

Special Font For Dyslexia?

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Abstract

Abstract: Reading errors like switching letters is a persistent characteristic of errors for dyslectics (Braams, 2001). This type of error can be explained by the magnocellular theory (Stein, 2001; Stein, Talcott, & Walsh, 2000). The font “Dyslexie” is developed to increase the reading accuracy and readability of texts for dyslectics, so that the errors by switching letters are reduced.

Aim: To examine difference in reading speed and accuracy between dyslectics and normal readers, while reading printed words and non-words in the fonts “Dyslexie” and Arial.

Sample: Twenty-one dyslectic and twenty-two normal reading students participated voluntarily or received European Credits or money

Method: Students read the reading tests EMT and Klepel twice. Once printed in the font Arial and once in the font “Dyslexie”. The order was randomly assigned. In-between the reading tests an auditory task was fulfilled.

Results: No significant difference in speed was measured, but there were some positive and negative effects found for the interaction font and dyslexia on the accuracy for reading words and non-words.

Conclusion: Reading with the font “Dyslexie” does not improve the reading speed for reading words. However some specific type of reading errors are decreased, but others are increased. Overall the dyslectics read fewer errors while reading the words printed in the font “Dyslexie”. Further research is needed to examine the hypotheses that the reading speed and accuracy increases while reading texts that are printed in the font “Dyslexie”.

Keywords: Dyslexia, visual noise, special font, reading ability.

Samenvatting

Samenvatting: Leesfouten zoals het verwisselen van letters is een hardnekkig verschijnsel voor dyslecten (Braams, 2001). Het verwisselen van letters kan verklaard worden door de magnocellulaire theorie (Stein, 2001; Stein, et al., 2000). Het lettertype “Dyslexie” is ontwikkeld om de accuratesse en leesbaarheid van teksten, voor dyslecten, te vergroten. Enkele aanpassingen zijn specifiek gemaakt om verwisselingen van letters te verkleinen.

Doel: Het onderzoeken van de leessnelheid en accuratesse tussen dyslecten en normale lezers van het lezen van woorden en non-woorden in het lettertype “Dyslexie” en Arial.

Proefpersonen: Eenentwintig dyslecten en tweeëntwintig normaal lezende studenten hebben deel genomen op vrijwillige basis of met een vergoeding in European Credits of geld.

Methode: De studenten hebben de leestesten EMT en Klepel twee keer gelezen. Eén keer met het lettertype Arial en één keer met het lettertype “Dyslexie”. De volgorde was willekeurig toegekend. Tussen de twee leesmomenten werd een auditieve taak uitgevoerd

Resultaten: Er waren geen significante verschillen voor de leessnelheid, maar er zijn enkele positieve en negatieve effecten gevonden voor de interactie lettertype “Dyslexie” en de diagnose dyslexie voor de accuratesse van het lezen van woorden en non-woorden.

Conclusie: Het lezen met het lettertype “Dyslexie” heeft geen effect op de leessnelheid. Echter verminderen diverse specifieke leesfouten, terwijl andere toenemen. Over het algemeen maakten de dyslecten minder leesfouten, wanneer ze woorden lazen met het lettertype “Dyslexie”. Vervolg onderzoek is nodig om de hypothesen te testen dat de leessnelheid en accuratesse vergroten wanneer teksten gemaakt zijn met het lettertype “Dyslexie”.

Introduction

Dyslexia is a reading and spelling problem that is seen in every education level and age (Kuijpers, et al., 2003; Vellutino, Fletcher, Snowling, & Scanlon, 2004). The definition of dyslexia states that someone has dyslexia when his or her reading performance is significantly behind what may be expected based on his or her intelligence and the followed reading education and only when there are no neurological damages, that causes the reading disability (Lyon, Shaywitz, & Shaywitz, 2003). It is possible to deal with the disability and compensate the reading- and spelling problems that dyslectics have in daily activities. In the field of dyslexia and specific support for dyslectics there are many solutions to ameliorate the consequences. However a lot of these support methods are not based on scientific research. This is also the case for special dyslectic fonts. These fonts are designed to enhance the readability of texts and the reading accuracy. The current study is to investigate the possible effects of one of these fonts, on the level of word reading by dyslectics.

Phonological theory about dyslexia

When children learn to read, they learn to understand what a phoneme (single sound that represents a letter) and grapheme (single letter symbol) are and which phoneme are linked to which grapheme. During the learning process these skills, called the phonological skills, improve and young children learn to read small words and letters very quickly (Van der Leij, 2003). Yet, children with dyslexia have a hard time mastering the phonological skills, partly because they have trouble with the phonological awareness and phonological processing. Phonological awareness is the understanding and awareness that spoken words consist of individual phonemes, or speech sounds (Van der Leij, 2003). The phonological processing consists of several skills that are used to rhyme, spell and read pseudo words (non existing words). A deficit in the phonological processing can be found in the tasks such as rhyming, non word repetition, phonetic spelling and rapid naming (Snowling, 1998). The phonological core deficit theory explains the phonological problem for dyslectics due to a deficit in the phonological processing (Bradley & Bryant, 1978). Results of the studies by van der Leij and colleagues (Bekebrede, van der Leij, & Share, 2009; de Jong & van der Leij, 2003; van der Leij & Morfidi, 2006) indicated a deficit in phonological skills in Dutch and English for Dutch students learning English (van der Leij & Morfidi, 2006). Van der Leij and Morfidi (2006) also state that the results imply a universal phonological core, due to the pattern that was found for the problems of the phoneme awareness manifesting in Dutch and English. Even though it seems that the phonological awareness of a disabled reader changes and

develops over the years, a phonological deficit remains (de Jong & van der Leij, 2003). People with poor phonological skills can compensate these if they have good orthographic skills (Bekebrede, et al., 2009; van der Leij & Morfidi, 2006).

Orthography and dyslexia

Orthographic skills can be defined as the ability for accessing, storing and the forming of orthographic representations, in the mind (Burt, 2006). The orthographic skills are based on the orthographic and phonological awareness (Vellutino, et al., 2004). Orthographic awareness is the sensitivity to remember where the letters in a written word are placed (Vellutino, et al., 2004) and to recode (novel) letter strings (words) into spoken words, like with reading pseudo words (de Jong & van der Leij, 2003; Siegel, Share, & Geva, 1995). In a study by Siegel, Share and Geva (1995) the orthographic awareness skills of dyslectics was significant higher when compared with the normal readers. The explanation that Siegel et al. (1995) give for their results is that the problems of dyslectics are caused by less integrated orthographic and phonological skills.

