

THE RELATION BETWEEN SPEED OF VISUAL-AUDITORY INTEGRATION AND GENERAL INTELLIGENCE IN DYSLEXICS AND NORMAL READING CHILDREN

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Abstract

We investigated the relationship of general intelligence with visual and phonological processing. German elementary school children diagnosed with developmental dyslexia were compared to a control group in order to determine, whether (a) their reaction times differ for tasks requiring visual-auditory integration and, if so, whether (b) training of these skills using AudiLex® would eliminate the difference, and whether (c) such a learning effect would depend on general intelligence (reasoning) in one or both groups. The relevance of these results is discussed in the dual framework of the discrepancy definition of developmental dyslexia and of the relation between intelligence, speed of information processing, and reading skills.

In 1989, the Journal of Learning Disabilities published a special issue on the relevance of intelligence for different learning disabilities. One of these disabilities was the reading disorder, and was discussed by Siegel, Stanovich, Torgesen and others. According to ICD-10 Standards (Dilling, Mombour, Schmidt and Schulte-Markwort, 2006), in order to diagnose a reading disorder (developmental dyslexia) there has to be a discrepancy between the level of intelligence and the achievement in reading. This implies, in a way, that poor readers with low intelligence (IQ < 70) may read poorly because of their low general cognitive abilities and not because of any developmental reading disability. In these children, training of functions involved in reading would thus have little or no effect on reading skills. On the other hand, many scientists argue that there is no connection between IQ and reading disability (Marx, 2004; Siegel, 1989) and therefore the discrepancy definition does not make sense. Nevertheless, the discrepancy definition is still frequently used to date. If correct, disabled readers with low intelligence would benefit less from training than those with at least normal intelligence, for functions involved in reading.

In 2001, Kujala and her colleagues published a well noticed paper about the plastic neural changes and reading improvement caused by a specific audio-visual training program in dyslexic children. They argued that a phonological deficit may be due to an underlying audio perceptual deficit (Tallal & Piercy, 1973). Kujala and her colleagues found an increased reaction time and a reduced Mismatch Negativity in dyslexics for non-linguistic auditory discrimination, as others did (Baldeweg et al., 1999; Lachmann, Berti, Kujala and Schröger, 2005; for a review see Bishop, 2007). These effects disappeared after a rather short training of auditory-visual integration. For training they used a commercial computer program named AudiLex®, developed by Karma (1999). Kujala et al. (2001) stated that “the factors underlying the beneficial effects of this computer program should be determined in further

studies. In our study to be reported here, one of our aims was to determine whether the effect of the training program AudiLex ®, if there is one, depends on general cognitive abilities in one or both groups.

Method

Participants: There were 27 children from the third and fourth grade of an elementary school in Leipzig, Germany, participating in a study reported elsewhere (Lachmann et al., in prep). While the control group (N=13) followed the normal German school curriculum, the Dyslexics (N=14) attended a special teaching program for reading-disabled children, in which the third grade is extended over two school years. The age ranged from 8 to 10 years. They had been diagnosed with developmental dyslexia one to two years earlier by school psychologists. In order to validate this diagnosis, we tested each child again about two weeks before the program with the Raven Standard Progressive Matrices Test (SPM, Raven J.C. 1979) and the "Salzburger Lese-Rechtschreibtest" (Salsburg reading and orthography test, SLT, Landerl, Wimmer, & Moser, 1997). While the former measures general intelligence but also the ability to incrementally discover transformational rules (Raven 1956), the latter measures the reading ability (frequent word, non-words, chain words, pseudo-word, short text). For Lachmann et al. (in prep), the criterion for developmental dyslexia was an overall reading time 2 SD below the reference population. For control participants performance had to be within 1 SD. Since the relationship between intelligence and reading time was of particular interest in Lachmann et al., no IQ cut-off criterium was used. The Percentage Rank (PR) in the Raven SPM ranged from 14 to 76 in the dyslexic group and from 4 to 99 in the control group.

