is actually to divide up the problem and define missions and get some research on the way, there is going to have to be some money to do it.

Mr. Ingham: I think you will have something if that's what you're getting at, if you're telling us to go look for somebody, I don't know about that. Let me ask a question. There seems to be little doubt in my mind that Bob, for example, could polish his code along the line that we suggested. The question is suppose he did have a code? It's also pretty apparent that we could find a way of getting at least a sample prepared of varying material.

Okay. Now, can anyone in this committee take on the job, with a certain amount of financial support, say, from the Foundation, to set up a reasonable research questionnaire, or whatever have you, thermoform a very long set of copies, and distribute many hundreds of them, carrying on first this gross kind of test, and maybe perhaps somebody else in the committee here will be willing to go on at the same time carrying on fine legibility research? These two approaches immediately offhand could be quickly carried out, I think, and at a minimum of cost. I just wonder whether we could start on that now. Do we need these as definite avenues to work on?

Chairman Rodgers: To whom did you address that?

Mr. Ingham: I'm addressing it to the Foundation or the powers that be or anyone who would like to take the ball as far as trying this research out.

Chairman Rodgers: As far as the Foundation is concerned--and Mr. Roberts is not here now, so I have to speak on behalf of the Foundation--again I have to fall back on what Mr. Barnett said this morning. It's on the record. If that is the consensus, if that is the recommendation of this group, the Foundation will try to do all it can to help.

I seem to sense that if the problem of funding is solved either through the Foundation or through the United States Office of Education--

Mr. Ingham: Or anybody.

Chairman Rodgers: Or anybody else, that this group is ready to take on specific assignments with respect to carrying on the research projects.

Mr. Ingham: Why don't we go around and ask everybody that question? I think that would help.

Chairman Rodgers: I certainly propose to do just that.

Mr. Strom: Everybody isn't here now.

Mr. Liechty: Dr. Nolan had to leave, Carl, and he sent his regrets to you. You were talking and he didn't want to interrupt and he said goodbye. He has to catch a plane. Dr. Ashcroft stepped out into the library and will be back in a few minutes.*

Chairman Rodgers: All right. Then we can proceed in the meantime with the others, and the first one would be Dr. Benham.

Dr. Benham: I don't feel qualified to do more than heckle in any research program that might be set up, because there are a lot of the aspects of it, psychological and so forth, that are not down my line. I could offer assistance in the way of perhaps getting some hardware taken care of, or distribution or names of people that you might want to send the material to and things of that sort. But as far as taking any major responsibility in heading up or in working out the research program, I don't think I'm qualified. So I will offer my services wherein they are useful, but it wouldn't be in the top echelon part of it.

Chairman Rodgers: By "hardware" you mean reproduction of the material; is that it?

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*Dr. Nolan stated in his subsequent letter of June 22nd, 1964, as follows---

"Please accept my apologies for having to leave last Friday's conference before it was over. I was especially sorry not to be able to participate in considering how the research might be undertaken.

"I have since talked with Emerson Foulke and he described the statements of intention to participate made by the members of the conference. I certainly feel that APH would be willing to contribute by reproducing materials and possibly by making computer time available for data analysis. It does not appear to me that individual and cooperative efforts of the type agreed upon are the best way of energetically studying this problem. A better way would be to set up a funded project with its own personnel for just this purpose. Project staff could, of course, rely on outsiders for assistance of various kinds. This could be done at AFB or through a nearby university and would provide continuity that is rarely possible through cooperative efforts."

Dr. Benham: Yes, or getting machinery of one kind or another that you might want. Perhaps even being able to find a little money here and there, but not from the point of view of setting up an actual research program.

Chairman Rodgers: The design for the research project itself. That in itself is essential to carrying on the work.

All right, that's on the record. Dr. Foulke, would you be agreeable to accept an assignment granted that the funding problem was solved, and so on?

Dr. Foulke: Yes. If funding were available, I would be willing to participate in any of this work, and if I had my choice I would prefer to work on an effort to develop an ideal code based upon what information is now available and could be collected within a reasonable amount of time.

Chairman Rodgers: Dr. Ashcroft, the question on the floor now is being addressed to each individual participant, and the question is: Assuming that the funding problem in carrying out a well planned long range research project were to be solved, either through the American Foundation for the Blind or the United States Government or a combination of private and public dollars, would you be willing to serve insofar as contributing to the project?

Dr. Ashcroft: Yes, perhaps primarily indirectly through scholars in our own program at Peabody. A direct contribution on my own part would be secondary to the commitments I have, but I would be interested in participating on both ways.

Chairman Rodgers: I see. Then you would be in a position to participate actively in some way. In what particular phase of research would you be interested in participating?

Dr. Ashcroft: I think primarily at the applied level of actual trials of nine-dot codes, field testing, and perhaps if there is a place for it, especially in terms of children and the introduction in educational programs. One other thing that I would be interested in is a programed instructional approach to moving "Nine-Dot Braille" into some kind of use.

Dr. Nemeth: What approach? I didn't hear.

Mr. Strom: Programmed instruction.

Dr. Nemeth: I see.

Mr. Strom: Perhaps we could get some people at IBM to help us out on this. I know a few people there who are interested in braille, and in programs.

Chairman Rodgers: Of course, Mr. Covici and Mr. Strom, they would not want to participate at all! My point is that I think we know what your roles would be.

Mr. Covici: Yes.

Chairman Rodgers: The development of codes and so on, right?

Mr. Strom: That's right. Also as far as programming computers are concerned and that technical area. I mean things like results of psychological experiments, program, production of "Nine-Dot Braille" according to certain transcription rules that can be fed into any machinery that Dr. Benham or Mr. Ingham can get for me, I can work on.

Mr. Ingham: I've already indicated that I am very much interested, both directly and indirectly, through whomever we can grab at the lab at MIT. I can't commit them, obviously.

Chairman Rodgers: Dr. Nemeth, are you a research specialist?

Dr. Nemeth: Well, I've done research in the past. I would be willing to do this much. I would be willing to heckle along the literary lines, but when it comes to the mathematical end of it, I would be willing to look over any program or even help in the development of any program for the writing of mathematics in "Nine-Dot Braille" or any other technical kind of materials.

Mr. Ingham: There couldn't be a better man to do it!

Chairman Rodgers: Okay. Dr. Nolan has gone and Carl T. Rodgers is not a research specialist!

Mr. Ingham: Bowing out?

Chairman Rodgers: Neither a research specialist nor a financier. Dr. Scott.

Dr. Scott: In view of the objectives of my own study, I've made it a policy not to become actively involved in any research programs in the field other than those involved in sociology and I, therefore, would not be able to become involved actively in the committee, although I would be interested in monitering its activities and at the end of three years when I finish my present project, I would be happy to reconsider it. But at the present time I can't accept this because of the objectives of my own study.

Chairman Rodgers: I can assure you that after three years have elapsed there will be plenty of work left to do if you want to join then.

Okay. I think we've covered it all now. I'm very, very happy to have the specific ways in which this group of participants would be able and willing to contribute, because this will constitute a tangible set of recommendations from which we can proceed to try and solve the problems, or at least to look for the people that can solve them. Also, if any of you now or at any time can offer any suggestions with respect to funding outside the Foundation, if you find any money that is available, we would entertain those suggestions too.