Magnocellular deficit theory

Another theory about the cause of dyslexia is the magnocellular deficit theory. This theory states that a deficit in the sensitivity could be explained as a defect in the visual magnocellular system, that causes dyslexia (Vellutino, et al., 2004). The magnocellular system is responsible for the timing and tracking of the eye movements during reading. Research on the effect of deficits in sensitivity of the magnocellular pathways showed that dyslectics have impairments in motion sensitivity (Boets, Wouters, Van Wieringen, De Smedt, & Ghesquiere, 2008; Scheuerpflug, et al., 2004; Talcott, Hansen, Assoku, & Stein, 2000). Talcott and colleagues found a correlation between orthographic skills and the motion sensitivity for the dyslectic subjects, when the sensory sensitivity and word decoding were taken as correlations (Talcott, Hansen, et al., 2000; Talcott, Witton, et al., 2000).

Due to the deficits in the sensitivity of the magnocellular pathways, a dyslectic person may see letters moving over each other (Liederman, et al., 2003; Stein, 2001; Stein, et al., 2000). Switching letters is named as a common type of error for dyslectics (Grossar & Fiddelaers, 2004). Table 1.1 shows an example of the most common reading errors of dyslectics. Reading errors like switching and mirroring letters are made by young readers, but fade away when a reader is getting more experienced. For dyslectics it seems that switching and mirroring errors are persistent (Braams, 2001).

Table 1.1
Examples of Error Types

<i>Name</i> example	<i>Description of the error</i>
<i>Switches</i> (bad – dad)	A letter is switched by another letter that is a resemblance or stands in another place in the word.
<i>Complex vowels</i> (mouse – moose)	A complex vowel consists of two vowels. With this kind of error a complex vowel is switch for another complex vowel or a double vowel.
<i>Open or closed vowels</i> (plan – plane)	A reader reads an open vowel for a closed vowel or a closed vowel is read as an open vowel.
<i>Consonant cluster deletion</i> (twist – twit)	A consonant cluster deletion error is that in a cluster of consonants one of the consonants is deleted/not read.
<i>Deletion</i> (fat – at)	A letter, consonant or vowel, is deleted.
<i>Substitution</i> (pace – space)	A letter, consonant or vowel is substituted.
<i>Read guessing</i> (suspense – dispense)	A word is not well read, but the reader guessed what was written.

The theory about a deficit in the sensitivity of the magnocellular pathway is not supported by everyone. Sperling et al. (2005, 2006) have a different theory about the visual abilities and perception of dyslectics. This theory is called the perceptual noise exclusion theory (Sperling, Lu, Manis, & Seidenberg, 2005, 2006).

Perceptual noise exclusion theory

Sperling and colleague's (2005, 2006) point out that in the research to support the magnocellular theory, the visual stimuli contained visual noise. This visual noise affected the performances. Sperling et al.(2006) mention that signal enhancement and noise exclusion are different mechanisms and that the attention has an effect on the perception of signal enhancement and noise exclusion. To exclude the visual noise the perceptual filter has to be optimized (Sperling, et al., 2006). In the research conducted by Sperling et al. (2005, 2006) visual noise was the factor that dyslectics had trouble with. The dyslectics showed only a higher threshold for the conditions with a level of high-noise, in a motion-perception task with spatial-temporal and motion experiment (Sperling, et al., 2005, 2006). This finding demonstrated that dyslectics do not only have visual problems when there is visual noise for a task that activates the magnocellular path, but also when the parvocellular path is needed for a task (Sperling, et al., 2005, 2006). Results of another

study, which focused on the visual abilities of dyslectics, indicated that the dyslectics had visual impairments in identification of single and triple letters, and adding visual noise did elevate the thresholds (Shovman & Ahissar, 2006). In this study the visual impairments seems to be the result of the reading difficulties, rather than the cause, because there was no relation between the reading scores and the tested visual abilities (Shovman & Ahissar, 2006).

Sperling et al. (2005) also suggest that due to the difficulties in noise exclusion, dyslectics could have trouble with letter recognitions. This presumption is based on the skills that are needed for letter recognition. To recognize a letter it is necessary to abstract all kinds of characteristics of the font that potentially can be labelled as visual noise. The perceptual noise theory states that dyslectics have trouble with excluding noise. In the light of this statement it would be interesting to study the abilities of dyslectics on extracting subtle font characteristics. If some font characteristics can be seen as noise, it could be hypothesized that specific font characteristics make it harder to read with that font, for dyslectics. The question that arises then is: what particular aspects and characteristics of a font may introduce the visual noise?

Fonts

A font consists out of several aspects. Hypothesised by several researchers is that these aspects have an influence on the perception of a font and that the reading speed and accuracy of the readers is influenced by these aspects.

Typeface, size and serifs. There are several studies that tried to determine what aspects introduce visual noise in a font. A series of different experiments, with variation in types of fonts and sizes and reading tasks, by Wilkins and colleague's (Hughes & Wilkins, 2000; Wilkins, Cleave, Grayson, & Wilson, 2009; Wilkins, et al., 2007) showed that children benefit from a larger font. Also older adults (mean age 70) preferred an 14-point font size above the 12-point font size (Bernard, Liao, & Mills, 2001). Besides an impact caused by differences in size and spacing between fonts, there are fonts with a serif and fonts without serif. A serif is the end stroke at a letter, like in the font Times New Roman. For examples of serif and sans serif fonts, see figure 1.

Sans serif font

Typeface: dyslexie / regular, point: 12

The quick brown fox jumps over the lazy dog

Typeface: Arial / regular, point: 12

The quick brown fox jumps over the lazy dog

Typeface: Comic Sans MS / regular, point: 12

The quick brown fox jumps over the lazy dog

Serif font

Typeface: Times New Roman / regular, point: 12

The quick brown fox jumps over the lazy dog

Typeface: Georgia / regular, size: 12

The quick brown fox jumps over the lazy dog

Typeface: Courier New / regular, size: 12

The quick brown fox jumps over the lazy dog

Figure 1. Examples of fonts with and without serif, and size

Researchers on the impact of serifs in fonts are inconclusive in their results. Adults and children read significantly faster with a sans serif font presented at 14-point size (Bernard, Chaparro, Mills, & Halcomb, 2002; Woods, Davis, & Scharff, 2005). Arditi and Cho (2005) found that their own made font with serifs was read slightly faster, than their own made font without serifs. Their explanation for this result was that the font with serifs had a bigger spacing between the letters, which makes letters easier to read (Arditi & Cho, 2005; Bernard, et al., 2002). In another study, which focused on the visual stress caused by the amount of strokes (vertical and horizontal lines) in a string of letters (a word), the reading speed was a little faster for sans serif fonts (Wilkins, et al., 2007). As serifs are like extra strokes on single letters, Wilkins, Smith and colleges (2007) hypothesized that these serifs could be a noise factor in words, because the serif enhances the amount of strokes in a word.

