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Changing Fonts in Education: How the Benefits Vary with Ability and Dyslexia

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ABSTRACT. Previous research has shown that presenting educational materials in slightly harder to read fonts than is typical engenders deeper processing. This leads to better retention and subsequent recall of information. Before this extremely simple-to-implement and cost-effective adaptation can be made routinely to educational materials, it needs to be shown to benefit all students, or at the very least not to hinder any particular group. The authors found that students across the ability spectrum demonstrate a significant improvement in retention and recall when presented with information in a disfluent font. Significantly, those students with dyslexia are also found to greatly benefit.

Keywords: disfluent, dyslexia, font

Some teachers and educational researchers have suggested that it is always beneficial to simplify material and its presentation to reduce the cognitive load on the learner (Sweller & Chandler, 1994). In a school setting students and teachers sometimes judge the success of a lesson based on the ease of understanding, processing, and remembering the presented information. This can lead to a lesson being deemed effective by the teacher, students, and any observer. It perhaps also leads to the conclusion that students have made progress in a lesson even if they remember very little of the information they have studied at a later date.

In some cases it has been shown that making information harder to learn can improve future recall (Bjork, 1994, 1999). This has been linked by Craik and Tulving (1975) to the deeper cognitive engagement required to process the information, which consequently leads to better retention. Desirable difficulties are manipulations of the information to be learned that can make it harder for the learner and slow the learning process, but lead to increased retention of the information over time. For example, Richland, Bjork, Finley, and Linn (2005) found real-world educational benefits in two distinct imposed difficulties: first, requiring learners to partially generate word pairs (e.g., "fish:ch__s" instead of "fish:chips") and, second, to interleave lists of words (e.g., A1B1A2B2 rather than A1A2 B1B2). However, these methods increase the subjective and objective difficulty of learning the material. Additionally, a link has been made between the handwriting and keyboard typing speed of children: If they are slower at writing by either method, they use more mental resources as they find it more cognitively demanding (Connelly, Gee, & Walsh, 2007). When the goal is to remember the text, additional cognitive processing is beneficial.

Disfluency is the subjective experience of difficulty associated with completing a mental task. It has been shown that disfluency can be easily introduced by degrading or changing the font in which the information is written (Alter, Oppenheimer, Epley, & Eyre, 2007; Alter & Oppenheimer, 2009). In a previous study Alter et al. (2007) showed that when participants took a cognitive test in a degraded (and therefore disfluent) font they performed significantly better. However, this test looked for processing of information in a question-and-answer format and did not look for recall of information at a later time. Disfluency may indicate to readers that they do not fully understand the information and are less

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confident with it so that they try harder to learn it (Alter et al., 2007). In addition, the increased difficultly in reading the font may lead to enhanced cognitive processing (Craik & Tulving, 1975).

Most recently, Diemand-Yauman, Oppenheimer, and Vaughan (2011) showed a direct educational benefit (i.e., improved future recall) when information is presented in a disfluent font. However they raised the concern that because disfluent reading can be perceived as more difficult, less motivated or less able students may become frustrated and give up on the material.

Method

Participants

Participants were 275 students in Years 9–11 (age range = 13–16 years); the study was conducted across the Upper School at Clifton College, an independent public school of more than 1,000 students in Bristol, United Kingdom. Classes are mixed gender and set by ability ranging in size from around 10 to 24 students.

MidYIS Data

Middle Years Information System (MidYIS) tests comprise vocabulary, mathematics, nonverbal reasoning and skills sections. They are administered by the Center for Evaluation and Monitoring at Durham University and are primarily designed to be taken when students enter secondary school in Years 7, 8, or 9 in the United Kingdom (12, 13, or 14 years old, respectively). The tests are designed to measure, as far as possible, ability and aptitude for learning rather than achievement. All tests are designed to fit into a lesson period (about 1 hr) and are strictly administered to ensure that all students are exposed to the same instructions, explanations and examples, ensuring fair, high-quality, reliable data. Based on the results of the tests students are placed into one of four bands: Band A, which contains the most able 25% of students, through Bands B (25%) and C (25%) to Band D, which contains the least able 25% of students. They are used extensively across many schools in the United Kingdom to provide a measure of typical expected General Certificate of Secondary Education performance.

