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Effects of the design of written music on the readability for children with dyslexia

Nanke Flach
University of Groningen, The Netherlands

Anneke Timmermans
University of Groningen, The Netherlands

Hanke Korpershoek
University of Groningen, The Netherlands

Abstract

This study investigates the relationship between the design of written music and the number of mistakes dyslexic and non-dyslexic children make in reading music is investigated in this study. Previous research shows that children with dyslexia experience difficulties with reading music, especially discerning pitch. Common mistakes of dyslexic students are third-transpositions. Based on insights from previous studies, a questionnaire was developed with several design adaptations of written music. The questionnaire was filled out by 72 Dutch children aged between 8 and 13 years. The results show that children with dyslexia did make significantly more mistakes in reading pitch than non-dyslexic children. The number of mistakes was reduced by enlarging the staves and also by writing all the stems of the notes in the same direction. Using differently-coloured lines in the staff did not reduce the amount of mistakes and was in some cases counterproductive.

Keywords

dyslexia, layout adaptations, music education, pitch, written music

Children with dyslexia can encounter difficulties not only in school education, but also in music education. Most of the research on dyslexic students has focused on the problems those students face in school, particularly with respect to reading and writing. In the reading and writing development of

Corresponding author:
Anneke Timmermans, University of Groningen, Grote Rozenstraat 3, 9712 TG Groningen, The Netherlands.
Email: a.c.timmermans@rug.nl

dyslexic students several complications may occur, including phonological deficits, problems with verbal and working memory, visual and auditory perception, automatization, and spatial attention (British Dyslexia Association, 2014; Lorusso, Facoetti, & Bakker, 2011). Similarly, students with dyslexia may encounter problems in learning to read musical notation (Ganschow, Lloyd-Jones, & Miles, 1994; Gromko, 2004; Jaarsma, Ruijssenaars, & Van den Broeck, 1998; Oglethorpe, 2002), because the fundamentals of successful text reading are essentially the same as for music reading (Gudmundsdottir, 2010; Hubicki & Miles, 1991). Prior research shows that, on average, dyslexic children make more mistakes in music reading than non-dyslexic students (Jaarsma et al., 1998). A substantial part of these mistakes are so-called third transpositions, that is, reading notes a line or space too high or low. For example, "B" is read when "G" is written down. Notably, these mistakes were made more often for notes written *in* the staff than for notes written above or under the staff. In contradiction, typical mistakes of non-dyslexic students are second transpositions, that is, confusing a note with one immediately above or below it. In addition, dyslexic children need more time to learn reading music than non-dyslexic children (Jaarsma et al., 1998). Hence, dyslexic children will encounter various difficulties with reading musical notation in comparison with their non-dyslexic counterparts. The aim of the current study is to investigate the association between the design of written music and its readability for dyslexic and non-dyslexic students, by applying several small adaptations to the design of written music. The goal is to provide music teachers with suggestions that they can apply when their (dyslexic) students encounter difficulties with reading written music. The nature of music reading and possible causes of problems with music reading encountered by dyslexic students are described in the following literature review, as well as possible design adaptations of written music.

Music reading

Music reading is a complex sub-skill of musical performance (Hubicki & Miles, 1991) that is learned through explicit tutoring (Hébert & Cuddy, 2006) and usually forms a starting point in instrumental music instruction (Gudmundsdottir, 2010). Besides that, a large part of existing music is published as sheet music and therefore being able to read music contributes to the students' independence in learning new music. However, we still know relatively little about how music reading is acquired and about music-reading deficiencies (Hébert & Cuddy, 2006).

There are several reasons why dyslexic children can experience difficulties with reading written music. First, dyslexic students can have difficulties with automatizing the general principles of written music. In Western musical notation, both pitch and rhythm can be written down precisely. However, the intuitive interpretation of musical notation is not always consistent with the actual meaning of the notation (Tan, Wakefield, & Jeffries, 2008). For example, the direction of the stem of a note does not influence the pitch. Usually, stems from notes written high in the staff are written down, and vice versa. However, in the study of Tan et al. (2008), many respondents thought that the direction of the stems would affect the pitch. This example shows that, to be able to interpret Western musical notation, it is necessary to know the general practices and rules of written music (Hubicki & Miles, 1991).