X-height. Another difference between fonts such as, Arial and Times New Romans, apart from the difference in serifs is that the x-height of Arial is larger in the same point size as Times New Romans (Woods, et al., 2005). The x-height in a typeface is the distance between the baseline and the mean line. Research on the effect of the x-height showed that the reading speed was higher when children read a text in a font with an enlarged x-height (Bernard, et al., 2001). This enlarged x-height helps with discriminating between letters with the same appearance (Watts & Nisbet, 1974). However, not every x-height of each letter can be changed. Changing every x-height in a font, erases the discrimination characteristics between letters like ‘o’ and ‘d’ (Watts & Nisbet, 1974). Therefore Watts and Nisbet advised that a change in x-height should be considered per letter.

Distinguishing letters. Changing the x-height could make a letter distinguishable. Another research on making letters distinctive is from Lockhead and Crist (1980). In this study, conducted with children, letters could be distinguished by a dot or a little slash. The distinctive letters were read faster and more accurate by children who just learned to read in comparison with children who already can read (Lockhead & Crist, 1980). Lockhead and Crist (1980) also refer to the benefits of reading with distinctive letters for reading disabled children. These children also read faster and more accurate with distinctive letters. They cite from another research, conducted by them. Lockhead and Crist (1980) concluded their research on distinctive letters by stating that “*The particular letter itself is not intrinsically easy or difficult to classify or to identify; relations among letters determine task difficulty*” (p.493).

As the results above indicate, there is no clear distinction about what the visual noise in a font is. However there are results that indicated that font size, spacing, serifs, x-height and letter distinction have an effect on the reading performances of normal and reading disabled children and adults. The present study will be researching the font “Dyslexie”. “Dyslexie” is a font that is designed to make less reading errors such as mirroring, turning and switching letters in a text (Boer, 2009). Figure 2 gives an example of the font “Dyslexie”.

The quick brown fox jumps over the lazy dog. (point 12)

The quick brown fox jumps over the lazy dog. (point 14)

Figure 2. Example of font "Dyslexie"

The question is if dyslectics and normal readers perform better when reading words printed in the font "Dyslexie", compared with reading words printed in Arial. The performances will be measured in reading speed and the amount of errors. Expected is that a single letter is easier to discriminate and recognize, with the font "Dyslexie". This would make the reading speed go up and the amount of errors decreases. Also the type of errors, like switching letters, is expected to be less with the experimental font "Dyslexie". These expectations are based on the developmental study of the font "Dyslexie" and the positive comments of users who already use the font "Dyslexie" (Boer, 2009).

Based on these expectations the next hypotheses will be tested in this study: 1) The reading speed will be increased when dyslectics read printed words in the font "Dyslexie"; 2) The accuracy will be increased when dyslectics read printed words in the font "Dyslexie"; 3) The reading speed of the normal readers will increase while reading words printed in the font "Dyslexie" and 4) the attitudes of the dyslectics are positive towards the font "Dyslexie". To test the first three hypotheses the reading skills and type of errors of dyslectic students and normal reading students will be tested and compared between the font "Dyslexie" and the font Arial. The last hypothesis about the attitude towards the font "Dyslexie" is included in this study by the advice of Watts and Nisbet (1974). They recommended that a questionnaire would assess the participants' subjective opinions about a font. The expectation for the results of the questionnaire is that the answers of the dyslectics are in favour for the font "Dyslexie". This is based on the positive comments of users of the font "Dyslexie" (Boer, 2009).

Method

Participants

Forty-three students (mean age 21,6, range 19 to 28) of the University of Twente participated in this study. Twenty-one students were diagnosed with dyslexia (13 male and 8 female, mean age 21, range 19 to 25) and twenty-two were normal reading students (10 male and 12 female, mean age 22, range 19 to 28). The dyslectic participants were all diagnosed with developmental dyslexia and had no co-morbid diagnoses like AD(H)D or dyscalculia.

The normal reading students also did not have AD(H)D or dyscalculia.

The study was approved by the ethics committee of the faculty behavioral science. The participants signed an informed consent and received a compensation of € 7,50 or 1 European Credit (EC) for participation. Some participants participated voluntarily.

Material and design

Reading tests: The reading test consists of the Dutch One Minute Test (EMT) (in Dutch: Een Minuut Test) (Brus & Voeten, 1973) and the Klepel (Van den Bos, Spelberg, Scheepstra, & De Vries, 1994). Both the A and B version were used in this study. The EMT is a word reading fluency test which is scored in words read correctly in one minute (raw score). The Klepel is a non-word reading test with two minutes reading time, to read as much non-words out loud as possible. The amount of corrected read words is scored as the raw score. With the Klepel the technical reading aspect is tested. The tests were conducted conform the manual of the EMT and Klepel.

Participants were assigned to one condition. There were four conditions, namely:

- reading first the A version of the EMT and Klepel, printed in Arial, and second the B version of the EMT and Klepel, printed in “Dyslexie”;
- reading first the A version of the EMT and Klepel, printed in “Dyslexie”, and second the B version of the EMT and Klepel printed in Arial;
- reading first the B version of the EMT and Klepel, printed in Arial, and second the A version of the EMT and Klepel, printed in “Dyslexie”;
- reading first the B version of the EMT and Klepel, printed in “Dyslexie”, and second the A version of the EMT and Klepel printed in Arial.

Font: For this study Arial (point size 14, rule liner 23) was used as the standard font. Arial is a common used sans serif font (Woods, et al., 2005) The experimental font is “Dyslexie” (point size 12, rule liner 23) (Boer). “Dyslexie” is developed by making the next adaptations; the base of the letter is heavier (more bold looking), the x-height and openings in the letters are increased, but not the widths, some letters are tilted a little bit, resembling letters differ in their heights and forms (like the belly’s of the b and d), capitols and reading sings are more bolt, and the spacing between the letters is enhanced (Boer, 2009).