I think it has been very fruitful and I was so glad to hear the comment--I forget who made it--that, after all, this is research and that there is no reason why we should limit ourselves to any set of signs or anything else. No one is going to impose anything on anybody. We're just trying to learn, find out and then, when the appropriate time comes that we know what we're talking about, it will be enough time to include the general field and in particular those who are responsible for the development and standardization of braille codes, because that's very important, too-- we have to have a stable system--the development and standardization of braille codes, literary and special.

Mr. Ingham: Before you go away, though, what happens next? We have all indicated interest and willingness to participate. When do we hear from you next or what or how?

Chairman Rodgers: I understand that within two weeks or so we will get the transcript of this meeting. From it I shall draw up the Proceedings which will be available for distribution. At the same time I think we have enough concrete material to seek the interest

of those who would be able to help us, one of them of course being the Foundation's administration and its Board of Trustees. No doubt we will get suggestions from the Administration as to other possible sources of funding, and so we will keep each other in thorough communication, step by step, so that when the necessary funds are available the various phases of research which you have suggested might be set in motion. Hopefully, each individual, in consultation with everybody else concerned, will take on the phase of research in which he has expressed interest in carrying out.

Dr. Foulke: I would like to add a bit to my statement. I said I would be interested in developing an "ideal" code, and I would consider as a necessary step of doing this, a study of legibility.

Mr. Ingham: I suppose I'm the only one who hasn't expressed an opinion.

Chairman Rodgers: Did I pass you by?

Mr. Ingham: No. I just didn't state what I would be interested in. Let me just say that I would be interested in approaching our group leaders at MIT on the whole project, and for myself I would like to take the development of new codes and testing, especially the gross testing and distribution and determination of results, as well as any instrumentation problems which might arise, because there are lots of facilities available at MIT and elsewhere and we should be able to tape them. I would be interested in that.

Mr. Covici: I have one question. Should we set some sort of date by which we have some material, because otherwise things might go on for a long time. At least some sort of date.

Mr. Strom: A time for which we have--

Mr. Covici: The material to distribute, to send out to people to have them try to read it.

Mr. Ingham: I think before we can do that, Bob and whoever else is going to work on the optimization of this present code have to get together.

Mr. Covici: True.

Mr. Ingham: That should be the first thing. The duplication problem worked out and the duplications made, and at the same time a list of "x" number of people should be available to whom this material could be sent, graciously received and looked over, and the questionnaire drawn up.

Chairman Rodgers: I think Dr. Benham said he could help out on people available for that purpose.

Mr. Ingham: But he couldn't be the only one, I suspect, because much of what Dr. Benham has with his tape library probably consists of people who are not regular braille readers, of course. Many of them would be of course, but not all of them. His list should be supplemented.

Mr. Covici: We could do this immediately.

Mr. Ingham: Surely.

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CONSENSUS OF THE PARTICIPANTS ON THE QUESTION OF PUBLICITY.

The following is a summary of the participants' lengthy discussion on this subject. With one exception, the consensus was that publicity should not be avoided altogether, but should definitely be limited to a concise, general announcement, in highly professional journals, of the June 19th, 1964, "Nine-Dot Braille" Conference and its recommendations to structure and carry out a research project on six and "Nine-Dot Braille".

Dr. Nemeth's reasons for opposing any kind of publicity at this time are as follows:

1. Potential volunteer transcribers will defer becoming braillists until the outcome of the proposed research is known.

2. Publicity at this time will engender much opposition from the field of work for the blind.

3. At the present time there is really nothing that can be reported to any individual or group. When preliminary results are available a summary statement can be prepared for distribution to interested people.

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Chairman Rodgers: Thank you very, very much gentlemen, for what I think are most valuable contributions from each of you.

We are now adjourned.

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APPENDIX A

WORKING PAPER
"NINE-DOT BRAILLE" CONFERENCE

JUNE 19, 1964

Submitted by:

CARL T. RODGERS

PROGRAM SPECIALIST IN BRAILLE
and
OTHER TACTUAL EDUCATIONAL MATERIALS

AMERICAN FOUNDATION FOR THE BLIND

AGENDA

"NINE-DOT BRAILLE" CONFERENCE

Friday, June 19, 1964 at 9:30 A.M.	Helen Keller Room American Foundation for the Blind
9:30-9:50 A.M.	Welcoming and Introductory Remarks M. Robert Barnett, Executive Director American Foundation for the Blind
9:50-10:15	Resume of Efforts in Developing "Nine-Dot Braille" Robert Strom, Protagonist Student-Harvard College
10:15	Ten minute break
10:25-12:30	Discussion: Readability of Nine-Dot Cell characters--Type Scale; Tactually Discriminable Space Difference of Modifying Dots (See Items 1-2, Summary Statement of Working Paper).
12:30-1:30	LUNCH-at the Foundation
1:30-2:30 P.M.	Discussion: Character Configuration; Extension and Position in the Nine-Dot Cell (See Items 3-6, Summary Statement).
2:30-3:00	Discussion: Space-Saving Efforts (See Item 7, Summary Statement)
3:00	Ten minute break
3:10-4:30	Concensus of the Participants on the structuring of an effective research project to determine whether or not nine-dot cell characters are feasible from the standpoint of: a) readability b) use for writing by blind individuals c) small-and large-quantity duplication. Carl T. Rodgers Conference Co-ordinator

"NINE-DOT BRAILLE" CONFERENCE

At the July 1961 Convention of the "American Association of Workers for the Blind", in a paper entitled "Some Developments in the Various Braille Codes--Literary, Mathematics, Music", I happened to raise this question: "In light of the continuing birth of new sciences, new scientific discoveries, new methodologies, and, therefore, new terminologies and new forms of established older ones, may not the time come when the braille system will begin to burst at its orthographic and legibility seams?"

By taking the number of single dots and dot arrangements (64--two to the sixth power) which the six-dot cell permits as the constant factor, and the increasing need to represent new terminologies and new orthographic styles as the variable factor, we may then conceive of the whole braille problem as one of trying to crack the six-dot barrier. I believe that Mr. Robert Strom's "Nine-Dot Braille" proposals represent the first major current effort toward this end. Only the most extensive and carefully-structured research efforts will determine whether or not a nine-dot cell is tactually and technically feasible.

Preliminary analysis of Mr. Strom's proposals seems to show a very close similarity between "Nine-Dot Braille" problems and those of regular braille. In essense these are problems relating to readability of embossed characters as a function of:

A. Number of dots in a character.
B. Vertical and horizontal extension of characters.
C. Character shape.
D. Characters which are the same in shape, but which derive their meaning from rotational position changes in the cell.
E. Characters which are the same in shape but which derive their meaning from their upper or lower position in the cell.
F. Type scale (spacing values)
G. Space-saving efforts through the use of contractions and short-form words.

A. Number of dots in a character.

The blind participants who evaluated Mr. Strom's original illustrative material at the first "Nine-Dot Braille" Conference said that "jumbled" or over-dotted characters cause confusion in discrimination and recognition. While Burklen (Touch Reading for the Blind) states that optimal tangibility does not depend on the number of dots in a character as much as on such characteristics as simplicity of

geometric form, and also on what he called "open characters" (like the braille letters "m", "u", or "x"), the tests conducted by the Uniform Type Committee of the AAWB indicated a higher degree of legibility with respect to characters containing fewer dots, from the standpoint of both speed and accuracy (Proceedings of the AAWB Conventions--1907, 1909, 1911, 1913, 1915). The Committee's tests were conducted with American braille and New York Point, the two punctographic systems then in use in the United States. The relationship of character configuration and number of dots in a character to readability awaits scientific investigation on a much more thorough level than has hitherto taken place.