Second, music reading differs in several ways from text reading that may lead to difficulties for dyslexic students. Written music contains an important spatial component (Sloboda, 1980), which is of less significance in text reading (Sergent, Zuck, Terriah, & MacDonald, 1992). Whereas text reading proceeds sequentially (i.e., horizontally) music reading proceeds both sequentially and simultaneously (i.e., vertically). Unlike text reading, music reading involves decoding the vertical dimension (pitch) over time (Hébert & Cuddy, 2006). The importance of this spatial component of music reading became very clear in the study of Gromko (2004), who investigated differences in the music-reading performance among US secondary school students. It was found that 48% of the differences between students in music reading were related to rhythmic imagination, text understanding in normal reading, recognizing visual patterns in written music, and spatial-temporal reasoning. This important spatial component might be particularly challenging for dyslexic students, as these students sometimes have specific difficulties discriminating between left and right, high and low, and between rising and descending patterns (British Dyslexia Association, 2014; Jaarsma et al., 1998; Oglethorpe, 2002). The finding that students with dyslexia make more mistakes, and, typically, third transpositions suggests that dyslexic students are less sensitive to the crucial position of the notes on the lines (Jaarsma et al., 1998). Students with dyslexia may be able to see whether a note is on a line or in a space, but they cannot quickly work out which line or space (MacMillan, 2004). Notwithstanding the importance of these findings, to our knowledge, the attention given to music-reading difficulties among students with dyslexia in the literature remains limited.

Design adaptations of written music for dyslexic students

Unfortunately, only a few scientific studies have been published on suitable design of written music for dyslexic people. Nevertheless, some music teachers have experimented with different designs for dyslexic students and have described their experiences. These adaptations of written music concentrate on using colour and size of written music, and thereby offering support in the spatial component of music reading, the discrimination between high and low, and between rising and descending patterns (Hubicki & Miles, 1991). Using colour is a well-known phenomenon in music-reading research; however, it is mainly investigated in the context of beginning musicians (Kuo & Chuang, 2013). Specifically for dyslexic students, Hubicki developed a programme called Coloured Staff to stimulate the recognition of visual patterns by means of colour (MacMillan, 2005). However, we have not yet found evidence for the effectiveness of this programme. A different modality of using colour was described by O'Brien, a music teacher with dyslexia. O'Brien declares in her study "Adapting music for students with dyslexia" (2004) that printing music on coloured paper can help. She further suggests using exercise books in which important information and new concepts are coloured in, to make it easier to recover important information. Another example of colouring in important information is the study conducted by Rogers (1991), an experimental investigation of the use of coloured-in notes. In the experimental condition, every pitch in the sheet music received a different colour, whereas in the control condition, the usual black and white sheet music was used. Although not statistically significant, students in the experimental condition performed better when reading the coloured-in notation than students in the control condition did when reading the common notation. An interesting result was found for a small group of students with learning disabilities included in this study whose results in the coloured-in notation were very similar to those of the students without learning disabilities, while they made a lot more mistakes when reading the common notation. Unfortunately, the group of students with learning disabilities was very small ($n = 4$) and not well described in terms of their specific learning difficulties.

In addition, O'Brien, Mansfield, and Legge (2005) investigated the effects of enlarging text for students with dyslexia. Both for dyslexic and non-dyslexic readers, there proved to be a critical font size. Below this size, the reading speed decreased rapidly. O'Brien et al. (2005) found, apart from a critical font size, an optimal font size. Dyslexic students needed 32% larger fonts to reach their maximum reading speed compared to normal readers at the same level of word reading.

The present study

These previous studies have indicated that various designs adaptations have been applied in order to promote music reading among dyslexic students. However, the scientific evidence proving that

Table 1. Descriptive statistics.

Groups	Dyslexic students	Non-dyslexic students	Students experiencing reading difficulties
Sample size	*N* = 18	*N* = 41	*N* = 13
Boys (%)	83.3	39.0	46.2
Girls (%)	16.7	61.0	53.8
Mean age (years)	10.4	10.0	9.8
Plays an instrument (%)	55.6	41.5	53.8
Music lessons outside school (%)	38.9	61.0	46.2
Can read written music (%)	44.4	48.8	53.8
Difficulties in reading written music (%)*	71.4 (*N* = 7)	40.0 (*N* = 25)	50.0 (*N* = 6)
Difficulties with reading/writing (%)	83.3	0.0	69.2

*Only for those students that took music lessons.

design adaptations of written music lead to improved music reading performance remains rather scarce. In the present study, an empirical investigation was conducted to assess the association between layout adaptations of written music and the readability for dyslexic and non-dyslexic students. The main research question in this study is: What are the effects of design adaptations in written music on the performance of dyslexic students in music reading in comparison with non-dyslexic students? The design adaptations chosen were those suggested in the literature, namely size, use of colours, and additionally stem direction.