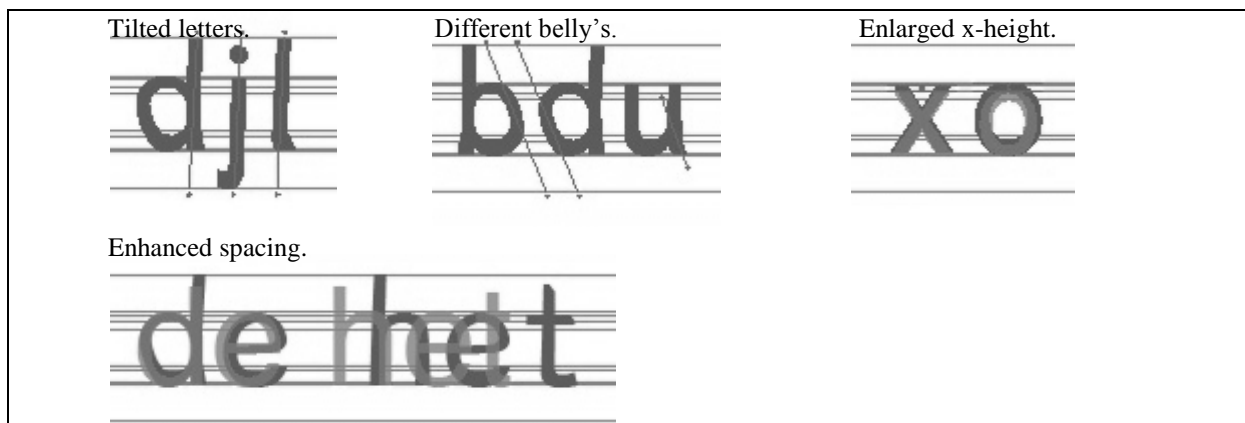


Figure 3. Examples of adaptations for font “Dyslexie”

Auditory task: In-between the reading tests the participants had to fulfill an auditory task on a laptop. The participants needed to discriminate and classify the words /bak/-/dak/ (bin and roof) under three levels of white noise.

Questionnaire: The participants filled out a questionnaire to give their opinion about the font “Dyslexie”. Together with the questionnaire a text printed in “Dyslexie” was given to illustrate the font, see Appendix I for the questionnaire (in Dutch) and Appendix II for the text.

Procedure

The test procedure was equal for all participants and the test was conducted individually. After reading and signing the informant consent, the experiment took place. The participant started with the first reading test, then performed the auditory test, and was subsequently given the second reading test, and ended with the questionnaire about the font “Dyslexie”.

Analyses

This study employed an experimental design with the font as an independent variable within subjects with two levels, and dyslexia and gender as independent between-subjects variables. The dependent variables are the raw score, errors and type of errors on the EMT and Klepel to estimate the reading speed and accuracy of the font “Dyslexie” for word and non word reading, also the errors were labeled with the error type. The labels and type of errors are based on the master thesis of Grossar and Fiddelaers (2004), see table 1.1 for the specific type of errors. A 2x2 (font by version) design was used for the EMT and Klepel, which resulted in four test conditions. The order of the conditions was balanced.

For the analyses the raw scores, amount of errors and specific type of errors, on the EMT and Klepel, were examined by using a repeated measure analyses.

Results

Results of the reading tests

The means, standard deviations and cases per gender, dyslexia and font for the EMT errors and raw score are placed in table 2.1. In table 2.2 are the means, standard deviations and cases per gender, dyslexia and font for the Klepel errors and raw score shown.

EMT, raw score

The raw score is the amount of correct read words. There was no main effect for font on the EMT raw score. There were also no significant interaction effects for the factor combinations font and dyslexia, font and gender and font and dyslexia and gender.

Table 2.1

Statistics per Gender and Dyslexia on the Font Arial and Dyslexie, Based on the Amount of Correct Read Words (Raw Score) on the EMT

EMT, raw score	Arial	Dyslexie	EMT, errors	Arial	Dyslexie
Dyslectics	Mean (SD)	Mean (SD)	Dyslectics	Mean (SD)	Mean (SD)
Man (n=13)	89.15 (16.98)	87.38 (18.71)	Man (n=13)	2.00 (1.29)	1.31 (1.49)
Female (n=8)	65.13 (8.56)	65.25 (1.11)	Female (n=8)	1.25 (1.28)	1.25 (1.39)
Normal readers			Normal readers		
Man (n=10)	88.30 (20.68)	89.10 (19.55)	Man (n=10)	0.80 (1.14)	1.60 (1.71)
Female (n=12)	96.92 (13.95)	96.67 (12.38)	Female (n=12)	0.58 (.79)	0.58 (.52)
All dyslectics (n=21)	80.00 (18.48)	78.95 (19.35)	All dyslectics (n=21)	1.71 (1.31)*	1.29 (1.42)*
All normal readers (n=22)	93.00 (17.45)	93.23 (16.09)	All normal readers (n=22)	.68 (.95)*	1.05 (1.29)*

Note: * p<0.10, **p <0.05

EMT, amount of errors

The analyses for the main effect of font on the EMT errors showed no significant results. There were also no significant interactions between font and gender for the EMT errors. However, a trend was found for the interaction effect between font and dyslexia for the amount of errors on the EMT ($F(1, 39) = 4.00, p = .053$). Subsequent analyses showed that there is an effect for the dyslectics with the font Arial ($F(1, 41) = 8.85, p = .005$), but not with the font “Dyslexie” ($F(1, 41) = .33, p = .564$). The dyslectics ($M = 1.71, SD = 1.31$) made more errors than the normal readers ($M = 0.68, SD = 0.95$) on the EMT with the font Arial.

An interaction effect between font and dyslexia and gender showed a trend for the amount of errors on the EMT ($F(1, 39) = 3.99, p = .053$). A subsequent analysis for separate levels of the factor gender could not be performed for the females, because there was no difference in the amount of reading errors on the EMT. The analysis of font by dyslexia for the male participants showed that there is a significant result ($F(1, 21) = 5.70, p = .026$). Next, effects of the factor font were tested for the normal reading males ($F(1, 9) = 3.69, p = .087$) and for the dyslectic males ($F(1, 12) = 2.43, p = .145$). The normal reading males made more errors on the EMT with the font “Dyslexie” ($M = 1.60, SD = 1.71$), than with the font Arial ($M = 0.8, SD = 1.14$). These results showed that the trend of reading errors for the interaction effect font, dyslexia and gender could be explained by the performances of the normal reading males.