B. Vertical and horizontal extension of characters.

In its 1907 report to the AAWB Convention of that summer, the Uniform Type Committee described a test designed to find out whether characters two points high were easier to read than characters three points high. The following brief except from the Committee's report will enable the group at the Conference to judge the value of the test: "In fifty-five trials, the list which included the tall letters was read in one per cent less time, with two per cent less errors, than the one in which only the short letters were used". Burklen's mention of "the easier perception of open characters" (characters which are always three points high) may add some support to the Committee's finding on the higher degree of readability of the "tall" letters.

Because a "Nine-Dot Braille" cell would constitute a horizontal extension of the Louis Braille cell, interest may be added to the "Nine-Dot Braille" discussion by citing an excerpt from the 1961 Proceedings of the Conference on Research Needs in Braille, relating to the Uniform Type Committee's investigation of vertical versus horizontal signs:

"At the 1909 AAWB Convention the Committee reported on an experiment designed to find out which signs are more legible--the horizontal or the vertical ones. Two lists of two hundred signs each were prepared. In one of the lists all the signs, varying from one to three dots long, were placed horizontally, while in the other list the same signs were placed vertically. Each of the twelve readers who took part in the experiment, all of whom knew both New York Point and American Braille, read the two lists aloud,

while a seeing person followed the reading with an ink copy, marking the errors and checking the time spent on each list. The signs were called not by their letter values buy by the number of dots they contained. The signs used represented more than one-third of the recurrence of the alphabet in New York Point and American Braille. The longest of them could be taken as the extremes of the two positions--the most horizontal and the most vertical.

"The horizontal signs were read in 33 per cent more time, with 321 per cent more errors than the vertical signs. Subsequent tests gave similar results".

C. Character shape.

See Paragraph A.

D. Characters which are the same in shape but which derive their meaning from rotational position changes in the cell.

Burklen indicated that certain symmetrical characters of braille (some 26) differ only in angular position from one another, causing reversal reading errors, as in the case of the characters composed of dots 1-6, 1-3, and 4-3. Examination of Mr. Strom's revised illustrative "Nine-Dot Braille" material reveals that these "mirror characters" may occur with equal or greater frequency in the nine-dot codes than in regular braille, as in the case of the sign for the word "here", dots 8-1-2-5, which is the regular Braille "r" rotated 90 degrees counterclockwise.

(The nine dots of the cell are numbered: 7,8,9, downward on the left; 1,2,3, downward in the middle; and 4,5,6, downward on the right).

E. Characters which are the same in shape but which derive their meaning from their upper or lower position in the cell.

The Uniform Type Committee designated these as "equivocal characters". It summarized its findings as follows:

"Experiments tend to show that time is consumed and certainty diminished by the labor of determining the position of characters which are like other characters except for their level in a line."

Ashcroft ("Errors in Oral Reading of Braille at the Elementary Grade Levels") found lower-cell contractions to be fourth (within a total rank of seven categories) in the order of difficulty from easy to hard, and stated that "lower-cell contractions were the most difficult of the group of single-cell contractions."

There seems to be nothing in the literature in contradiction to these findings. This is worth pointing out in view of the fact that lower-cell characters occur in "Nine-Dot Braille" at least with equal frequency as in regular braille.

F. Type scale or spacing values.

This is perhaps the most difficult problem of "Nine-Dot Braille". For the original material (see paragraph A) the spacing values were:

vertical and lateral distance between two dots in a single cell..... 0.080"

total lateral-cell space..... 0.160"

distance between corresponding dots of two adjoining cells..... 0.288"

unknown value between adjoining lines of writing.

Some of the participants at the first Conference thought that the impression of "jumbled characters" resulted from the over-reduced spacing values between dots in a single cell. The judgement of the participants may or may not have been correct, but it is interesting to note that the total lateral cell spacing used for the material was 0.160", or 0.070" greater than the lateral cell spacing (0.090") of a regular braille cell, and the distance between corresponding dots of two adjoining cells was 0.038" greater than that of two adjoining regular braille cells, which is 0.250".

Each of the three "Nine-Dot Braille" slates which were constructed for embossing new material represents a different spacing value as follows:

First slate. Distance between dots in a single cell....0.085"
Second slate. Distance between dots in a single cell....0.090"
Third slate. Distance between dots in a single cell....0.095"

The spacing between cells and between lines was the same for the three slates; namely, 0.160" between cells and point 0.220" between lines.

As indicated in the "Addendum Sheet", the addition of the modifying dots 7, 8, 9, at the left of the cell is unfeasible without an increase of "x" decimal of an inch between the modifying dots and dots 1,2,3, the mid-cell dots. For instance, the "Nine-Dot Braille" contraction for "ast", dots 3-4-7, can be read as the regular braille "ch" sign (dots 1-6) followed by dot 4; the contraction for "full", dots 1-2-4-7-8-9, can be read as the regular braille "q" followed by dot 4; the contraction for "ound", dots 1-4-5-7-9, (the regular Grade Two contraction written as a one-cell contraction), can be read as the regular braille "m" followed by dots 4,5, and so on.

The reason for these ambiguities is obvious. The distance between dots 3-7 of the "ast" contraction equals the distance between dots 1-6--the regular braille "ch" sign; the distance between dots 1-2-7-8-9 of the "full" contraction equals the distance between dots 1-2-3-4-5--the regular braille "q"; the distance between dots 1-7-9 of the "ound" contraction equals the distance between dots 1-3-4--the regular braille "m".

Many more examples of ambiguities and distortion of regular braille configurations can be cited, but it is believed that enough has been said to show the need for an increase of "x" decimal of an inch between the modifying dots and the remainder of the cell. Since this appears to be true, and since the spacing values which were used in the original "Nine-Dot Braille" material seem to have disturbed a number of readers at the first Conference, the following figures on spacing variables are offered in the hope of stimulating more thinking on the problem.

Regular Braille Cell

Distance between corresponding dots of two adjoining cells.....	0.250";
between corresponding dots of adjoining lines..	0.400".
Number of cells in a 10" long line.....	40.
Number of lines on 10" high writing space.....	25.
Total number of cells per page.....	1,000.

Nine-Dot Cell

(Until otherwise indicated, the distance between two lines of writing should be taken to be 0.220".)

Distance between corresponding dots of two adjoining cells when the distance between dots in a single cell is 0.080", and the distance between cells is 0.123": 0.283".

Number of cells in a 10" long line.....35.

Number of lines in 10" high writing space.....25.

Total number of cells per page.....875.

Distance between corresponding dots of two adjoining cells when the distance between dots in a single cell is 0.090", and the distance between cells is 0.123": 0.303".

Number of cells in a 10" long line.....33.

Number of lines in 10" high writing space.....25.

Total number of cells per page.....825.

Distance between corresponding dots of two adjoining cells when the distance between dots in a single cell is 0.080", and the distance between two cells is 0.160": 0.320".

Number of cells in a 10" long line.....31.

Number of lines in 10" high writing space.....25.

Total number of cells per page.....775.

Distance between corresponding dots of two adjoining cells when the distance between dots in a single cell is 0.090", and the distance between two cells is 0.160": 0.340".

Number of cells in a 10" long line.....29.

Number of lines in 10" high writing space.....25.

Total number of cells per page.....725.

When the preceding four lateral variables are applied in the same order, but the vertical distance between dots is reduced to 0.072", and the distance between the lines is reduced from 0.220" to 0.163", then the number of lines on a 10" high writing space increases from 25 to 32, and the cell totals per page are as follows: 1,120; 1,056; 992; 960.