Procedure

In a double-blind study, conducted by members of the biology and physics departments during normal 40-min lessons, students were shown a PowerPoint slide projected at the front of the class with the following text describing eight facts about a fictional star filling the screen. This ensured the students had no prior knowledge of the material.

> The white dwarf star Amethyst is in the constellation Cassiopeia. It is half the mass of the Sun but has a diameter one hundred times less than the Sun. On its surface it has a temperature of twelve thousand Kelvin. It is mostly made up of carbon. Currently, we have found three planets orbiting around it.

This text was easy for students 13–16 years old to read, and they were given ample time of 90 s to read the text in silence. This ensured the content and length of the text was at the independent level for all students. The lesson then continued in the usual way with copying material from the board and answering questions on worksheets or from a textbook. Approximately 35 min later the students individually completed a short test of seven multiple-choice questions testing their recall of facts from the PowerPoint slide. The content of the test along with the multiple-choice answers was the following:

1) What is the name of the star?

Amethyst/Amey/Myethyst/Alpha-Centauri

2) In which constellation is it?

Cassiopeia/Cancer/Capricorn/Pavo

3) What type of star is it?

White Dwarf/Red Dwarf/Red Giant/White Giant

4) How many times the mass of the Sun is it?

Half/Double/Ten Times/Five Times

5) What is the temperature on its surface?

Twelve Kelvin/Twelve Thousand Kelvin/Twelve Thousand Centigrade/Three Thousand Kelvin

6) What is it mostly made up of?

Carbon/Helium/Iron/Cadmium

7) Have we found planets orbiting it?

Yes/No

Students were not warned about the test when they read the text. Students wrote their names on the surveys: This allowed their score out of seven to be linked with their MidYIS band and whether they had a diagnosis of dyslexia.

A control group of 121 students was shown the star facts in Arial font (the control font). The study group of 154 students was shown identical star facts in Monotype Corsiva font (the disfluent font; see Figure 1). Classes were assigned randomly to either the control or disfluent font groups in such a way as to provide approximately the same number of students in each band and reading each font. Monotype Corsiva was one of three disfluent fonts tested by Diemand-Yauman et al. (2011). In their research no difference was found between the effects of italicized Comic, Monotype Corsiva, or Haettenschweiler. However, all showed a significant improvement compared with an Arial control font.

Results and Discussion

The tests were scored out of 7 and the results linked to the individual students by name. The students' MidYIS band, the font in which they saw the star facts, and whether

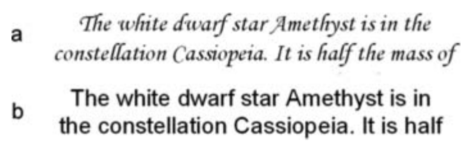

FIGURE 1. Example of the text used in the study in (a) the disfluent font (Monotype Corsiva) and (b) the control font (Arial).

they were dyslexic were recorded. For each student the raw score out of 7 was converted to a percentage. The mean percentage score was found for each group of students (Arial and Monotype Corsiva): This allowed the overall mean percentage difference to be calculated. The students' results were converted into Z scores and an independent samples t test (for samples with unequal sample sizes and unequal variances) revealed if the results were significant ($p < 0.05$). The full results are detailed in Table 1.

Overall, the mean score was 12.8% higher for those students who had read the star facts in the disfluent font (Monotype Corsiva) compared with those who read the star facts in the control font (Arial). A t test revealed this was statistically significant with $p < 10^{-7}$. It is also in good agreement with the 14% difference found by Diemand-Yauman et al. (2011) in their first study.