Method

Sample

The present study was conducted among students from four primary schools and one secondary school in the northern region of the Netherlands, who had permission of their parents to participate in this study. A sample of 72 students aged between 8 and 13 years old filled in a paper-and-pencil questionnaire. Descriptive statistics of the respondents in the sample are presented in Table 1. For the analysis, the students were clustered in three groups based on the indicated and experienced difficulties with reading. Students were categorized as the dyslexia group ($n = 18$) if the student was formally indicated with dyslexia. Students were categorized as the group experiencing reading difficulties ($n = 13$) if the students experienced reading problems, but for whom we could not find objective indications of dyslexia. Finally, 41 students were categorized as the group of normal reading students.

Questionnaire

A questionnaire was developed that was administered in classes.[1] A short verbal instruction was given at the start to ensure that each student understood how the questionnaire should be filled in. This instruction was also included in the questionnaire in a written form. In the questionnaire, notes had to be marked; therefore we did not expect that students with dyslexia had additional difficulties in filling in the questionnaire.

The questionnaire started with some items regarding the background characteristics of students with respect to reading, music education and colour-blindness. The second part contained items with short pieces of written music varying in terms of size, colour of the lines, and the direction of stems. Examples of the different conditions in the questionnaire are presented in Figure 1.

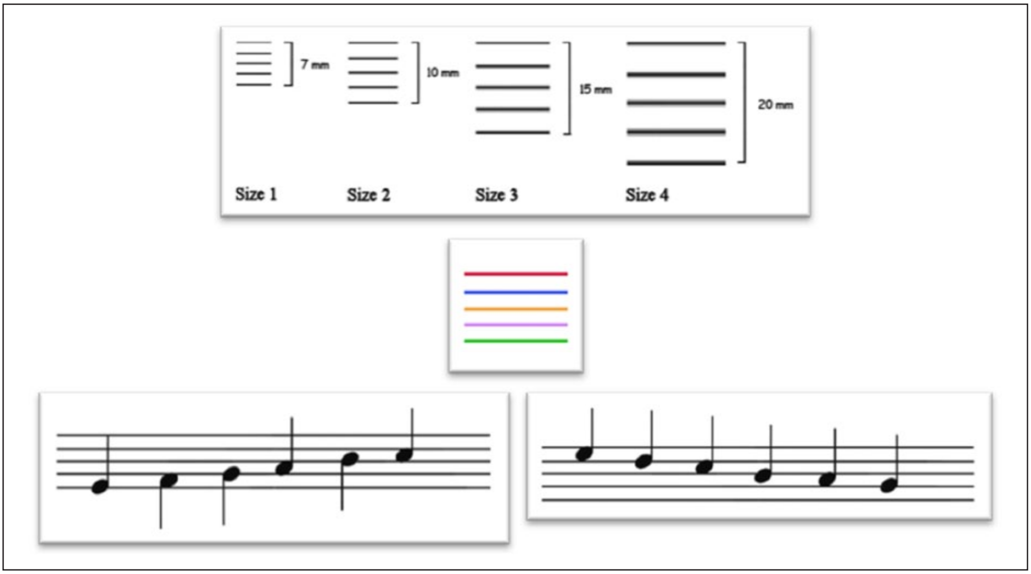

Figure 1. Example of the sizes and colouring.

The internal consistency of this part of the questionnaire is .80 (Cronbach's α). The final two items of the questionnaire concerned the students' preference for specific conditions with respect to size, colour and stem direction. In these questions different conditions were shown and students had to choose the condition they preferred the most.

Size and colour. For the size of the pieces of written music, four conditions were tested. In the first place, the regular sizes of written music for advanced and beginning musicians were used. For the additional two size conditions, both regular sizes were enlarged by 32%, as suggested by the literature on text reading. Two colour conditions were tested, namely regular pieces of music in black and white and pieces of written music with coloured in lines. Colouring in of the lines was chosen, as the most common mistake of students with dyslexia in reading written music are third-transpositions. The colours were chosen in such a way that optimal contrast between the lines and the background was realized. The four size and two colouring conditions have been combined in the questionnaire, resulting in eight different combinations of size and colour. This means that all sizes as presented in Figure 1 appear in a black and white and in a coloured in version.