EMT, specific type of errors

The results on the analysis for font, as main effect, showed that there is a trend on the EMT Open or Closed Vowel errors ($F(1, 39) = 3.10, p = .086$). This result could be explained by the fact that there were no open or closed vowel errors made with the font “Dyslexie”. There were no other significant results or trends reported for font effects for the other specific type of errors on EMT.

There was a significant interaction effect between font and dyslexia on the EMT for the error type Complex Vowels ($F(1, 39) = 4.90, p = .033$), see figure 4.

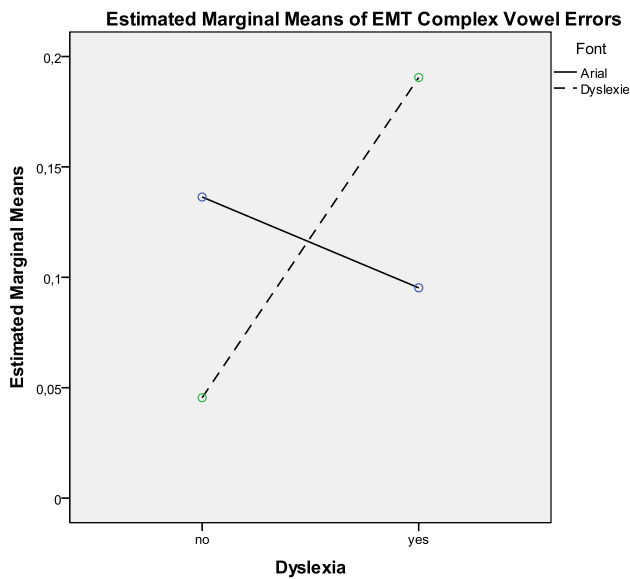


Figure 4. EMT Complex Vowel Errors

Further analysis on the Complex Vowel errors failed to show significant font effects for the normal readers ($F(1, 20) = 1.82, p = .193$), but there was a near trend reported for the dyslectics ($F(1, 19) = 4.00, p = .100$). Subsequent analyses for separate levels of the factor font did not indicate significant results for the dyslectics on the font Arial ($F(1, 41) = .17, p = .683$) or on the font “Dyslexie” ($F(1, 41) = 2.21, p = .145$), see table 2.1 for the M and SD results. This interaction effect between font and dyslexia could be further analyzed when the interaction effect is extended with gender. The interaction effect between font and dyslexia and gender did give a significant result on the EMT Complex Vowel errors ($F(1, 39) = 8.68, p = .005$). Because the analysis of the factors font and dyslexia gave no significant results, the next analysis will start with analyzing the gender factor. There were no significant results for the males ($F(1, 21) = .76, p = .393$), but there was a significant result for the females ($F(1, 18) = 7.16, p = .015$). Subsequently an analysis was conducted for the dyslectic females ($F(1, 7) = 4.20, p = .080$) and the normal reading females ($F(1, 11) = 2.20, p = .166$). Dyslectic females did make Complex Vowel errors, on the EMT, with the font “Dyslexie” ($M = 0.38, SD = 0.52$), but not with the font Arial. This indicated that the significant effect, noted for the EMT Complex Vowel errors, can be explained by the results of the dyslectic females. There were no further significant effects or trends for the interaction effect font and dyslexia or the interaction effect font and dyslexia and gender on the specific type of errors on the EMT.

Klepel raw score

The results for the analyses on the Klepel raw score were not significant. There were also no significant interaction effects.

Klepel amount of errors

The analyses for the main effect of font on the amount of errors read with the pseudo words of the Klepel showed no significant result. There were also no significant interaction effects on the Klepel between font and gender, font and dyslexia, and between font and dyslexia and gender for the amount of errors.

Table 2.2
Statistics per Gender and Dyslexia on the Fonts Arial and Dyslexie, Based on the Amount of Correct Read Words (Raw Score) on the Klepel

Klepel, raw score	Arial	Dyslexie	Klepel, errors	Arial	Dyslexie
Dyslectics	Mean (sd)	Mean (sd)	Dyslectics	Mean (sd)	Mean (sd)
Man (n=13)	75.00 (16.75)	77.38 (20.86)	Man (n=13)	7.46 (5.19)	7.69 (4.03)
Female (n=8)	53.75 (15.31)	50.38 (13.67)	Female (n=8)	6.75 (6.84)	6.75 (6.14)
Normal readers			Normal readers		
Man (n=10)	89.30 (22.18)	84.90 (22.91)	Man (n=10)	4.30 (2.83)	3.70 (2.91)
Female (n=12)	98.75 (18.99)	98.25 (16.25)	Female (n=12)	4.00 (2.86)	4.67 (2.31)
All dyslectics (n=21)	66.90 (19.03)	67.10 (22.52)	All dyslectics (n=21)	7.19 (5.72)	7.33 (4.81)
All normal readers (n=22)	93.00 (17.45)	92.18 (20.24)	All normal readers (n=22)	94.45 (20.56)	4.23 (2.58)

Note: *p <0.10, ** p<0.05

Klepel specific type of errors

When analyzing the specific type of errors made on the Klepel two trends were shown for the interaction font and dyslexia. The first trend was for the Substitution errors ($F(1, 39) = 3.12, p = .085$). A second analysis of the trend on the Substitution errors, with dyslexia as factor, showed that there is a significant result for the dyslectics ($F(1, 39) = 4.49, p = .048$), but not for the normal readers ($F(1, 20) = 0.26, p = .617$), see figure 5. The dyslectics make

les Substitution errors, on the Klepel, with the font “Dyslexie” ($M = 0.95$, $SD = 0.28$), than with the font Arial ($M = 1.33$, $SD = 0.31$).

