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A View on Dyslexia

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Abstract

We describe here, briefly, a perceptual non-reading measure which reliably distinguishes between dyslexic persons and ordinary readers. More importantly, we describe a regimen of practice with which dyslexics learn a new perceptual strategy for reading. Two controlled experiment on dyslexics children demonstrate the regimen's efficiency.

This report describes research done within the Center for Biological and Computational Learning in the Department of Brain and Cognitive Sciences, the Media Laboratory and the Research Laboratory for Electronics at the Massachusetts Institute of Technology.

1 General considerations

By all measures of intelligence and of clinical optics, and by the results of neurological screening, the dyslexic should be able to read efficiently but doesn't, and seems unable to learn the skill in spite of ample tutoring. Although dyslexia is currently thought to be mainly a problem of language ability, especially phonemic awareness, other studies have shown consistent differences in visual perception between dyslexics and ordinary readers. A common ground for all proposed explanations is that a higher order process is involved. Such processes are notoriously hard to qualify. The symptom is definite enough. Common to all dyslexics is the specific weakness of the ability to read in spite of dedicated tutoring. Our approach to the problem has been to address the symptom directly rather than the arguable cause. That is, there should be some measure, aside from scoring a test for reading ability, that suggests a physiology for the expression of the symptom, whatever the remote causes. This is justifiable because, as we will show, dyslexia is a symptom that can be remedied. Our working definition of dyslexia excludes any reference to causes and only describes the symptom. Dyslexia is an unexplained retardation of reading skill in spite of dedicated tutoring and in the absence of any recognizable aberration in vision, neurological assessment or intellectual status.

2 Task-determined visual strategies and lateral masking

In visually guided task performance whatever is important for the performance is salient and considered as foreground; what is not important is indistinct and taken as background. For different tasks different regions in the visual field will assume the foreground/background relation. The distribution of foreground and background is the spatial setting of a visual strategy, while the visual strategy itself is a complex of many cooperative processes (like accommodation, vergence, color identification, motion identification etc.) which are all set for optimizing task performance. An operation which relegates a visual region to be the background is called lateral masking (or crowding). We suggest that lateral masking reduces an ordered arrangement of presented forms to a less definitely perceived aggregate, a visual texture. We hold that lateral masking is actively imposed and its distribution over the visual field is not fixed. That allows different distributions of lateral masking, as determined by optimization of the different task performances. The different distributions of lateral masking we measure by the newly designed form- resolving field (FRF) measure.

3 The form-resolving field (FRF), a perceptual measure

In this measure we present tachistoscopically letter pairs. One letter of the pair is displayed in the center of gaze and the other in the periphery along the horizontal axis. The letters in each pair are different from each other. In twenty successive different pair-presentations the peripheral letter of the pair is presented randomly to the right or left of the center letter. This is repeated with five different angular distances from the center. The subjects are to identify both letters of each pair verbally. At the end of the 100 presentations we plot the average correct recognition of the peripheral letters at each of the ten eccentricities (letter distance and direction). This plot of letter recognition as a function of eccentricity is the FRF. The score of correct recognition of the letters presented in the center is given numerically. Throughout the measurement the duration of stimulus presentations is constant. However, the determination of stimulus duration is made individually for each subject for normalization and to avoid saturation response.