Stem direction. The questionnaire furthermore contained two conditions with respect to the direction of the stems. In the first condition, all stems had the same direction (all up or all down). In the second condition, the direction of the stems differed, that is, pieces of written music with both stems up and stems down.

Measurement of reading accuracy. Within each condition, several types of questions were asked in order to assess the music-reading accuracy of the students. In the first type of questions, the students were asked to identify notes on or between particular lines within a written piece of music. Mistakes could be made by not identifying all notes in the position of interest or by identifying notes that were not on the position of interest. Therefore students could make multiple mistakes in these questions. In the second type of questions, the students were asked to assess whether a sequence of notes is going up or down in pitch. In the third type of questions, students were asked to assess the position of a particular note on or between lines. Four or five answer alternatives were given for these questions and the student had to find the alternative with the right position of the note. The number of mistakes made by the students for each question was recorded. We chose these specific type of questions because they can be taught in a few minutes and we did not expect a large difference in experience between students that play instruments or sing compared to those who do not (Sloboda, 1984). The length of the pieces of music and the type of questions were equal for each of the conditions. Because we expected that the students would learn and become more accurate during the questionnaire, the questions were not ordered by condition nor by type of question.

Method of analysis

As the questionnaire filled in by the students contains multiple conditions of design adaptations, the empirical study can be regarded as a within-subjects design. The benefits of a within-subjects design is that with a relatively small number of subjects a lot of information can be collected (Keppel & Wickens, 2004). The differences in number of mistakes between the conditions was analysed by means of repeated measures analyses of covariance (ANCOVA). The total number of mistakes in each of the conditions is used as the dependent variable in the Repeated Measures ANCOVA. The size, colour, and stem direction functioned as explanatory variables at the within-subjects level, as these variables might explain why students performed differently among the several layout conditions. The effects of size and colour were tested simultaneously, to investigate not only their main effects, but also the interaction between size and colour. A separate analysis was performed for the two conditions of stem direction. The grouping of students based on dyslexia and experienced difficulties with reading were included as an explanatory variable at the between subject level. This variable might explain differences in the number of mistakes made by normal reading students, dyslexic students and students experiencing reading problems without formal indications of dyslexia. The repeated measures ANCOVA also assesses the interaction between the between-subjects variables (grouping) and the within-subject variables (size, colour, stem direction), thereby providing the opportunity to assess whether some groups of students benefit more from some design adaptations of written music than others. Other background characteristics of students were included in the analyses as (between-subjects) covariates. Partial eta squared (η_p^2) was used as a measure of effect size to interpret the differences between conditions (Cohen, 1988).

Results

Descriptive results of reading accuracy in the questionnaire

Students made on average 11.99 mistakes (SD = 9.44) during the total questionnaire. The total number of mistakes for each of the background characteristics of students is presented in Table 2. Dyslexic students made on average 18.76 mistakes during the total questionnaire, while normal reading students made 9.31 mistakes, which is a significant difference, $F(2, 69) = 7.59$; $p = .001$, and this can be considered a large difference ($\eta_p^2 = .18$).

Effects of adaptations of the size and colouring of written music

The size and colouring conditions were combined in the questionnaire, resulting in eight different combinations of size and colour. The mistakes made in each of these eight conditions are presented

Table 2. Number of mistakes made during the total questionnaire per background characteristic.

Variable	Category	Mean number of mistakes	Standard deviation in number of mistakes
Gender	Girls	13.33	10.71
	Boys	10.57	7.67
Plays an instrument	Yes	12.33	11.18
	No	11.69	7.60
Music lessons outside school	Yes	11.63	9.50
	No	12.34	9.44
Can read written music	Yes	11.01	9.74
	No	13.13	9.18
Difficulties in reading written music	Yes	13.73	9.51
	No	9.41	8.74
Colour-blind	Yes	9.07	4.57
	No	12.16	9.60
Dyslexia	Dyslexic student	18.76	11.55
	Non-dyslexic students	9.31	6.73
	Students experiencing reading difficulties	11.08	9.41

in Table 3. This table provides the first insight in the effects of the size and colouring of written music. Based on the descriptive statistics, in all of the eight conditions, the dyslexic students made more mistakes than normal reading students and students experiencing reading difficulties. Furthermore, it becomes apparent from the descriptive statistics in Table 3 that the number of mistakes decreased as the size of written music increased. Furthermore, the students made a few more mistakes in the coloured conditions than in the black and white conditions.