The figure 1,000, which is the total number of cells per page for regular braille using a 10 x 10" writing surface, might serve as the constant factor when studying the readability of "Nine-Dot Braille" as a function of "x" spacing variables--lateral and vertical. In offering these figures the dot-base diameter has been assumed to be 0.055". Changes in dot diameter, and possibly also in dot height, might help increase the legibility of nine-dot cell characters.

The foregoing figures were suggested by the 1920 Report of the AAIB-AAWB Commission on Uniform Type for the Blind, and by the study on spacing variables of Meyers, Ethington and Ashcroft ("Readability of Braille as a Function of Three Spacing Variables"). Attempts to ascertain the spacing values for embossing New York Point--which in some respects resembles the nine-dot cell--have thus far been futile.

Two more considerations with respect to spacing problems seem appropriate. The first relates to diagonal dot distances. Since both the six-and nine-dot cells are quadrangular, these distances may be calculated through the formula "a" square plus "b" square equals "c" square. The diagonal distances yielded are as follows:

Regular-Braille Cell

Distance between dots 1,6 or dots 3,4.....0.201".

Nine-Dot Cell

Distance between dots 7, 6 or dots 4, 9 when the distance between both vertical and horizontal dots is 0.090"....0.254"

Distance between dots 7, 6 or dots 4, 9, if the lateral distance between dots is reduced to 0.080" and the vertical distance is reduced to 0.072".....0.215"

The second consideration is concerned with the relationship of dots 7, 8, 9, of the nine-dot cell to dots 4, 5, 6 as modifying dots in regular braille two-cell signs. In regular braille, words and letter-groups are contracted into a two-cell sign by prefixing one or several dots to a letter or a contraction--dots 5, 1-5 for "ever", dots 4-5-6,2-3-4-6 for "their" and so on.

Query: Aren't dots 4, 5, 6 in effect functionally identical with dots 7, 8, 9, in a "nine-dot cell", except for a larger space between them and the remainder of the signs of which they are a part?

If investigation reveals that "Nine-Dot Braille" type, in order to be tactually feasible, must exceed the 0.1 square-inch surface scale of regular braille, is the solution to the problem to be found in a more extensive use of contractions?

G. Space-saving efforts through the use of contractions and short-form words.

This has been one of the most highly controversial aspects of touch reading. Limited investigations by the Uniform Type Committee, the Commission on Uniform Type for the Blind, and Ashcroft, reveal that certain contraction categories tend to facilitate reading, while others tend to produce various types of reading errors. There is no reason to believe that in this respect, except perhaps for the possibility of substituting contractions for short-form words, "Nine-Dot Braille" contraction problems would be any different from those of regular braille. Only through additional and extensive scientific investigation can one hope to arrive at suitable solutions to the whole touch-reading problems. One would also hope that in the continuing development of embossed systems for blind persons, this principle will always be rigidly follows: It is the needs of the blind reader--not of the system---that must be met.

The enormous scope of the subject in itself has precluded the possibility of a truly suitable working paper. For one thing, only a cursory review of the investigation records available was feasible, since any well-structured research project would require a far lengthier review of the literature than could be presented here. The purpose of the foregoing material has been simply to attempt to set up the kind of questioning frame of mind that it is hoped fully will lead to a fruitful, analytical discussion at the on-coming "Nine-Dot Braille" Conference.

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SUMMARY STATEMENT OF SUGGESTED RESEARCH

1. Readability of nine-dot cell characters as a function of type scale--dot size, dot height, lateral and vertical distances between dots in a cell, distance between adjoining cells, distance between adjoining lines of writing.

2. Readability of nine-dot cell characters as a function of tactually discriminable space difference between dots 7, 8, 9, used as modifying dots at the extreme left or right side of the cell, and the remainder of the cell.

3. Readability of nine-dot-cell characters as a function of character configuration and character extension--lateral and vertical.

4. Readability of nine-dot-cell characters as a function of characters which are the same in shape, but which derive their meaning from their lateral position in the cell--left, middle, right position; left-middle, middle-right position.

5. Readability of nine-dot-cell characters as a function of characters which are the same in shape but which derive their meaning from their upper or lower position in the cell.

6. Readability of nine-dot-cell characters as a function of characters which are the same in shape but which derive their meaning by being rotated as much as 360 degrees.

7. Readability of nine-dot-cell characters as a function of greater space-saving efforts than those prescribed in the "AAIB-AAWB Braille Authority's English Braille-American Edition 1959-Revised 1962".

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APPENDIX B

REPORT ON

"NINE-DOT BRAILLE" CONFERENCE

HELD AT

AMERICAN FOUNDATION FOR THE BLIND

JULY 6, 1962

Submitted by:

Carl T. Rodgers
Program Specialist in Braille and Other Tactual Aids

PARTICIPANTS

Miss Kathern F. Gruber, Chairman
Director of Division of Program Development
American Foundation for the Blind

Mr. Howard M. Liechty, Editor of
the "New Outlook for the Blind" and
Member of the Board of Trustees of
the American Foundation for the Blind

Mr. George F. Meyer, Executive Director
New Jersey State Commission for the Blind
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Dr. Thomas A. Benham
Professor of Physics
Haverford College
Haverford, Pennsylvania

Mr. Robert A. Bowers
Leadership Fellow
American Foundation for the Blind

Mr. John K. Dupress, Director of
Technological Research
American Foundation for the Blind and
Research Associate of the Department
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Mr. Kenneth Ingham
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Mr. Carl T. Rodgers
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Dr. James Slagle
Research Associate
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Mr. Robert Strom
Inventor and Protagonist of the
"Nine-Dot Braille" and an
undergraduate student at
Harvard University

Mr. Arthur L. Voorhees
Program Specialist in Vocational
and Rehabilitation Services
American Foundation for the Blind

Dr. Everett E. Wilcox
Program Specialist in Education
American Foundation for the Blind

Miss Joan M. Stapleton, Secretary
American Foundation for the Blind

PARTICIPANTS INVITED -- UNABLE TO ATTEND

Mr. Ted Glazer
Manager, Systems Division
Burroughs Research Center
Paoli, Pennsylvania

Mr. M. Robert Barnett
Executive Director
American Foundation for the Blind

Mr. Louis H. Rives, Chief
Division of Services for the Blind
Office of Vocational Rehabilitation
Dept. of Health, Education, and
Welfare
Washington 25, D.C.

"NINE-DOT BRAILLE" CONFERENCE

This Conference was held on July 6, 1962, from 10:00 a.m. to 4:00 p.m. in the Helen Keller Room of the American Foundation for the Blind. Miss Gruber opened the Conference by stating its purpose as follows:

> One of the major responsibilities of the American Foundation for the Blind is to evaluate all ideas, systems, methods, aids, etc., that are formally presented to the Foundation for this purpose. Within the past two months, Mr. Robert Strom presented to the Foundation a complete system of "Nine-Dot Braille" for evaluation. The Program Specialist in Braille, Mr. Carl T. Rodgers, made the preliminary investigations, and as a result of his findings, he recommended to the Foundation administration that a small group of totally blind readers be convened for the purpose of further analysis and exploration of this "Nine-Dot Braille.

Miss Gruber then established a most satisfactory auditory rapport among those present by having each of them make a brief statement of self-identification. Following this, the Program Specialist in Braille described the content and the arrangement of the Conference material; told how it had been prepared and duplicated; explained some of the technical difficulties which were encountered in producing the material on a somewhat crude prototype "Nine-Dot Braille" slate; and stressed that all of the samples and the spacing values used were tentative and subject to whatever changes and revisions might be indicated by reader reaction and adequate research studies.