4 How dyslexics and ordinary readers differ in their FRF

Dyslexics differ in their FRF significantly from ordinary readers. The FRF of adult ordinary readers falls off monotonically from the center of gaze to either side; it is symmetric and narrow. That is, best recognition of a letter pair is when the peripheral letter is nearest to the center; recognition falls off rapidly and monotonically with eccentricity. The FRF of adult dyslexics is asymmetric, is not monotonic and it has a dip in the near center on the right and is wide in the direction of reading. That is, recognition of the letter pair when the peripheral letter is nearest to the center on the right is worse than when the peripheral letter is further away in the periphery. Also recognition of the peripheral letter farther in the periphery in the direction of reading is significantly better than on the other side and significantly better than that of ordinary readers (by factor of 2 or 3). We mention the direction of reading because this extension of recognition is to the right for adult English native dyslexics but to the left, for adult Hebrew native dyslexics (Hebrew is read from right to left). We have shown that these measures of the FRF reflect direct measures of the distribution of lateral masking. We also have demonstrated that letters are self masking in that the different distinct parts of a letter mask each other. Thus we take the FRF to be the appropriate measure of the distribution of lateral masking, and can say that adult dyslexics and adult ordinary readers significantly differ in the distribution of lateral masking. The FRF of dyslexic children is similar in its main points to that of adult dyslexics but has some differences. For most dyslexic children the FRF is wide to the right and to the left, and is wider than that of children (or adults) who are ordinary readers. That is, the FRF of children is not significantly asymmetric. Also some of the children do not have the dip in the FRF in near right center as adult do. But as with adults the FRF of dyslexics is significantly wider than that of ordinary readers. That the FRF of ordinary readers is narrow around the center of gaze and falls off sharply with eccentricity argues that readers see clearly words at which they gaze while the surrounding text is unclear due to lateral masking. In this way the reader, by shifting gaze progresses from one word fixation to another. But for dyslexics, words as letter strings are laterally masked where they gaze; while farther in the direction of reading, a large part of the text is much less laterally masked. That is, letter strings or words which are gazed at are perceived texturally as a swarm of elements while at the same time the letter strings in the periphery are perceived as ordered. However, because the FRF in the periphery is wide, words are not perceived in isolation. As a result the dyslexics have great trouble in picking out one word from another in the welter of them, all seen at once, and so cannot read any word in isolation as in ordinary reading. This account tallies with what dyslexics report to us. They say that they "see the whole page" at once, that they "cannot see what is first and second", that "the letters fly all over the page", that "the text is moving". We have found the FRF measure to be a reliable tool for distinguishing dyslexics and ordinary readers whatever the different sub-types of dyslexics: dyseidetic and dysphonetic dyslexics or the P and L dyslexics suggested by Bakker.

5 Learning a new visual strategy for reading

A critical test for the notion of task-determined visual strategies and the notion that the symptom in dyslexia is learned, is to show that dyslexic persons can learn a new visual strategy which provides a marked improvement of reading skills, and that at the same time the distribution of lateral masking (the FRF) changes and comes to resemble that of ordinary readers. We first tested the method and the regimen of practice on four severe adult dyslexics. Within 12 to 20 weeks after the initial testing and starting practice of the regimen, we noted marked improvements in reading skills for all subjects, and at the same time changes of the FRF toward that of ordinary readers. This demonstrated that learning a new visual strategy for reading is possible. It also showed that rapid improvement in reading is accompanied by change of the distribution of lateral masking toward that of ordinary readers. After that we proceeded to formal studies with children.