A repeated measures ANCOVA was performed to test whether these differences were statistically significant.[2] A negative linear trend was found for the size of written music and the number of mistakes made, $F(1, 66) = 13.89$, $p < .001$; $\eta_p^2 = .17$. This negative trend confirms that, on average, fewer mistakes were made when the size of written music increased. A partial eta squared of .17 indicates a moderate effect size. Besides the linear trend in size, there appears a strong interaction between the size of written music and the grouping based on dyslexia and the experienced reading problems, $F(2, 66) = 16.81$, $p < .001$; $\eta_p^2 = .34$. The interaction between size and this grouping is presented in Figure 2. For all groups, the number of mistakes decreased as the size of written music increased, although this decrease in number of mistakes was much stronger for students with dyslexia. The difference in the number of mistakes between normal reading students and dyslexic students decreased considerably when the size of the written music increased.

No significant differences were found in the number of mistakes between the two conditions of colouring, $F(1, 66) = 0.50$; $p = .48$; $\eta_p^2 = .01$. The effects of colouring of the lines in written music are presented in Figure 3. In this figure, category one on the x axis corresponds to the black and white condition and category two corresponds to the colour conditions. More mistakes were made in the coloured condition compared to the standard back and white condition. The interaction between colouring and the grouping based on dyslexia was also not significant, $F(2, 66) = 1,55$; $p = .22$.

Besides the separate main effects of size and colouring, there was no evidence of an interaction between colouring and size, $F(1, 66) = .17$; $p = .68$. This implies that the linear negative trend of size of written music seems independent of the colouring of the lines. This can also been seen in

Table 3. Average number of mistakes in each condition for size, colouring and stem direction.

		Dyslexic students	Non-dyslexic students	Students experiencing reading difficulties	Mean over all students
Black and white	Size 1	2.28	0.77	0.85	1.16
	Size 2	2.12	0.87	1.40	1.29
	Size 3	1.06	0.65	0.40	0.70
	Size 4	0.99	0.40	0.55	0.57
Colour	Size 1	3.70	1.11	1.76	1.87
	Size 2	2.00	0.93	1.15	1.24
	Size 3	1.56	0.55	1.33	0.94
	Size 4	1.46	0.76	1.15	1.01
Stem direction	Equal	0.67	0.73	0.69	0.71
	Different	1.28	0.90	0.85	0.98

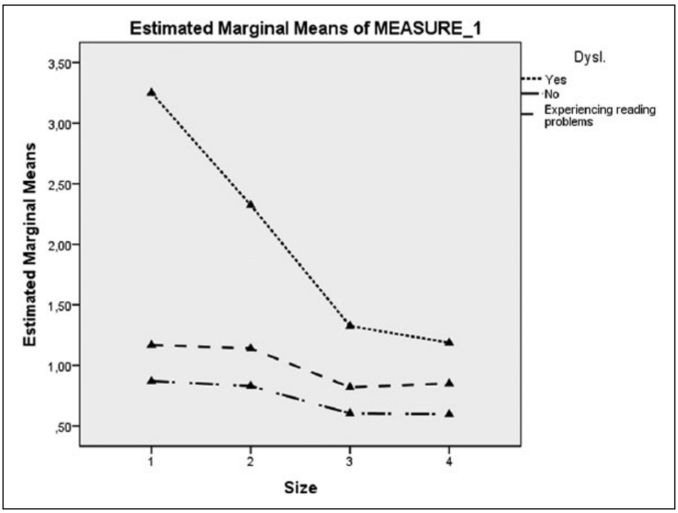

Figure 2. Effects of size of written music on number of mistakes made.

Table 3, where the number of mistakes decreased in a fairly similar rate in both the coloured and black and white condition.