GENERAL DISCUSSION TOPICS:

1. Legibility and Spacing Values of "Nine-Dot" Characters

It was observed by the participants that "bunching of dots" and widely-spaced, isolated dots decrease reading facility. Among such signs were the "any" sign (dots 1-2-3-4-6-7-8-9), the "ity" sign (dots 1-3-4-5-6-7-8-9), and the "an" sign (dots 1-9).

It was also noted that "Nine-Dot Braille" characters which did not "overcrowd" the sense of touch are more easily read. Among such symbols were the "is" sign (dots 2-4-9), the "ate" sign (dots 1-8-9), and the "ly" sign (dots 1-2-3-7-9).

It was suggested that some of the signs which appeared "bunched together" might be made more legible by appropriate alterations of the spacing values of the nine-dot cell, and it was agreed that optimal spacing values would have to be established through adequate research. It was stated that the findings of the study entitled "Readability of Braille as a Function of Three Spacing Variables" by Meyers, Ethington and Ashcroft was a fine contribution to the field of research in braille and a good starting point for further investigations concerning suitable spacing values, dot diameter, and dot height.

2. The Writing of "Nine-Dot Braille"

Mr. Strom's "Nine-Dot Braille" slate was examined by the participants. It was pointed out that dot 5, being the middle point of the square, (the nine-dot cell) might be difficult to write, to which Mr. Strom, who had punched out all of the "Nine-Dot Braille" Conference material replied that he had encountered no difficulty with the writing of characters containing dot 5. Brief mention was also made of a keyboard suitable for writing "Nine-Dot Braille" as well as for manual operational requirements.

3. "Nine-Dot Braille" Structure

The Nine-Dot cell was developed simply by adding the column of dots 7,8,9 to the right of the conventional braille cell. It was suggested at the Conference that the added column might be placed at the left, rather than at the right of the conventional cell for the purpose of using combinations of the dots of the added column much the same as dots 4, 5, 6 of the standard cell are presently used in compound symbols. This would retain, more compactly, the already existing symbols of Grade 2 braille, avoiding obsolescence and affording the possibility for the creation of new symbols. Mr. Strom and the Program Specialist in braille stated that this alternative for developing nine-dot characters might be quite feasible since the nine-dot characters would then be truly an extension of the six-dot cell characters. Mention was made by Mr. Meyer of the possibility of a variable cell in order that some of the characters might occupy less space than the full nine-dot cell. It was felt by some of the participants that this idea, which would be feasible through a properly constructed slate or machine, might serve to save considerable space and lend continuity to the legibility of the characters.

4. Purposes and Needs of Braille

Mr. Meyer, addressing himself directly to the Program Specialist in braille, asked him to state his "impressions" concerning braille needs. The following summarizes Mr. Rodgers' effort to answer Mr. Meyer's request.

"First, I believe that as a system of touch reading and writing for blind persons, braille is a multi-purpose system. When we speak of 'needs', what needs are we talking about? Are we talking about the needs of the reader who wants to read for recreation only? Are we talking about the needs of the 'John Covicis' who need an orthographic system for the accurate recording of current mathematical and scientific concepts and data? Consider the orthographic discrepancies that exist between the symbols provided for in Braille Chemical Notations and How to Use Them by Loomis and Mitchell, and the symbols of the Nemeth Code. At the present time, braille mathematical and scientific notation is in a state of complete fuidity. Are we talking about the needs of the blind musician, whose present braille notation is highly technical and multi-celled? When speaking of 'needs' we have to break them down the way we do when dealing with the needs of any handicapped group -- into highly individualized needs. Each available medium -- braille, talking book records, tapes -- must be used to meet the needs of <u>individuals</u>."

The rest of the discussion on the question of needs revealed the feeling that a nine-dot system would be welcomed by "the blind individual seeking a way in which to record highly specialized work", but that "the individual who reads non-technical braille is going to rebel."

SOME CRITERION TO USE IN DEVELOPING NINE-DOT CHARACTERS

The following is a summary of the ideas offered by the participants to give order and meaning to the potential creation of "Nine-Dot Braille":

1. Wherever possible there should be strict adherence to the principle of orthographic representation (each symbol to be assigned <u>one</u> meaning).

2. Concentrate on developing characters not now available in braille for representing certain existing ink-print characters.

3. While absolute standardization of symbols and symbol meanings does not really exist in inkprint, it would seem wise to establish code uniformity by providing braille equivalents for those inkprint symbols used most commonly and having the least variations of meaning.

4. Whenever possible use the right side of the "Nine-Dot Cell" for the special symbols of mathematical and scientific notation, using the left side of the cell only when it becomes necessary to avoid confusion with a symbol of the literary code.

5. New characters should be created according to a consistent pattern or system of development.

6. "Nine-Dot Braille" characters should be developed in keeping with logical inkprint presentation. For example the representation of the inkprint notation which means "a-sub-one" should be designed so as to read exactly like that, and not "a-one-sub."

7. In developing "Nine-Dot-Braille" make it as compatible as possible with the old system so as to reduce the necessity of learning an entirely new system.

8. The establishment, through scientific experimentation, of optimal spacing values as an indispensable requisite to the legibility of nine-dot characters.

9. Experimentation with other types of cells, such as 2 points vertical and 4 points horizontal, etc., should be included in future research on touch reading.

BRAILLE SYMBOLS FOR "PRINCIPIA MATHEMATIC" AND MATHEMATICAL LOGIC

For the purpose of illustrating the urgency for creating a system of touch reading and writing that can adequately meet the requirements of modern symbology, Mr. Strom read a passage from the book Principia Mathematica, a reading "must" for students of higher mathematics, and which cannot be made available to blind mathematicians because the existing mathematical braille notation provides no orthographic equivalents for the symbols used in this book. Mr. Strom stated that suitable single-cell equivalent symbols could be provided by "Nine-Dot Braille", for not only Principia Mathematica but mathematical logic as well.

The material prepared by the Program Specialist in Braille included the four following questions, the answers to which sum up the participants' consensus of opinion on what action, if any, the American Foundation for the Blind might take regarding Mr. Strom's "Nine-Dot Braille" proposal:

1. In general, does it appear that the reading finger can span and comprehend Nine-Dot characters?

   Dr. Benham ---- Yes.
   Dr. Slagle ---- Yes.
   Mr. Dupress --- Yes.

   Mr. Ingham ---- Yes, but samples of "Nine-Dot Braille" should be produced with more adequate writing equipment in order to be able to judge better.

   Mr. Meyer ---- Yes, it could be.

2. Does it appear that some of the characters are especially difficult to read?

   Dr. Benham ---- Yes, some are hard to read, but if dot height and spacing values were uniform, they would be easier to read. Uniformity and better character designing (placing indicators before instead of after the basic symbols) would, I think, make the system easy to read.

   Dr. Slagle ---- Yes, characters that have many dots are difficult to read. The use of dot 5 might, in general, be avoided when you have a choice. Sparsely-located dots cause difficulty.

   Mr. Ingham ---- Yes, characters with too many dots are hard to read. Also, the column of dots 7,8,9, might make for easier reading if added at the left instead of at the right of the basic cell.

Mr. Meyer ---- Yes, difficulties increase when you consider adjacent characters. Because of the spacing values which have been used for this material, you can't tell where one cell leaves off and the other begins.