AudiLex ® computer program: The AudiLex ® training program includes two "games". In both games, the participants will hear various sound patterns, which are represented visually by rectangles arranged horizontally on a computer screen. The auditory patterns are combined by sound elements which will differ in frequency, intensity, duration and number. These patterns are one-to-one visually represented by the rectangles on the screen as follows (see Figure 1):

- (1) *auditory:* frequency; *visual:* location
- (2) *auditory:* intensity; *visual:* size/height
- (3) *auditory:* duration; *visual:* size/width
- (4) *auditory:* number; *visual:* number

The latter group contains only 5% of the items and will thus be neglected from analysis. Here we focus on Game 2. The participant first is given the visual representation of the sound pattern. The first sound element starts after a certain Stimulus Onset Asynchrony (SOA) period. The task is to hit the space bar of the computer keyboard exactly at the moment of onset of the *last* sound element of the pattern. The author of the program (Karma, 1999) argues that in order to solve this task, synchronized visual auditory information processing is needed. It should be mentioned, however, that since some of the sound patterns are symmetrical, the task could, in principle, be solved without any visual information (see Lachmann et al, in preparation).

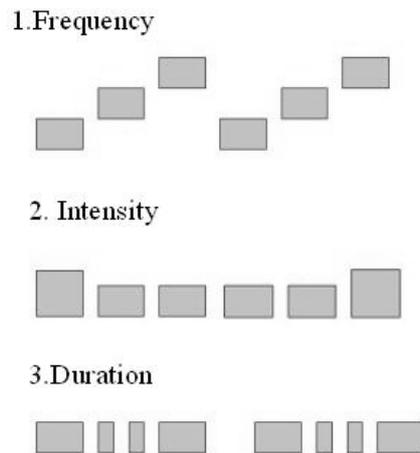


Fig. 1: Three Itemcategories in AudiLex®

The number of rectangles/ sound elements can differ from 3 to 15 per Item. Items longer than 5 sound elements are either a repetition (1) or a mirror image (2) of the first half. Some longer Items can have short pause in the middle (3)

The game accepts as correct any answer given within an interval of 200ms before and 500ms after the onset of the last sound element. After a response within this interval a smiley face is presented on the screen. If the response is out of this range it was considered as “wrong”. In these cases participants will hear the sound elements once again while the corresponding rectangles will change their color, respectively when the corresponding sound element is presented. The author of the programs assumes that the child will learn visual-auditory synchronization by this procedure (see Fig. 2).

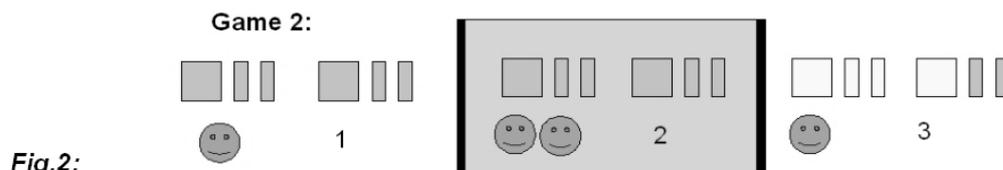


Fig.2:

The participant has to hit the space bar at the same time, the last sound element of the sound patter would be heard. (2) After a correct answer the participant will be rewarded with a smile face and a change in the background colour. (3) After a wrong answer the sound pattern can be heard once more, the correct answer will be marked visually.

Training program: Before training each student was tested with 40 items. Reaction times (RT) were measured for each item between the onset of the last sound element and the reaction (hit of the space bar). These “pre-test” RTs were considered as baseline. The SOA was set to 55% of stimulus duration; pattern presentation speed was set to 500ms.