Effects of adaptations of stem direction in written music

In Table 3, the number of mistakes made by students are presented for the conditions of stem direction. A repeated measures ANCOVA was performed to test whether these differences are statistically significant.[3] Results from the repeated measures ANCOVA are also presented in Figure 4. In this figure, stem direction condition 1 corresponds with equal stem directions (all up or all down) and stem direction condition 2 corresponds with differing stem directions (some up and some down). Both the figure and the descriptive statistics from Table 4 show that students made more mistakes in pieces of written music with differing stem directions. It appears from the Repeated Measures ANCOVA that stem direction explained significant differences in

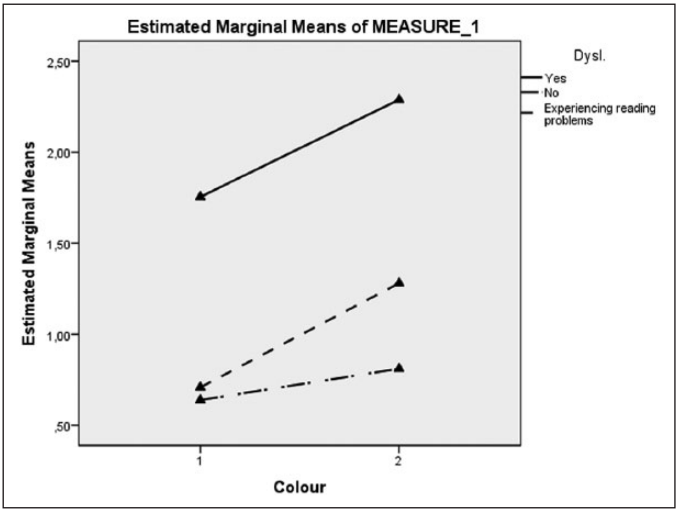

Figure 3. Effects of colour of written music on number of mistakes made.

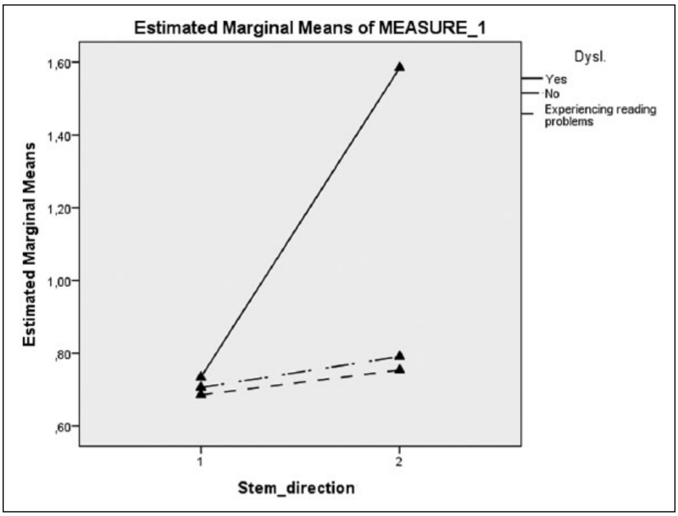

Figure 4. Effects of stem direction in written music on number of mistakes made.

the number of mistakes within students, $F(1, 66) = 7.38$; $p = .008$; $\eta_p^2 = .10$. This confirmed the greater accuracy of the students in the condition with equal stem direction. A partial eta squared of .10 indicates a moderate effect size. Also, in this case, an interaction was found between stem direction and the grouping based on dyslexia and the experienced reading problems, $F(2, 66) = 8.49$; $p = .001$; $\eta_p^2 = .21$. The difference in number of mistakes between the two stem direction conditions was evidently larger for dyslexic students than for the other two groups. In case of equal stem directions, the three groups hardly differed in terms of number of mistakes made. For differing stem directions, dyslexic students made considerably more mistakes than students in the other two groups.

Table 4. Preferences of students for colour and size.

		Dyslexic students	Non-dyslexic students	Students experiencing reading difficulties
Colouring	Preference colour	88.9%	56.1%	76.9%
	Preference black and white	5.6%	12.2%	7.7%
	No preference	5.6%	31.7%	15.4%
Size	Preference size 1 (smallest)	0.0%	0.0%	7.7%
	Preference size 2	11.1%	12.2%	0.0%
	Preference size 3	22.2%	19.5%	15.4%
	Preference size 4 (largest)	61.1%	39.0%	69.2%
	No preference	5.6%	29.3%	7.7%

Student preferences for lay-out of written music

Table 4 shows that students preferred the coloured condition over the black and white condition and, moreover, students preferred the largest size of written music. However, for only 25% of the students the colouring condition that they preferred corresponded to the colouring condition in which they made the least mistakes. For size of written music, 36% of the students preferred the condition in which they made the least mistakes.

Conclusions and discussion

This study has concentrated on the difficulties that dyslexic students encounter in reading musical notation, and investigated how design adaptations of written music can help to reduce these difficulties. Our main research question was: "What are the effects of design adaptations in written music on the performance of students with dyslexia in music reading in comparison with normal reading students?" Our results suggest that a larger size and equal stem direction in particular had very positive effects on decreasing the amount of mistakes made by dyslexic children.