Mr. Dunress -- I will agree with the group that where there are only a few dots, left or right, the characters are difficult to read. There is need for research on this.

3. Would it be desirable to treat the "Nine-Dot Cell" as an extension of the "Six-Dot Cell" in developing nine-dot symbols?

All agreed in the affirmative, since this would avoid rendering the old system obsolete, would eliminate the need for relearning many new characters and would, therefore, result in potential subjects being more willing to cooperate in field-testing projects.

4. From the standpoint of present-day orthographic needs on the one hand, and of tactual legibility requirements on the other, does the "Nine-Dot Braille" concept appear sufficiently promising to justify undertaking the extensive and comprehensive experimentation, field-testing, and other long-range steps necessary for the development of the proposed concept into an optimal, multi-purpose system of touch reading and writing?

All agreed that additional investigation must precede any large-scale experimentation and other long-range action. As part of further preliminary investigation, the participants recommended a better-constructed, more sophisticated "Nine-Dot Braille" slate to afford better evaluation of the readability of nine-dot characters. A few Foundation people and a few well selected outsiders should continue the investigation. Furthermore, a second conference on "Nine-Dot Braille" was recommended, at which time a definite decision could be made in answer to question 4.

The protagonist of "Nine-Dot Braille" posed the query: "Do you think we can recommend experimentation as to the size of the cell and specific values?" The unanimous reply was "Definitely Yes".

Finally, everyone recommended gradual and thorough investigation, evaluation and data gathering of the proposed system, with emphasis on technical needs for the benefit of the blind student of higher mathematics in particular and technical training in general. Stress was laid on making no announcements or taking any action which might lead to a renewal of a "War of the Dots" or "Battle of the Types" among the users of braille or among the workers in the field.

APPENDIX C

MATHEMATICS OF SIX-DOT BRAILLE AND EXPANDED PUNCTOGRAPHIC CODES FOR TOUCH READING AND WRITING

Submitted by: Dr. Abraham Nemeth
Assistant Professor of
Mathematics

THE MATHEMATICS OF SIX-DOT BRAILLE AND EXPANDED FUNCTOGRAPHIC CODES FOR TOUCH READING AND WRITING

Submitted by: Dr. Abraham Nemeth
Assistant Professor of Mathematics

A. COMPARISON OF SPACE REQUIREMENTS OF SIX-DOT BRAILLE WITH "NINE-DOT BRAILLE".

Spacing Parameters

Between dot centers within a single cell.....	.090 inches
Between right side of one cell and left side of next cell.....	.160 inches
Between bottom of cell on one line and top of cell on next line.....	.220 inches

In normal six-dot braille, it is possible to emboss 40 cells to the line and 25 lines to the page if the dimensions of the page are 11 inches by 11½ inches while still maintaining suitable margins. With the same spacing parameters for "Nine-Dot Braille", it is possible to emboss 29 cells per line and 25 lines per page while still maintaining suitable margins. There are thus 1,000 cells per page available in six-dot braille compared with 725 cells per page available in "Nine-Dot Braille". Proper comparison of the two systems requires that the spacing parameters be assumed equal in both.

It is assumed that ordinary adult prose has been transcribed in the two systems being compared. Because of the variable length of words and syllables, it is not possible to emboss either all of the 1,000 cells per page in six-dot braille or all of the 725 cells per page of "Nine-Dot Braille". It is estimated that an average of 1.6 cells per line are unused at the ends of lines for these reasons. Accordingly, there will be 40 cells per page lost in either system. There will thus be 960 cells per page available for six-dot braille and 685 cells per page available for "Nine-Dot Braille". The 40-cell-per-page loss constitutes a 4 per cent loss in six-dot braille, but a 5.5 per cent loss in "Nine-Dot Braille". We will continue to assume, from this point onward, that there are 960 cells and 685 cells per page, respectively, available for braille transcription in the two systems.

It has been proposed that a nine-dot cell be regarded as composed of a left third to accommodate either composition signs or "prefixes" of two-cell contractions, and a right two-thirds to accommodate letters or part-word signs affected by such composition signs,

or the "bodies" of two-cell contractions. Four of the six composition signs of English Braille can be accommodated in the left third of a nine-dot cell. These are the capital, italic, letter, and accent signs. The number sign and the termination sign cannot be accommodated in this way.

Each two-cell combination of composition sign followed by a single letter or part-word sign, or of a prefix followed by the body of six-dot braille can be accommodated in a single cell of "Nine-Dot Braille", so that there is a gain in "Nine-Dot Braille" of one efficiency unit. In order for "Nine-Dot Braille" to be more efficient than six-dot braille with respect to the amount of space occupied, "Nine-Dot Braille" must score a gain in excess of 275 efficiency units, since this is the number by which the cells per page in "Nine-Dot Braille" falls short of the cells per page in six-dot braille.

In English Braille, Grade Two, there are 47 two-cell contractions. A survey of adult prose material suggests that the frequency of occurrence of such contractions is at the rate of about 25 per page of six-dot braille. Since there are seven prefixes and 56 bodies available, it is theoretically possible to construct 7 x 56 or 392 two-cell contractions, as in Grade Three. It will be assumed that the rules for forming contractions can be formulated in such a way that no conflict arises from the dual role played by four of the prefixes as composition signs. Whether the increased number of contractions acts to slow down or to speed up the reading rate is a psychological matter for investigation, and is entirely disregarded here. Thus, when 392 is compared with 47, it is seen that the incidence of two-cell contractions could be about eight and one-third times as great as is the case in grade two. It will therefore be assumed that the density of two-cell contractions would be eight and one-third times as great when using all the possible 392 two-cell contractions than is the case when using the 47 two-cell contractions of English Braille.

It may therefore be expected that the frequency of occurrence of two-cell contractions would be at the rate of (8 1/3) times 25 or about 209 occurrences per page of six-dot braille. This is a somewhat generous assumption, since it is likely that the first 47 two-cell contractions of English Braille have a greater frequency of occurrence than the remaining possible 345 two-cell contractions.

A survey of adult prose material suggests that the occurrence of the capital, italic, letter, and accent signs combined is at the rate of about 15 per page of six-dot braille, grade two. If the fully contracted system of 392 two-cell contractions were used, these composition signs would occur in 751 (that is, 960 - 209) cells instead of in 960 cells, as in grade two braille. At the rate of 15 occurrences in 751 cells, there would be 19 composition signs per page of highly-contracted six-dot braille.

The occurrence of the double capital sign or of the double italic sign might also be taken into account. However, the single capital sign followed by a two-cell contraction can result in a gain of only one, and not two, efficiency units in nine-dot braille. Because these two factors tend partially to cancel each other, and because the occurrence of either is relatively rare, we neglect both factors.

The 209 occurrences per page of two-cell contractions in highly contracted six-dot braille, plus the occurrence of 19 composition signs per page result in a gain of 228 efficiency units when the same material is embossed in "Nine-Dot Braille". As was indicated earlier, a gain of 275 efficiency units is required just to break even. The gain of 228 units of efficiency thus falls short of the break-even point by 47 efficiency units. We must therefore conclude that if the same spacing parameters and the same set of two-cell contractions are used both in six-dot and in "Nine-Dot Braille", six-dot braille still has an advantage over "Nine-Dot Braille" with respect to space requirements.

An alternative suggestion has been made that the "prefix-body" concept be abandoned, and that each nine-dot character be made to represent a contractable combination in its own right. From this point of view no more contractions are available than in the prefix-body concept, and its application can only result in a permutation of the available nine-dot characters for the representation of the desirable contractable combinations.