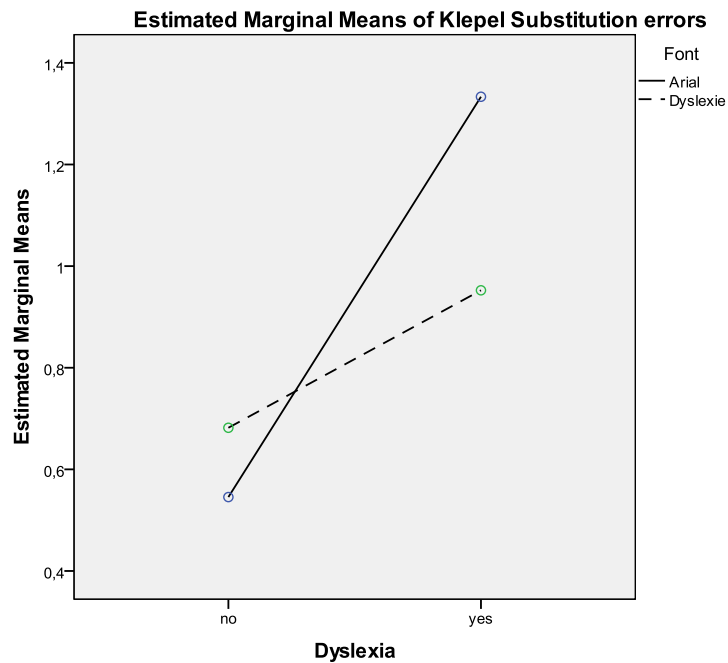


Figure 5. Klepel Substitution errors

The second trend noted with the analysis of the interaction effect between font and dyslexia, was a trend on the Read Guessing errors ($F(1, 19) = 3.29$, $p = .077$). Further analysis was conducted with dyslexia as factor. There was a significant result for font for the dyslectics ($F(1, 19) = 5.37$, $p = .032$). Figure 6 indicates that the dyslectics made more Read Guessing errors with the font “Dyslexie” ($M = 1.62$, $SD = 0.44$), than with the font Arial ($M = 1.00$, $SD = 0.32$).

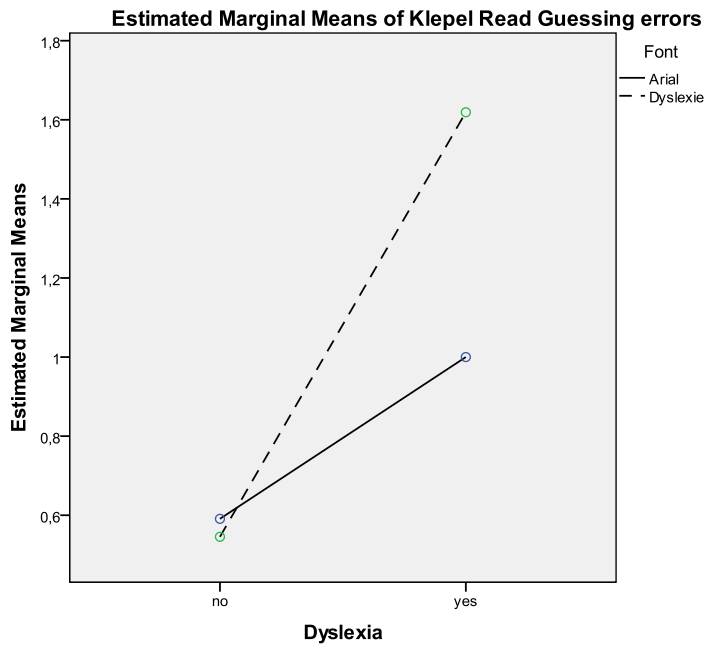


Figure 6. Klepel Read Guessing errors

There were no other significant results or trends found when analyzing the specific type of errors on the Klepel with the interaction effect font and dyslexia.

A font and gender interaction was shown on the Klepel Substitution errors ($F(1, 39) = 4.64, p = .037$). To test the effect of the factor gender, a further analysis was conducted. The results showed that there was a trend for the female participants ($F(1, 18) = .43, p = .053$). The results indicated that the females made less errors with the font “Dyslexie” ($M = 0.65, SD = 1.09$), than with the font Arial ($M = 1.15, SD = 1.42$).

Other effects could not be noted in the analysis of the specific type of errors made on the Klepel for the interaction effects between font and gender, and font and dyslexia and gender.

Results of the questionnaire

As mentioned before, we were not only interested in factual data, but we also wanted to know what the opinions of our participants were about the font “Dyslexie”. As we hypothesized, we expected that the answers on the questionnaire are in the favor of the font “Dyslexie” for the dyslectic participants.

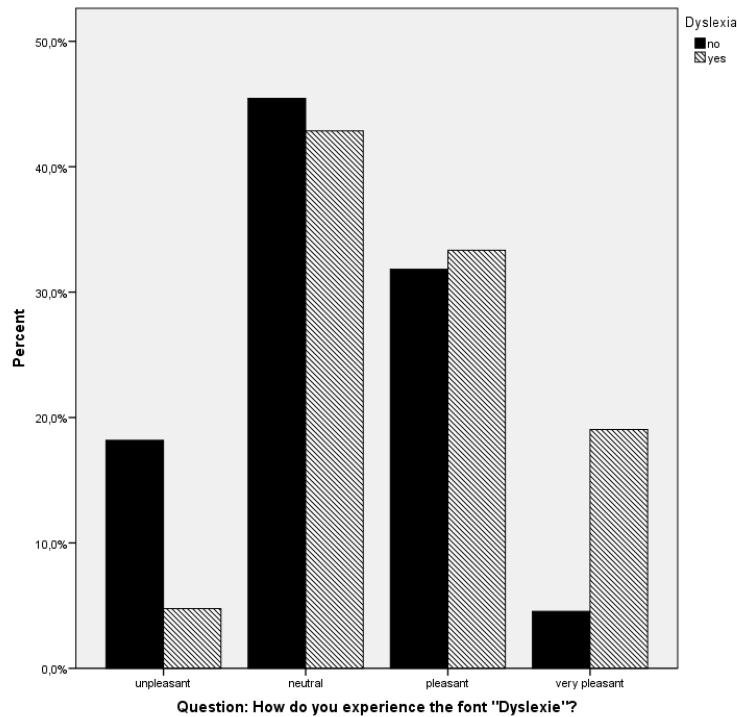


Figure 7. Responses on the question “How do you experience the font “Dyslexie”?”

The results on the question “How do you experience the font “Dyslexie”?” were measured separately for the dyslectics and normal readers, to test the hypothesis that the dyslectics respond in favor of the font. As figure 7 indicates there is a difference in the experience of the font “Dyslexie”. The dyslectics have a more positive attitude towards the font “Dyslexie”, than the normal readers. However the responses of the dyslectics on the question “Would you use the font “Dyslexie”?” were near equal in the responses ‘yes’ and ‘no’.