Positive effects of the size of written music was found for all students, but was more profound for dyslexic students than for non-dyslexic students. Dyslexic students made four times as many mistakes as normal reading children in the samples printed on the average size for sheet music, while in the largest samples dyslexic children made only one and a half times as many mistakes as non-dyslexic children. The finding that increasing the size of written music led to a decrease in mistakes is consistent with the findings in text reading (O'Brien et al., 2005). The results also showed that the number of mistakes made by dyslexic students increased rapidly when the size was smaller than the regular size for beginning musicians. This finding suggests the possible existence of a critical size for written music as it was found for text in previous studies. For the normal reading students, a slight decrease in the number of mistakes was found when enlarging the music samples, but a strong decrease of mistakes below a certain size was not found. This suggests that the average size of written music is large enough for normal reading children, but too small for dyslexic children.

Although colour is mentioned by several music teachers (see MacMillan, 2005; O'Brien, 2004) as a useful tool for music reading, we did not find evidence for improved music reading accuracy by colouring-in the lines of the staff. A possible explanation for the fact that we did not find significant effects of using colour is found in the difference in methods used; none of the mentioned papers used coloured lines in the staff. Another explanation is the lower contrast between the lines and the white background when using coloured staves, which could have actually increased the difficulty of reading the music sheets. Moreover, it is also possible that the positive effects of colour experienced by teachers are based on the student's preferences rather than their effect on reading accuracy. That is, the current research revealed that only 25% of the students preferred the colouring condition that corresponded with the design in which the least mistakes were made. Presumably, coloured staves are more attractive to children, but colouring does not seem to reduce the amount of mistakes.

With respect to stem direction, in general, students made more mistakes when the direction of the stems changed within a music fragment. This effect was even stronger for dyslexic students. As reported by Tan et al. (2008), people intuitively consider the direction of the stems to be of importance. A possible explanation for children with dyslexia making more mistakes than normal reading children is the general difficulty they have discriminating between high and low (Jaarsma et al., 1998; Oglethorpe, 2002), combined with the distraction that might be caused by the changing stems. Further research is recommended to find out why changing the direction of the stems causes children with dyslexia to make more mistakes.

As stated in the literature review, students with dyslexia have problems recognizing where exactly on the staff a note is written (Jaarsma et al., 1998; Hubicki & Miles, 1991). A final important finding of the present study is that, although on average student with dyslexia made more mistakes, some children with dyslexia performed equally well as normal reading students. This may be caused by the fact that reading music and reading text partially require different skills (Sergent et al., 1992). This could explain why, in our study, some children with dyslexia seemed to have no difficulties reading music while others did have trouble reading music. Following our research findings, it seems important to find out why some children with dyslexia have less problems with music reading than others. One option is to divide dyslexics into groups, based on the type of problems they experience from their dyslexia. Since spatial attention can be impaired in some readers with dyslexia (Lorusso et al., 2011), music reading can be influenced by the degree of spatial attention difficulties. Readers with dyslexia experiencing little or no spatial attention problems might have less trouble reading pitch than dyslexics experiencing severe spatial attention problems. Furthermore, research on the eye-movements of students while reading written music may provide some clues as to why dyslexic students make more mistakes.

The present study is not without limitations. Because of the relatively small number of students with dyslexia (n = 18) and students experiencing reading difficulties without formal dyslexia indications (n = 13) in this sample, our findings need to be interpreted with caution. Future studies that build on the results presented in this study are therefore suggested, preferably with a larger and less selective sample. Some of the students in our sample played a musical instrument or sang outside school, whereas others had no experience music outside school. This may have affected our results, because these two groups evidently differ in their experience with reading sheet music.

With regard to educational practice, enlarging written music for students to the size that is the best for them can easily be done by music teachers. Asking the students' preference seems insufficient, since the reported "easiest size to read" was, at least in our study, not consistent with the size in which they made the least mistakes. Changing stem directions can be done by some musical notation software, however, this is quite laborious. Music teachers teaching children with dyslexia could try to find sheet music that is as consistent as possible in the use of stem direction, at least while learning how to read written music. We acknowledge, however, that music sheets using different stem directions is common and generally seen as part of the ability necessary to read written music. Nevertheless, there is a possibility for music editors to bring out editions in which the difficulties experienced by dyslexics are taken into account, at least by introducing enlarged font sizes.

