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ABSTRACT

The authors review their work on the role of attentional variables, such as in exploratory hand movements, selection and pickup of haptic shape information in the education of blind students. Efforts to design a technology to permit unobtrusive study of hand movements during braille reading and to link observed differences in scanning to reading ability, comprehension, and stimulus properties (including orthography, syntactic, and linguistic features of the text) are described. A study involving microanalysis of 18 braille readers revealed consistency in hand movement patterns, with better readers using two headed styles more often than one handed styles. Results confirmed that hand movements in braille reading can be reduced to a finite number of microcounts, based on direction and duration of the movement across the braille cell. Larger movement units, such as regressing motions and fixations, appeared to vary with the reader's ability and differences in the stimulus. (CL)

SOME FUNCTIONS OF READING BY HAND[1]

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For the past decade, we have been studying the functions of active touch. Our main interest has been in the role of attentional variables, such as in the exploratory hand movements, selection and pick-up of haptic shape information. The end goal of this study is to develop a more comprehensive theory of haptic perception than is now available.

When I began this research as a graduate student in 1968, we had developed the hypothesis that haptic perception, like visual perception, probably was greatly influenced by experience. I was also persuaded that perceptual learning theory best described the effects of experience on perception. It was also clear to me that many functions of haptic information pick-up may be un- or under-developed in sighted persons due to relative inexperience in employing the haptic modulation and that an accurate view of haptics would result only from studying blind persons.

As our research has progressed, we have maintained this basic theoretical approach to the study of haptics and the blind. I have become increasingly concerned, however, about the gaps in knowledge that exist between existing theory in haptics and applied issues of habitulation and education of blind persons. Our efforts have, therefore, been involved with a dual concern for theory building on the one hand, and addressing these important questions of education of the visually handicapped on the other. This has not been an easy effort as you can imagine, since the gaps are large. But we are making some progress, some of which I should like to relate to you today.

Our early research dealt with exploratory movement effects on perception of haptic two- and three dimensional shape, including both Euclidean and non-Euclidean attributes. The main conclusions reached were as follows:

1. There are several major contributions of exploratory movement to verdical haptic perception, including an orienting of attention to distructive features, and a deceding of those features during the information gathering process. Therefore, what is both learned and remembered about shape properties is in part determined by how they are explored.

2. Proficiency in haptic search varies with perceptual experience and proficient and non-proficient haptic perceivers can often be distinguished on the basis of exploratory movement style.

3. There are similarities in principal between the role of search by hand and by eye, and differences between the means of information pick-up by the two systems may be quantitative and not qualitative.

These early findings with shape attributes promulgated an interest in functions of active handling in more complex perceptual tasks involving haptic form, and especially in braille reading. The variable regulating the perception and comprehension of braille are probably among the most infreqeuntly studied and least understood functions in the domain of haptics. Not only are we unsure of which perceptual and cognitive factors influence braille reading, but there is also little in the way of theory to help organize our efforts to build a solide empirical base.

Obviously, a better understanding of braille reading will aid in designing better reading instruction and reading systems for blind persons - an important applied educational issue. However, braille reading is one of the few tasks of haptics requiring the pick-up of sequentially meaningful information and the understanding of this process is very important for an overall theory of haptic perception - and quite probably for a theory of perception in general.

For the past few years, and with the generous continuing support of the National Eye Institute, we have undertaken a study of haptic reading by blind adolescents. Our interest has been in designing a technology to permit unobtrusive study of hand movements during braille reading and to link observed differences in scanning to reading ability, comprehension and text properties, such as difficulty level, orthography syntatic and linguistic features.

Our research began with a macroanalysis of videotaped recordings of finger and hand movements of a group of 18 braille readers of varying ability, reading passages of varying difficulty levels. This experiment has just been published in Neuropsychologia. Since then, we have been working on a microanalysis of these same reader's hand movements and have gone on to collecting new data using an on-live computerized system developed in our laboratory with the help of John Kennedy. Today, I would like to tell you a little bit about the data collected in the initial 18 subjects.

The subjects ranged in reading ability from grade 4.9 to 14.1 based on the WRAT and were all high school students with average intelligence at the New York State School for the Blind.

The first slide shows our system of data collection. The text was brailled in Grade 2 American on transparent acetate and video taped records made through a mirror beneath the glass of the hand reading the braille (camera 1). Camera 2 was used to verify which fingers actually touched the braille line.

Each subject read four 150 word passages, one each of 2-, 4-, 8- and 12-grade difficulty level, and were tested for retention immediately thereafter. Slides 2 and 3 show the reading errors and retention data, and serve to document that substantial group differences did exist.

We analyzed a large number of movement variables. For each aspect of scanning studied, a scoring system was developed and two independent coders scored the videotaped recordings of hand movements. Although some variables were scored with the tape moving and some, one frame of videotape at a time with the tape stopped, the overall intereader reliability ranged between 89% and 99% agreement.