5.1 a. The Tübingen study

Fifteen children (3rd - 6th grade) from the public school system in Tübingen Germany, were diagnosed as dyslexics after the following tests: an ophthalmologic examination, a standardized reading test (Züricher Lesetest), a handedness preference test and an interview, followed by the form-resolving field (FRF) measure. Their average age was 11 years and they had on average reading deficit of 2.5 grade levels. Six children who were ordinary readers were measured for reference. The dyslexic children had a wider FRF than that of the ordinary readers. Then the dyslexic children were divided into two groups: The reference-dyslexic group (6) which continued the remedial process offered in their school and the experimental-dyslexic group (9) which was given the new remedial regimen proposed in the studies above. The regimen of practice had two complementary parts. The first part was to practice novel, small-scale hand-eye coordination tasks like drawing, painting, clay modeling, etc. The second part was to read (recognize) words in isolation. To this end we asked the children to use a specially designed mask which they laid on the text to be read. The mask was a blank sheet (sometimes a colored transparent sheet) with a rectangular window, cut to be somewhat larger than a long word in the text. The children laid this mask on the text and read the word which appeared in the window. They shifted the mask along the lines of the text and read it word by word. The mask was individually tailored according to the FRF measure. The children performed both activities of the regimen on their own (with an occasional reminder by their parents) and without a structured lesson. They engaged in this practice for an hour (on average) each day. The rationale for this regimen is based essentially on the plasticity of the brain as demonstrated in the works of Held and colleagues and Kohler. We consider that the appropriate visual space (with respect to operations performed in it) is imposed on the content of perception not by volition directly but by practice. Since trial implies action of some sort and learning of hand-eye coordination seemed most obvious from the work of Held and his colleagues, we devised the regimen accordingly. In the second part of the regimen the mask simply substitutes for lateral masking, allowing the dyslexics to perceive words in isolation and cognize their forms. Parts of this regimen were used in the past by various practitioners and therefore might be seen as not new. However, the earlier practices were based on general developmental approach and did not incorporate the two parts. The regimen we suggest here is narrowly directed towards the task of reading and the learning of a particular strategy for it. After 3 months of practicing their separate regimens all the dyslexic children who were in the two groups were retested for reading and the FRF. The experimental-dyslexics improved in reading by 1.22 grade level on average (each individual improved by at least 1 grade level) while the reference-dyslexics improved by 0.17 grade on average (no individual improved more then 0.5 grade levels). Both groups had equal reading time. The form-resolving field (FRF) plots narrowed significantly for the experimental-dyslexics while they changed little for the reference- dyslexics. At the end of the second testing the reference-dyslexics were also given the new regimen of practice. Five months later all the dyslexic children were tested for the third time. The dyslexics who were initially in the reference-dyslexics group and later practiced the regimen improved in reading by 2-2.5 grade levels and their FRF plot narrowed. The experimental dyslexics continued to improve yet further. In summary, before practice of the regimen all the dyslexic children were on average 2.5 grade levels behind their expected one. After 8 months of practice they were on average 0.75 grades behind their expected grade level, which is an average of 1.75 grade levels improvement in reading within 8 months, a rate larger than that of ordinary reading subjects. This study confirmed the applicability of this method for children and the usefulness of the FRF measure. It also showed that improvement under that regimen of practice is rapid.

5.2 b. The Brookline study

Children volunteers from the Brookline (MA) public School system, twelve dyslexics and six ordinary readers, participated in the study, The average age of the dyslexic children was 10.8 years. Every child, accompanied by a parent, was first measured for Letter-Word Identification and for Passage Comprehension from the standardized Woodcock-Johnson Psycho-Educational Battery-Revised, 1989. The dyslexic children were on average 1.8 years equivalent behind the expected standard in the Letter-Word Identification test and 2.0 years equivalent behind in Passage Comprehension. In the combined cluster of these two tests (the Broad Reading cluster) they were 1.9 years equivalent behind. All the children were also measured for their FRF's. The average FRF of the dyslexics was wider than that of the ordinary readers. At the end of these measurements the dyslexic children were assigned to two matched groups by a random process, (matched in age, reading deficit and sex). The experimental-dyslexic group was given our regimen of practice which was similar to the one given to the Tübingen children (above); and the reference- dyslexic group continued their special reading program at school, mainly in phonemic awareness. After 3.3 months all the dyslexic children were measured again for their reading skills (with the same sections of the test as before) and their FRF's. Broad Reading improvement of the experimental-dyslexic group was significantly higher then that of the reference-dyslexics. The experimental-dyslexics improved in that period by an average of 1.8 years equivalent in Broad Reading, compared with improvement, at the same period, of 0.3 years equivalent for the reference-dyslexics. The FRF's of the experimental-dyslexics narrowed significantly, while that of the reference-dyslexics did not change. Then the reference-dyslexics were also given our regimen. The final session of measurements was 3.7 months later; reading skills and the FRF's were measured for all dyslexic children. The ten dyslexic children who practiced the regimen (two reference-dyslexics did not practice) had improved during these 7 months (3.7 months for some) by an average of 2.75 years equivalent in Broad Reading cluster. This is an improvement larger than expected from ordinary readers in the same period. The FRF's of all the dyslexics who practiced the regimen had narrowed after practice.

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