Confident that a similar effect to that seen by Diemand-Yauman et al. (2011) had been reproduced, the results were split by MidYIS band (see Table 1). Notably, this revealed there was a higher mean score for students in each band when reading the disfluent font. This indicates that using a disfluent font did not hinder students in any particular band. Additionally, there was no observable band related trend in the mean percentage difference in the scores. The mean score was 11.5% higher for the most able students (those in Band A) if they had read the star facts in Monotype Corsiva compared to Arial ($p = 0.035$). The minimum increase in the mean score seen was among the students in Band C (7.9%), however, this was still deemed significant with a p value of 0.041.

The final variable under investigation was the effect of the disfluent font on dyslexic students. The definition of dyslexia is not uniformly agreed on; however, the British Dyslexia Association (n.d.) defined it as "a specific learning difficulty which mainly affects the development of literacy and language related skills." The students identified as dyslexic in this study have been diagnosed by an educational psychologist, usually following a school referral after a sufficiently low score on the Edinburgh Reading Test 4 (2002). Present educational trends suggest that simple fonts should be used to aid reading by dyslexic students (British Dyslexia Association, n.d.).

Perhaps surprisingly, dyslexic students were found to follow the overall trend of a higher mean score on the star facts test if they had read the disfluent font (Monotype Corsiva). This improvement was even more marked than for the general group of student at 19% ($p = 0.032$). This is a significant finding and one that should certainly be investigated further, as it is in contrast to present educational trends. This study suggests dyslexic students benefit significantly from reading information in a harder to read front. This could provide support for the hypothesis that it is the greater cognitive processing, which is required for reading a disfluent font, that gives the retention improvement. What is not yet clear is the effect of frequently providing a dyslexic student with large blocks of text in a disfluent font: Does the student tire of reading more rapidly or does his or her motivation for continuing reading decrease? If their quality of processing of written material does decrease over a period of time, is this net effect offset in any way by a more accurate memory of (the first) part of the text? Further research will be necessary to investigate these questions; however, for short pieces of text at least up to a length of 56 words (the length used in this study), a significant improvement in retention has been demonstrated.

TABLE 1. Percentage of Correct Answers When Students Read Facts Printed in Arial or Monotype Corsiva Fonts

	Arial		Monotype Corsiva						
MidYIS band	%	*SD* (%)	%	*SD* (%)	% difference	Arial Z score	Monotype Corsiva Z score	t	p
A	83.0	22.9	94.6	9.67	11.5	−0.454	0.250	1.93	0.035
B	84.4	23.3	95.4	10.2	10.9	−0.428	0.236	2.10	0.023
C	80.1	20.8	88.0	12.8	7.9	−0.256	0.194	1.78	0.041
D	70.2	23.6	84.3	16.7	14.1	−0.294	0.345	3.24	8.6×10^{-4}
Overall	78.0	23.1	90.8	13.0	12.8	−0.371	0.291	5.43	9.0×10^{-8}
Dyslexic	66.7	30.7	85.7	14.9	19.0	−0.543	0.283	2.03	0.032

Note. The data are stratified by Middle Years Information Systems (MidYIS) Bands A–D, an overall total is given and finally the group of dyslexic students is separated out.

In conjunction with their study Diemand-Yauman et al. (2011) performed a short follow-up survey to find out the students' opinions about the use of a disfluent font. No liking or motivational differences based on the disfluent fonts were found.

The present study, together with previous work, provides evidence that harder-to-read, or disfluent, fonts hold promise for promoting recall and retention of written information. What is not yet clear is whether the effect can wear off over time as readers become accustomed to the disfluent font. Further research should focus on investigating the long-term effect of using the same disfluent font and whether there is a point at which a disfluent font becomes so difficult that it becomes a hindrance. Given the limited range of this study in terms of the length of the passage the students read and the nature of the factual recall tested with the multiple-choice questions it would be interesting to investigate whether these effects extend to longer passages of text or questions which rely more on synthesis of the information. The initial evidence (in this study and others) of the potential for harder to read fonts to benefit students' recall should not be ignored and future researchers should carry out further studies.

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