If each of the spacing parameters is reduced by .010 inches, it would be possible to emboss 42 cells of six-dot braille per line compared with 31 cells of "Nine-Dot Braille" per line. It would also be possible to emboss 27 lines per page in each system. With the new parameters there would thus be 1,134 cells per page of six-dot braille compared with 837 cells per page for "Nine-Dot Braille". Again allowing a loss of 1.6 cells at the end of each line due to the variable length of words and syllables in each system, there would be available 1,091 cells of six-dot braille per page compared with 794 cells of "Nine-Dot Braille" per page and the break-even point would come with a gain of 297 units of efficiency. The increase from 960 cells to 1,091 cells per page represents a gain of about 13.7 per cent. If there are 128 occurrences of two-cell contractions and composition signs using the standard parameters, then, at the same rate, there would be 259 such occurrences using the smaller spacing parameters. "Nine-Dot Braille" would thus provide 259 units of efficiency per page but this is still 38 units of efficiency short of the break-even point. We must again conclude that six-dot braille still remains more efficient than "Nine-Dot Braille" with respect to space requirements even when the smaller parameters are used.

The apparent advantage of "Nine-Dot Braille" over six-dot braille which is evidenced in the sample materials distributed to the conference participants comes from the fact that the nine-dot transcriptions were made using both the smaller parameters as well as a highly contracted system, whereas the six-dot braille with which it was compared used standard parameters together with the standard contractions of Grade Two.

B. COMPARISON OF INTRINSIC AMBIGUITIES IN SIX-DOT AND "NINE-DOT BRAILLE".

As is well known, many of the characters of six-dot braille are intrinsically ambiguous, and that their precise orientation within the cell is often indicated by the placement of a full cell of dots in an adjacent position. In the reading of standard prose material, such ambiguity is almost entirely resolved both by the presence of adjacent characters which serve as orienting symbols, and by the context of the material itself. What role each of these factors plays in the resolution of these ambiguities is not known. We shall here be concerned only with intrinsic ambiguity, and both of the factors which resolve it will therefore be absent.

Characters vary with respect to their degree of ambiguity. Thus a one-dot character has six degrees of intrinsic ambiguity; the letter b has four degrees of ambiguity, since, without orientation and context, it could be taken as dots 1-2, 2-3, 4-5, or 5-6; the letter c has three degrees of ambiguity since, without orientation and context, it could be taken as dots 1-4, 2-5, or 3-6; the letter e has two degrees of ambiguity since, without orientation and context, it could be taken as dots 1-5 or 2-6; the letter m has but one degree of ambiguity, since it can only be taken as dots 1-3-4. It is thus clear that a rating of one constitutes no ambiguity at all. It is proposed, then, to neglect the space, and to rate the ambiguity of each of the remaining 63 characters of six-dot braille and the remaining 511 characters of "Nine-Dot Braille". The average of these ratings, obtained by dividing the sum of the ratings in each system by 63 and by 511, respectively, will then be a measure of the intrinsic ambiguity of each system and these intrinsic ambiguities may then be compared.

We use the letters A, B, and C to designate the dots in the left third of a nine-dot cell from top to bottom, respectively; the numbers from 1 to 6 are used for the remaining dots of the nine-dot cell in complete correspondence with the dot numbering of six-dot braille. In "Nine-Dot Braille" a one-dot character has nine degrees of ambiguity; a character consisting of dots A-B has six degrees of ambiguity since it could be taken as dots A-B, B-C, 1-2, 2-3, 4-5, or 5-6; etc.

While it is possible to assign an ambiguity rating to each character of each system by inspection, it is also possible to develop a formula for this purpose. With each character there is associated a certain number of exterior blank columns and exterior blank rows.

To find the number of exterior blank columns associated with any character, start from the left edge and from the right edge of the cell and count the number of blank columns which are present. For example, the character which consists of dot 1 in six-dot braille has one blank exterior column; the same character in "Nine-Dot Braille" has two blank exterior columns. The character consisting of dots 1-3-4 has no blank exterior columns in six-dot braille, but has one blank exterior column in "Nine-Dot Braille". The character consisting of dots A-C-4-6 in "Nine-Dot Braille" has no exterior blank columns although the middle column is blank. In a similar way, to find the number of exterior blank rows associated with a character, start from the top edge and from the bottom edge of the cell, and count the number of blank rows which are present. For example, the character consisting of dot 1 has two blank exterior rows in both systems, the character consisting of dots 1-3-4-6 has no blank exterior rows in either system even though the middle row of this character is blank.

We let c denote the number of blank exterior columns associated with a character. In six-dot braille, c can have one of the values 0 or 1; in "Nine-Dot Braille" it can have one of the values 0, 1, or 2. Similarly, we let r denote the number of blank exterior rows associated with a character. In both systems r can have one of the values 0, 1, or 2. If R denotes the ambiguity rating for any character, then the formula for R is $R=(c+1)(r+1)$. For example, the character consisting of dot 1 in six-dot braille has associated with it one blank column and two blank rows. Therefore for this character, $R = (1 + 1)(2 + 1)=2 \times 3 = 6$. The same character in "Nine-Dot Braille" has associated with it two blank columns and two blank rows, so that $R = (2 + 1)(2 + 1) = 3 \times 3 = 9$ for this character in "Nine-Dot Braille". The formula for R holds equally well for any rectangular cell such as the two-by-two cell of New York Point and the four-by-two cell of the German shorthand system.

The tables which follow list the 63 characters of six-dot braille and the 511 characters of "Nine-Dot Braille", together with the ambiguity rating of each character in each system. It is found that the average ambiguity for six-dot braile is 2.05 and that the corresponding rating for "Nine-Dot Braille" is 1.72. We, therefore, conclude that "Nine-Dot Braille" has less intrinsic ambiguity than six-dot braille and that the ratio of the ambiguities is 1.72/2.05, or .84; "Nine-Dot Braille" is only .84 as ambiguous as six-dot braille.

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TABLE 1

INTRINSIC AMBIGUITY OF SIX-DOT BRAILLE

NOTE: In the following table the column headed (1) specifies the six-dot braille characters by dot numbers; hyphens are omitted between these numbers. The column headed (2) specifies the ambiguity rating of the corresponding character in column (1).

(1)	(2)	(1)	(2)	(1)	(2)
1	6	123	2	1235	1
2	6	124	2	1236	1
3	6	125	2	1245	2
4	6	126	1	1246	1
5	6	134	1	1256	1
6	6	135	1	1345	1
12	4	136	1	1346	1
13	2	145	2	1356	1
14	3	146	1	1456	1
15	2	156	1	2345	1
16	1	234	1	2346	1
23	4	235	2	2356	2
24	2	236	2	2456	1
25	3	245	2	3456	1
26	2	246	1	12345	1
34	1	256	2	12346	1
35	2	345	1	12356	1
36	3	346	1	12456	1
45	4	356	2	13456	1
46	2	456	2	23456	1
56	4	1234	1	123456	1

Total rating 129
Average rating 2.05

TABLE 2

INTRINSIC AMBIGUITY OF "NINE-DOT BRAILLE"

NOTE: In the following table the column headed (1) specifies the "Nine-Dot Braille" characters by dot numbers; hyphens are omitted between these numbers. The column headed (2) specifies the ambiguity rating of the corresponding character in column (1).