The present article underlines the general assumption that adapting sheet music for dyslexics improves their performance in reading pitch. Although these adaptations cannot completely take away the difficulties encountered by dyslexic children, adapting the design of musical notation might be a useful tool to improve their performance in reading pitch.

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Notes

1. The complete questionnaire contained 46 items and can be requested from the corresponding author.
2. Results of this analysis are presented in Appendix A1 (within-subject effects) and Appendix A2 (between subject-effects) (both available online). The within-subject effects refer to differences in number of mistakes between conditions and interaction between conditions and the grouping variable. The between-subjects effects refer to differences in the total number of mistakes made between students.
3. Results of this analysis are presented in Appendix B1 (within-subject effects) and Appendix B2 (between-subject effects) (both available online).

References

British Dyslexia Association. (2014). *Teacher guide to music and dyslexia*. Retrieved from http://www.rhinegold.co.uk/downloads/magazines/music_teacher/music_teacher_guide_music_and_dyslexia.pdf

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Ganshow, L., Lloyd-Jones, J., & Miles, T. R. (1994). Dyslexia and musical notation. *Annals of Dyslexia*, *44*, 185–202.

Gromko, J. E. (2004). Predictors of music sight-reading ability in high school wind players. *Journal of Research in Music Education*, *52*, 6–15.

Gudmundsdottir, H. R. (2010). Pitch error analysis of young piano students' music reading performances. *International Journal of Music Education*, *28*, 61–70. doi:10.1177/0255761409351342

Hébert, S., & Cuddy, L. L. (2006). Music reading deficiencies and the brain. *Advances in Cognitive Psychology*, *2*, 199–206.

Hubicki, M., & Miles, T. R. (1991). Musical notation and multisensory learning. *Child Language Teaching and Therapy*, *7*, 61–78. doi:10.1177/026565909100700104

Jaarsma, B. S., Ruijssenaars, A. J. J. M., & Van den Broeck, W. (1998). Dyslexia and learning musical notation: A pilot study. *Annals of Dyslexia*, *48*, 137–154.

Keppel, G., & Wickens, T. D. (2004). *Design and analysis: A researcher's handbook* (4th ed.). Upper Saddle River, N.J: Pearson Education, Inc.

Kuo, Y.-T, & Chuang, M.-C. (2013). A proposal of a color music notation system on a single melody for music beginners. *International Journal of Music Education*, *31*, 394–412. doi:10.1177/0255761413489082

Lorusso, M. L., Facoetti, A., & Bakker, D. J. (2011). Neuropsychological treatment of dyslexia: Does type of treatment matter? *Journal of Learning Disabilities*, *44*, 136–149.

MacMillan, J. (2004). Music & dyslexia. *ISM Music Journal*, 144–149.

MacMillan, J. (2005). Music and dyslexia – and how Suzuki helps. *European Suzuki Association Web-Journal*, spring 2005. Retrieved from http://www.jennymacmillan.co.uk/Music%20and%20dyslexia%20for%20ESJ.pdf

O'Brien, V. K. (2004). Adapting music instruction for students with dyslexia. *Music Educators Journal*, *90*, 27–31.

O'Brien, B. A., Mansfield, J. S., & Legge, G. E. (2005). The effect of print size on reading speed in dyslexia. *Journal of Research in Reading*, *28*, 332–349.

Oglethorpe, S. (2002). *Instrumental music for dyslexics: A teaching handbook*. London, UK: Whurr Publishers.

Rogers, G. L. (1991). Effect of color-coded notation on music achievement of elementary instrumental students. *Journal of Research in Music Education*, *39*, 64–73.
Sergent, J., Zuck, E., Terriah, S., & MacDonald, B. (1992). Distributed neural network underlying musical sight-reading and keyboard performance. *Science, New Series*, *257*, 106–109.
Sloboda, J. A. (1980). The uses of space in music notation. *Visible Language*, *15*, 86–110.
Sloboda, J. A. (1984). Experimental studies of music reading: A review. *Music Perception: An Interdisciplinary Journal*, *2*, 222–236.
Tan, S. L., Wakefield, E. M., & Jeffries, P. W. (2009). Musically untrained college students' interpretations of musical notation: Sound, silence, loudness, duration, and temporal order. *Psychology of Music*, *37*, 5–24.