During a period of four weeks, all children participated in 7 training sessions, in which the AudiLex ® Game 2 was “played” for ten minutes (Game 1 was also trained but those results will be reported elsewhere). Session by session, speed was increased by reducing the presentation time of the elements, stepwise, from 1800 ms to 450 ms. Intervals: 1800ms – 1000ms – 800ms – 700ms – 600ms – 550ms – 450ms. Note that this procedure differs from

the instruction in the program manual, which suggests adjusting speed depending on individual “hit rate”. After the training period a post-test was conducted using the same conditions as the baseline session. The children were rewarded with comical stickers after each session. Their goal was to collect all 7 stickers. All children completed the sessions.

Results and Discussion

We measured “hit rate”, a hit being defined in accordance with the training procedure, as a response given between 200 ms before and 500 ms after the onset of the target, i.e. the final tone. Our independent variables were Category (frequency, duration, and intensity), Training (pre vs. post) and Group (dyslexics vs. controls). An ANOVA revealed a significant main effect for Training ($p < .01$), hit rate was 62 % in the pre-test and 90 % in the post-test. Interactions were found between Category and Group ($p < .05$); controls performed with 83 % in duration conditions, 77 % in frequency conditions, 79 % in intensity conditions; dyslexics performed with 67 % in duration conditions, 74 % in frequency conditions, 74 % in intensity conditions. The interaction likely is due to specific problems of dyslexics with duration items (see Figure 3). There was no interaction between Training and Group, both groups benefit from the training sessions.

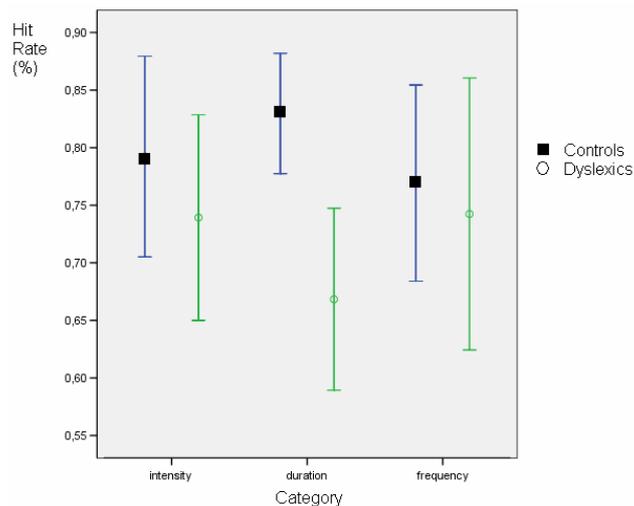


Fig. 3: Interaction between Hit Rate and Category

In order to consider the role of intelligence, a further ANOVA was conducted, using IQ as a co-variate. The pattern of results was as follows. Besides Training, a main effects was found for Category ($p < .05$), due to a lower hit rate for duration items as compared to intensity and frequency items. Furthermore, IQ was found to affect hit rate. IQ and hit rate were positively correlated ($p < .05$). This effect was about equal in both groups (see Figure 4). The results can be interpreted in terms of the perceptual speed theory of general intelligence (e.g. Oswald and Roth, correlation between Raven IQ and perceptual speed, $R > .78$). Because there is no interaction between IQ and Group, this effect seems interdependent from processing deficits underlying developmental dyslexia. Besides the interaction between Category x Group, interactions were found for Category x Training and for Category x IQ. The latter interaction is due to the fact that IQ affects the hit rate in frequency conditions ($R = .53$; $p < .01$) as well as in intensity condition ($R = .47$; $p < .05$), but not at all in the duration condition ($p > .1$).

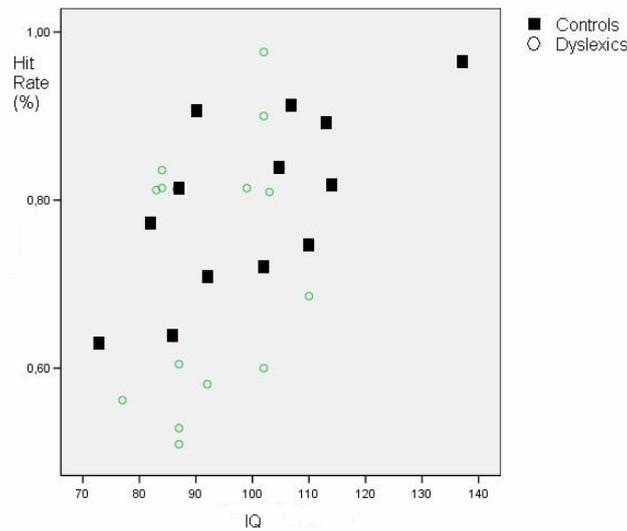


Fig. 4. Correlation between IQ and Hit Rate. For explanation see Text.