(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
A	9	ABC	3	B36	2	AB12	4	A256	1
B	9	AB1	4	B45	2	AB13	2	A345	1
C	9	AB2	4	B46	1	AB14	2	A346	1
1	9	AB3	2	B56	2	AB15	2	A356	1
2	9	AB4	2	C12	2	AB16	1	A456	1
3	9	AB5	2	C13	2	AB23	2	BC12	2
4	9	AB6	1	C14	1	AB24	2	BC13	2
5	9	AC1	2	C15	1	AB25	2	BC14	1
6	9	AC2	2	C16	1	AB26	1	BC15	1
AB	6	AC3	2	C23	4	AB34	1	BC16	1
AC	3	AC4	1	C24	1	AB35	1	BC23	4
A1	6	AC5	1	C25	2	AB36	1	BC24	1
A2	4	AC6	1	C26	2	AB45	2	BC25	2
A3	2	A12	4	C34	1	AB46	1	BC26	2
A4	3	A13	2	C35	2	AB56	1	BC34	1
A5	2	A14	3	C36	3	AC12	2	BC35	2
A6	1	A15	2	C45	1	AC13	2	BC36	2
BC	6	A16	1	C46	1	AC14	1	BC45	1
B1	4	A23	2	C56	2	AC15	1	BC46	1
B2	6	A24	2	123	3	AC16	1	BC56	2
B3	4	A25	2	124	4	AC23	2	B123	2
B4	2	A26	1	125	4	AC24	1	B124	2
B5	3	A34	1	126	2	AC25	1	B125	2

TABLE 2 (Continued)

(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
B6	2	A35	1	134	2	AC26	1	B126	1
C1	2	A36	1	135	2	AC34	1	B134	1
C2	4	A45	2	136	2	AC35	1	B135	1
C3	6	A46	1	145	4	AC36	1	B136	1
C4	1	A56	1	146	2	AC45	1	B145	2
C5	2	BC1	2	156	2	AC46	1	B146	1
C6	3	BC2	4	234	2	AC56	1	B156	1
12	6	BC3	4	235	4	A123	2	B234	1
13	3	BC4	1	236	4	A124	2	B235	2
14	6	BC5	1	245	4	A125	2	B236	2
15	4	BC6	1	246	2	A126	1	B245	2
16	2	B12	4	256	4	A134	1	B246	1
23	6	B13	2	345	2	A135	1	B256	2
24	4	B14	2	346	2	A136	1	B345	1
25	6	B15	2	356	4	A145	2	B346	1
26	4	B16	1	456	3	A146	1	B356	2
34	2	B23	4	ABC1	2	A156	1	B456	1
35	4	B24	2	ABC2	2	A234	1	C123	2
36	6	B25	3	ABC3	2	A235	1	C124	1
45	6	B26	2	ABC4	1	A236	1	C125	1
46	3	B34	1	ABC5	1	A245	2	C126	1
56	6	B35	2	ABC6	1	A246	1	C134	1
C135	1	AB245	2	BC256	2	ABC345	1	B12356	1
C136	1	AB246	1	BC345	1	ABC346	1	B12456	1
C145	1	AB256	1	BC346	1	ABC356	1	B13456	1
C146	1	AB345	1	BC356	2	ABC456	1	B23456	1
C156	1	AB346	1	BC456	1	AB1234	1	C12345	1
C234	1	AB356	1	B1234	1	AB1235	1	C12346	1
C235	2	AB456	1	B1235	1	AB1236	1	C12356	1

TABLE 2 (continued)

(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
C236	2	AC123	2	B1236	1	AB1245	2	C12456	1
C245	1	AC124	1	B1245	2	AB1246	1	C13456	1
C246	1	AC125	1	B1246	1	AB1256	1	C23456	1
C256	2	AC126	1	B1256	1	AB1345	1	123456	2
C345	1	AC134	1	B1345	1	AB1346	1	ABC1234	1
C346	1	AC135	1	B1346	1	AB1356	1	ABC1235	1
C356	2	AC136	1	B1356	1	AB1456	1	ABC1236	1
C456	1	AC145	1	B1456	1	AB2345	1	ABC1245	1
1234	2	AC146	1	B2345	1	AB2346	1	ABC1246	1
1235	2	AC156	1	B2346	1	AB2356	1	ABC1256	1
1236	2	AC234	1	B2356	2	AB2456	1	ABC1345	1
1245	4	AC235	1	B2456	1	AB3456	1	ABC1346	1
1246	2	AC236	1	B3456	1	AC1234	1	ABC1356	1
1256	2	AC245	1	C1234	1	AC1235	1	ABC1456	1
1345	2	AC246	1	C1235	1	AC1236	1	ABC2345	1
1346	2	AC256	1	C1236	1	AC1245	1	ABC2346	1
1356	2	AC345	1	C1245	1	AC1246	1	ABC2356	1
1456	2	AC346	1	C1246	1	AC1256	1	ABC2456	1
2345	2	AC356	1	C1256	1	AC1345	1	ABC3456	1
2346	2	AC456	1	C1345	1	AC1346	1	AB12345	1
2356	4	A1234	1	C1346	1	AC1356	1	AB12346	1
2456	2	A1235	1	C1356	1	AC1456	1	AB12356	1
3456	2	A1236	1	C1456	1	AC2345	1	AB12456	1
ABC12	2	A1245	2	C2345	1	AC2346	1	AB13456	1
ABC13	2	A1246	1	C2346	1	AC2356	1	AB23456	1
ABC14	1	A1256	1	C2356	2	AC2456	1	AC12345	1
ABC15	1	A1345	1	C2456	1	AC3456	1	AC12346	1
ABC16	1	A1346	1	C3456	1	A12345	1	AC12356	1
ABC23	2	A1356	1	12345	2	A12346	1	AC12456	1
ABC24	1	A1456	1	12346	2	A12356	1	AC13456	1

TABLE 2 (Continued)

(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
ABC25	1	A2345	1	12356	2	A12456	1	AC23456	1
ABC26	1	A2346	1	12456	2	A13456	1	A123456	1
ABC34	1	A2356	1	13456	2	A23456	1	BC12345	1
ABC35	1	A2456	1	23456	2	BC1234	1	BC12346	1
ABC36	1	A3456	1	ABC123	2	BC1235	1	BC12356	1
ABC45	1	BC123	2	ABC124	1	BC1236	1	BC12456	1
ABC46	1	BC124	1	ABC125	1	BC1245	1	BC13456	1
ABC56	1	BC125	1	ABC126	1	BC1246	1	BC23456	1
AB123	2	BC126	1	ABC134	1	BC1256	1	B123456	1
AB124	2	BC134	1	ABC135	1	BC1345	1	C123456	1
AB125	2	BC135	1	ABC136	1	BC1346	1	ABC12345	1
AB126	1	BC136	1	ABC145	1	BC1356	1	ABC12346	1
AB134	1	BC145	1	ABC146	1	BC1456	1	ABC12356	1
AB135	1	BC146	1	ABC156	1	BC2345	1	ABC12456	1
AB136	1	BC156	1	ABC234	1	BC2346	1	ABC13456	1
AB145	2	BC234	1	ABC235	1	BC2356	2	ABC23456	1
AB146	1	BC235	2	ABC236	1	BC2456	1	AB123456	1
AB156	1	BC236	2	ABC245	1	BC3456	1	AC123456	1
AB234	1	BC245	1	ABC246	1	B12345	1	BC123456	1
AB235	1	BC246	1	ABC256	1	B12346	1	ABC123456	1
AB236	1								

Total rating 877
Average rating 1.72