Discussion and conclusion

This study examined the following hypotheses: 1) The reading speed will be increased when dyslectics read printed words in the font “Dyslexie”; 2) The accuracy will be increased when dyslectics read printed words in the font “Dyslexie”; 3) The reading speed of the normal readers will increase while reading words printed in the font “Dyslexie” and 4) the attitudes of the dyslectics are positive towards the font “Dyslexie”. The first three hypotheses were tested via comparison of the reading speed and accuracy of dyslectic and normal reading students on the reading tests EMT and Klepel, with Arial as the standard font and “Dyslexie” as the experimental font. The fourth hypothesis was tested via a questionnaire about the subjective opinions of the font “Dyslexie”.

The results of this study do not confirm hypotheses 1 and 3. The results indicated that neither the dyslectics nor the normal readers did increase their reading speed significantly while reading the words on the EMT and Klepel with the font “Dyslexie”.

The results of the analysis showed that hypothesis 2 is partially supported. The dyslectics made fewer errors, then the normal readers, on the EMT with the font “Dyslexie”. This is an indication that reading with the font “Dyslexie” decreases the amount of reading errors. The results of the analyses of the interactions between font and dyslexia and the interaction between font and dyslexia and gender showed that the normal reading males made more errors on the EMT with the font “Dyslexie”. This assumes that the font “Dyslexie” is only beneficial for dyslectics and that there is no evidence for hypothesis 3.

There is support for hypothesis 4 however a contradiction in responses was noted. Where as the attitudes towards the font “Dyslexie” are positive for the dyslectics they would not use the font. One of the most given explanation is that the font “Dyslexie” would not be accepted by teachers or other students.

The question that arises is which of the adaptations, that created the font “Dyslexie”, has a positive effect on the decreasing of reading errors for the dyslectics? Or are there other explanations for the results of this study?

Adaptations in a font

The literature is inconclusive about the factors of font adaptation. One of the font characteristics of “Dyslexie” is that the font has an enlarged x-height. Literature indicated that increasing the x-height could increase the reading speed (Bernard, et al., 2002; Watts & Nisbet, 1974; Woods, et al., 2005). However, the literature also points out that changing the x-height for every letter has a counter effect. Several letters are harder to discriminate from each other when their x-height is changed. If all letters or the letters that are less characteristic have an enlarged x-height, the reading speed is likely to decrease (Watts & Nisbet, 1974). We cannot state that the adapted x-height is the cause for the amount of errors made by the normal reading males on the EMT. However for a follow up study it would be interesting to research the readability with x-heights that have been changed.

There were also adaptations made in the font “Dyslexie” to increase the specific reading error of switching and mirroring letters. These adaptations were made to decrease the chances of switching or mirroring letters that look alike. The analysis on the specific type of errors indicated that neither the dyslectics, nor the normal readers did make less

switching errors with the font “Dyslexie”, there were also no significant differences between the dyslectics and normal readers for the amount of switching errors. These results are in line with the results of Hutzler, Kronbichler et al. (2006) and Vellutino et al. (2004). They did not find any differences in the processing and reading of letter strings, words and pseudo words and the accuracy for dyslectics.

It would be speculation to explain the performances with the font “Dyslexie” due to the heavier base or x-height adaptations. The literature indicates that there are negative effects of the x-height (Watts & Nisbet, 1974), but there is no literature about the effects of heavier bases of letters. Furthermore in this study the font “Dyslexie” was tested and not the effects of the separated adaptations that are used to make the font “Dyslexie”. Therefore it is not possible to say that changing the x-height or the characteristics of a letter caused the decrease in the amount of errors, like the open or closed vowel or substitution errors for the dyslectics. Or that those adaptations were the reason for the increase of the amount of complex vowel errors for the dyslectic females. A follow up study would be necessary to study the effects of adaptations in a font on the reading speed and accuracy.

Other explanations

Gender differences. The literature review of Wallentin (2009) showed that studies of gender differences for verbal abilities and language cortex did not find a difference, or the differences that were found, were close to 0% (Wallentin, 2009). Based on these results it is stated that no clear explanations or reason based on gender differences can be given in the current study.

Dyslexia. Research pointed out that dyslectics make more complex vowel errors, than normal readers (Grossar & Fiddelaers, 2004). Therefore the differences between the dyslectics and normal readers could be explained by the characteristic errors that dyslectics make.

The results of the specific type of errors for technical reading indicated that the dyslectics made more guessing errors with the font “Dyslexie”. This result could be explained by the possibility that the dyslectics used the strategy of guessing while reading the pseudo-words in the font “Dyslexie”. The combination of pseudo-words and the font “Dyslexie” could have caused an overload of the reading skills of the dyslectics. This could be explained by the fact that dyslectics have a hard time reading pseudo-words (Braams, 2002) and that some of the

adaptations in the font “Dyslexie” are not increasing the readability of words and that thereby the dyslectics made more guessing errors, than the normal readers.

Using a special font

The results of the questionnaire indicated that the dyslectics in this study were positive about the font “Dyslexie”. These results supports hypothesis 4. This is an important factor for the decision of using a font or not (Watts & Nisbet, 1974). If the font would work, but the users would not like it, the chance that the font would be used is very small.

What was interesting in the responses of the dyslectics is that they would not use the font, because other people, who would have to read their work, would not like the font. This gives the impression that dyslectics are adapting to others, instead of ask for understanding of the use of an adapted font, so that a dyslectic can cope with his/her handicap.

Future research and design options

The development of the font “Dyslexie” was especially made for texts (Boer, 2009). This study was conducted with words. A follow up study with sentences and texts, printed in the font “Dyslexie” could give information about the reading speed and accuracy on text level.

This study did not measure the orthographic skills of the participants and the reading comprehension for reading with the font “Dyslexie”. An extra between-subject variable that could be taken in consideration for further research is the orthographic skills. This would be interesting when taking in consideration that the orthographic skills effects the reading skills (Siegel, et al., 1995). Also a second study could research the reading skills and reading comprehension of texts with the font “Dyslexie. The reading could be read aloud or silence. A study as proposed here, could test the hypothesis that the reading of a font with an expected higher readability increases the reading comprehension, because the focus of the technical part of reading decreases. Also further research with the font “Dyslexie” and the increase of the guessing errors on technical reading could be interesting. This because the question arises that if a dyslectic reader is making more guessing errors; the reading comprehension could be expected to be different.

Another variation for a follow up study would be to take different ages and education level. The participants in this study were university students. This could have influenced the results, because the participants of the current study have more reading experience than other participant groups of different age and education levels. The performances of the participants can be explained from the results of a study on life-span reading. This study indicated that the

word-reading speed keeps increasing when dyslectics get older (van den Bos, Zijlstra, & Spelberg, 2002). Another study indicated that the education level of a dyslectic has an influence on their word-reading speed, which could be explained by the amount of reading that is necessary for the higher education levels (Kuijpers, et al., 2003). Therefore future research with different age and education levels are necessary to study the possibilities of the font “Dyslexie”.