Considered the interaction between Group and Category, it seems worthwhile to explore the IQ x Category interaction for each group separately in planned post hoc analyses. These analyses showed that controls replicate the overall pattern of results ($p < .01$) as reported before, whereas dyslexics do not show a correlation between IQ and hit rate in any Category condition ($p > .1$). The Category x Training ($p < .05$) interaction was found to be due to a lower training effect for duration times as compared to frequency and intensity. Figure 5 displays the Category x Training interaction and the Category x Group interaction; there was, however, no triple interaction.

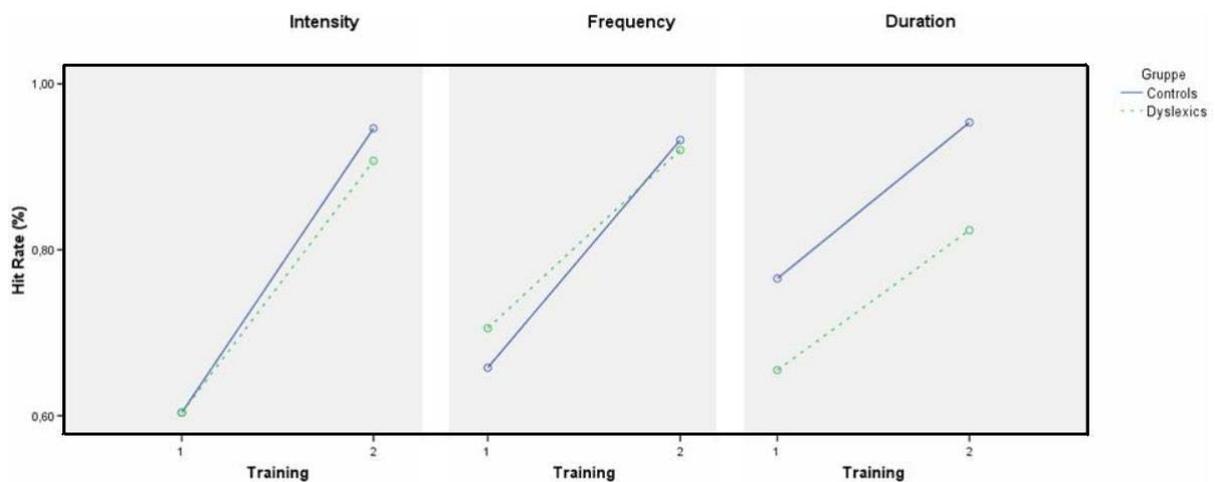


Fig. 5: Category x Training interaction displayed for different groups.

Summary

The study revealed a specific problem that Dyslexics have with duration items in AudiLex[®]. In fact, a group difference in Hit Rate was found only for this condition, and this difference does not disappear with practice. In both groups the effect of training is smaller for duration

items as compared to others. This underlines the specific role of duration items within the training program. The main findings considering intelligence were that IQ, as measured by Raven SPM, affects the Hit Rate for Frequency and Intensity items but not for duration items. Most importantly, concerning the groups our study showed that this pattern was found in Controls whereas in Dyslexics the Hit Rate did not depend on IQ in any of the conditions. These effects, however, were the same in the pre-test as well as in the post-test. Training effects do not depend on IQ in neither of the groups. Altogether, the role of intelligence seems to be much more convoluted than might have been expected. A more detailed discussion will be offered in Lachmann et al. (in preparation)

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