Our first scoring was for global styles of scanning. Several previous studies, including Critchley and Fertsch, suggested that such styles differed between proficient and non-proficient readers but their analyses were not systematic. We identified four basic styles; three involving two-handed reading and one in which one hand was employed. Slide 4 describes these styles.

Style usage did not vary according to passage difficulty, but was influenced by reading ability, as Slide 5 shows. A substantial preference for using two hands is shown by the better readers, whereas the reverse is true of poor readers. Half of the sample used the same style throughout the 80 or so lines read in the four passages, and only 1/4 of the sample used both one- and two-handed styles. These findings suggest impressive consistency in hand movement patterns, a common finding in other types of form judgements in blinded persons.

We found some interesting differences in regressing movements used by readers. All readers, regardless of ability, appear to use a variety of six styles of movements which review text already scanned, three of which employ one finger and three, two fingers, as described in Slide 6. Sometimes readers use one of these styles to review a portion of text - call it a wordspace - once, a movement we have labelled a single regress; sometimes the same wordspace is reviewed more than once before the finger proceeds forward; and we have labelled this movement a multiple regress.

Slide 7 shows the relationship between forward movement style and regress style utilization. When reading with one finger forward, readers always employ a one-finger regress, regardless of ability. However, better two handed readers tend to regress with the trailing finger only more often than the poorer two handed readers.

A most striking finding resulted when we analyzed frequency and duration of regresses. The mean number of single regresses per subject ranged from 27.87 for the Grade 2 passage to 67.81 for the Grade 12 passage. Multiple regresses were much less frequent, ranging from 4.56 to 14.70. But these data were independent of reading ability. Also, Slide 8 the average single regress duration reading ability; however, poorer readers show much longer multiple regress durations. Slide 9 shows that most of the variance in total reading time is accounted for by passage level differences in amount of time spent regressing, suggesting that regressing movements clearly play a significant role in the reading process. These data also suggest that the role may not be altogether deliterous since all readers' movement is punctuated by numerous single regresses.

To learn what stimulus attributes were being regressed upon, we summarized the relation between regress types and text wordspaces. Slide 10 shows these data for five of the subjects collapsed over reading ability, for two lines of text from each passage where the position of the finger in each video frame was scored. The bulk of single regresses occur over one cell of braille as difficulty of the passage increases, multicell and multiword single regresses are replaced by multiple regresses covering these larger text units. Slide II shows data from these same subjects, but organized from the point of view of text characteristics. These data suggest that orthographic characteristics and not linguistic properties may provoke single regresses. There are not enough multiple regresses to determine any meaningful text-movement relationships yet.

Analyzing the videotapes frame by frame, and comparing one frame to adjacent frames has permitted as to complete a microanalysis of finger movements within each braille cell. We have sampled the position of the finger relative to each braille cell every 33 msec. by placing a grid over the video monitor screen which corresponds to boundries between cells. Whereas the summarization of these data is not yet complete for all 16 readers, I can share some findings with you now. We have found movement in only three directions: forward, backward and return to last point of forward. Each micromovement can occur both with and without interruptions, e.g. pauses or fixations, and the rates of these micromovements vary with whether the reader uses one or two hands. For example, when reading with only the right hand, subjects appear to read a cell without interruption in 165 msec or less. Backward uninterrupted movement is faster, occurring in 132 msec or less. Slide 12 shows a frequency plot of 6 one-handed readers for each of these micromovements, and shows the dramatic separation of uninterrupted and interrupted micromovement distributions. A similar plot of the 10 two-handed readers' right hand revealed that both forward, backward, and return micromovement which was uninterrupted, was faster than for one handed readers by 33 msec for each category. I think this finding may parallel the earlier observation that better readers use two handed styles more often than one handed styles, perhaps because they are more efficient, but I'm not really sure why yet.

When these data are completely summarized we will have a detailed taxonomy of micromovements both by speed and direction which we can apply to larger units of the text, and to other variables such as reading ability and text difficulty. At the same time, we are beginning to collect new data with the help of a digitizer tablet that locates the finger at 10 msec intervals and feeds the co-ordinates directly into a PDR11 on-line computer. These new experiments are designed to vary text features and place specific response requirements on sub-jects in an effort to predict the occurrence of specific components of micro-movement.

In the interest of time, I shall leave the discussion of the general relevance of these experiments to Dr. Foulke. I would like to indicate some important specific conclusions. First, the existance of micro- and macromovements, we identified that appear quantitatively invariant across subject and text variables, seems of considerable theoretical importance. The short-duration, short-span regress, for example, appears consistently in all reader's movement, styles, and may be a basic and essential component of haptic reading. These regresses may serve to briefly expand the perceptual span (referred to in visual reading by Raynor) and reduce the demand placed on STM by the sequential pick-up and integration of braille information.

Fixations also appear to be a constant constituant of movement in haptic reading. It is not possible to tell from the data I've presented today, but subsequent analysis of these data suggest that slower, interrupted movements occur at key points on the line, and may constitute intervals of reading inter-posed between rapid transport movements (uninterrupted micromovements). If this turns out to be the case, then there may be substantial parallels between haptic and visual reading.

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FOOTNOTE

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