Another type of additional research could focus on the effects that single font adaptations have on the reading speed, accuracy and readability of words en texts for dyslectics and normal reader.

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Appendix I
Questionnaire

Vragenlijst

Bedankt voor uw deelname aan dit afstudeeronderzoek.

Dit onderzoek dient om de effecten van speciaal ontwikkelde lettertypes voor mensen met dyslexie in kaart te brengen.

Er zijn bij u twee versies van dezelfde testen afgenomen, naast een verschil in de woorden was er ook een verschil in lettertype.

Graag zou ik van u willen weten wat u van het lettertype "Dyslexie" vond. In de bijlage ziet u nog eens een stuk tekst met het speciale dyslexie lettertype. Bestudeer deze gerust nog even, voordat u uw mening geeft.

Hier volgen nu enkele vragen over het dyslexie lettertype. Omcirkel het antwoord wat het meest voor u van toepassing is.

Vindt u de tekst makkelijker leesbaar in het speciale dyslexie lettertype?

Ja

Nee

Hoe ervaart u het lettertype?

Zeer onprettig

Onprettig

Neutraal

Prettig

Zeer prettig

Ervaart u het lettertype als rustig?

Ja

Nee

Wordt u sneller vermoeid na het lezen van een tekst in dit lettertype?

Ja

Nee

Heeft u het idee dat u meer leesfouten maakt met dit lettertype?

Ja

Nee

Heeft u het idee dat u sneller leest met dit lettertype?

Ja

Nee

Zou u het lettertype zelf gebruiken, als u het tot uw beschikking heeft?

Ja

Nee

Nogmaals bedankt voor uw medewerking. Het onderzoek zit er nu volledig op.

Als u nog vragen heeft kunt u deze stellen aan de onderzoeker of e-mailen naar

renskeria@gmail.com

Als u op de hoogte gehouden zou willen worden van de vorderingen en resultaten van het onderzoek kunt een e-mail sturen naar bovenstaand adres.

Als u nog opmerkingen heeft kunt u deze hieronder noteren

Appendix II

Text for the questionnaire

Vrijwilligerswerk tijdens vakantie wint aan populariteit

Gebaseerd op: nrc.next (20-1-2009)

Een lekkere vakantie waarbij je ook nog tijd vrij maakt voor een goed doel is de nieuwste trend op reisgebied. Volgens Lucas Meijs, bijzonder hoogleraar vrijwilligerswerk aan de Rotterdam School of Management van de Erasmus Universiteit, wordt vrijwilligerswerk tijdens de vakantie steeds populairder. `Het Vrijwilligerstoerisme, het voluntourism, is onderdeel van een hele grote trend. Lonely Planet heeft zelfs een gids gemaakt: *Volunteer: A Travellers Guide*.`

Reisorganisatie Fox Reizen gaat mee in de trend met Fox Feel Good. De reisorganisatie biedt de luxe en rust van een vakantie en combineert die met het goede gevoel van vrijwilligerswerk. Fox is de nieuwste in een reeks van reisbureaus die soortgelijke reizen aanbiedt. Een andere speler, het ideële Commundo, biedt reizen aan waarbij men twee weken werkt en de laatste week rondreist door het land. Travel Active richt zich op jongeren; zij bieden taallessen, vrijwilligerswerk en excursies in één reis.

De meeste touroperators werken met particuliere organisaties. De grote goede doelen, zoals Unicef, Oxfam Novib en SOS-Kinderdorpen, hebben hierbij hun bedenkingen.

`Ontwikkelingssamenwerking is een complex vak. Wij werken met kinderen, dan moet je echt weten wat je doet. Vooropgesteld zijn het goed bedoelde initiatieven. Maar hoe

goed je het ook bedoelt, het blijft pleisters plakken`, aldus Martin de Beer, woordvoerder van Unicef.

(bron: <http://www.profnews.nl/903771/vrijwilligerswerk-tijdens-vakantie-wint-aan-populariteit>)

Appendix III
Frequencies of Responses on the Questionnaire

Question: Do you find the text easier to read with the font "Dyslexie"?

Dyslectic participants

42.9% yes, 52.4% no, 4.8% no response

Normal reading participants

36.4% yes, 59.1% no, 4.8% no response

Question: How do you experience the font "Dyslexie"?

Dyslectic participants

0.0% very unpleasant

4.8% unpleasant

42.9% neutral

33.3% pleasant

19% very pleasant

Normal reading participants

0.0% very unpleasant

18.2% unpleasant

45.5% neutral

31.8% pleasant

4.5% very pleasant

Question: Do you experience the font "Dyslexie" as low-key?

Dyslectic participants

71.4% yes, 28.6% no

Normal reading participants

45.5% yes, 54.5% no

Question: Do you get tired faster while reading with the font "Dyslexie"?

Dyslectic participants

4.8% yes, 90.5% no, 4.8% no response

Normal reading participants

18.2% yes, 81.8% no

Question: Are you under the impression that you make more reading errors with the font "Dyslexie"?

Dyslectic participants

9.5% yes, 85.7% no, 4.8% no response

Normal reading participants

22.7% yes, 77.3% no

Appendix IV
Comments of Participants on the Font “Dyslexie”

Quotes from normal reading participants:

P. 5 “I did not notice the differences between the fonts, only when the researcher told me that there were two fonts. The experimental font has more space between the letters, there for it seems to read easier.”

P. 17 “The experimental font is unsteady. I have to concentrate to read the words. This is probably an effect of the unfamiliarity with the font.”

P. 18 “The experimental font is fidgeted, but readable. Yet I do not notice a difference while reading.”

P. 24 “This special font for dyslectics is to get dyslexia! It is too messy.”

Quotes from dyslectic participants:

P.38 “I use the standard fonts, because they are recommended by the university and everybody uses them.”

P.10 “The experimental font is unstable.”

P.42 “With the experimental font I could read longer.”

P.14 “I would like to use this font on text level, I think that works best.”

P.9 “The experimental font looks messy, like someone should buy a new printer.”

P.32 “I like the spacing between the letters and the words in the font. But I do not like the thickness at the bottom of the letters.”

P.28 “The letters are much clearer!”

P.36 “Where can I get the font? I would like to try it on a longer time space, to see what the effect is.”
