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The impact of text fading on reading in children with reading difficulties

Abstract

The Acceleration Phenomenon (AP) has been demonstrated by studies showing that reading rate and comprehension improvements can be induced by a fading procedure, erasing text based on the previously measured individual's fastest reading rate. However, whether or not reading enhancements can also be observed through slow fading rates has not been explored in detail. The focus of the present study was hence to investigate whether a fading rate slower than the individual's self-paced reading rate can also induce AP effects which positively affect reading performance. A sample of 34 third graders with reading difficulties was selected to participate in this study. Two slow fading conditions were implemented: A condition in which text was faded out 40 % slower and a condition where text was faded out 70 % slower than the self-paced reading rate. The 40 % reduced fading manipulation significantly enhanced children's reading rate and comprehension scores compared to their self-paced reading performance. The 70 % reduced fading manipulation also resulted in slightly faster reading rates but not in better comprehension. The present data suggests that the fading rate does not need to be set at a rate at the upper limit of participants' reading performance. Still, it seems highly relevant to consider which rate is applied, as a fading manipulation that is too slow did not result in comprehension improvements. Implications for the pedagogical applicability and possible future research foci are discussed.

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Keywords
Acceleration Phenomenon; Reading difficulties; Reading rate; Reading comprehension

Veränderung der Leseleistung von Kindern mit Leseschwierigkeiten durch Ausblenden des zu lesenden Textes

Zusammenfassung
Studien zum Acceleration Phenomenon (AP) konnten zeigen, dass Probanden ihre Lesegeschwindigkeit und ihr Leseverständnis verbessern können, wenn präsentierter Text beim Lesen in der schnellsten individuellen Lesezeit ausgeblendet wird. Ob diese Leseverbesserungen auch erzeugt werden können, wenn die Ausblendegeschwindigkeit langsamer als die individuelle Lesegeschwindigkeit ist, wurde bisher nicht untersucht. Mit Hilfe der Untersuchung einer Stichprobe von 34 Drittklässlern mit Leseschwierigkeiten sollte in dieser Studie überprüft werden, welchen Einfluss langsames Ausblenden auf den Leseprozess hat. Zwei Bedingungen wurden eingeführt: eine, in welcher der Text um 40 % langsamer, und eine zweite, in welcher der Text um 70 % langsamer als die normale Lesegeschwindigkeit ausgeblendet wurde. In der um 40 % verlangsamten Bedingung verbesserten sich die Kinder signifikant in ihrer Lesegeschwindigkeit sowie in ihrem Leseverständnis. Die um 70 % verlangsamte Bedingung erzeugte zwar Verbesserungen in der Lesegeschwindigkeit, jedoch nicht im Leseverständnis. Die Ergebnisse verdeutlichen, dass die Ausblendegeschwindigkeit nicht schneller sein muss als die individuelle Lesegeschwindigkeit um positive Leseverbesserungen zu erzielen. Weiterhin konnte gezeigt werden, dass die Ausblendegeschwindigkeit große Relevanz hat, da keine Leseverständnisverbesserungen in der um 70 % verlangsamten Bedingung gefunden werden konnten. Die Anwendbarkeit der Befunde für die pädagogische Praxis sowie mögliche zukünftige Forschungsschwerpunkte werden in der Diskussion aufgegriffen.

Schlagworte
Acceleration Phenomenon; Leseschwierigkeiten; Lesegeschwindigkeit; Leseverständnis

1. Introduction

Information of any kind is often presented in written form. In order to be comprehensible, text needs to be decoded through the complex operation of reading, which depends on active information processing on the level of perception, storage, decoding, and retrieval of information units. Reading is a primary component of the educational system and literacy is essential for directed and self-directed learning. If a child fails to adopt the required reading skills, academic difficulties are likely to occur (Vellutino et al., 1996). Most children acquire adequate reading skills through formal education and reading practice (Huemer, Landerl, Aro, & Lyytinen, 2008) but reading acquisition can also be problematic. Deficits in *phonological recoding* (i.e., successful grapheme-to-phoneme mapping, Share, 1995) have been outlined as one of the crucial elements in dysfunctional reading acquisition; phonological coding has hence been recognized as the probable cause for reading difficulties (Vellutino, Fletcher, Snowling, & Scanlon, 2004). Besides phonological coding, however, efficient and fast word recognition (i.e., reading accuracy and reading fluency) play a significant role for reading proficiency (Kuhn & Stahl, 2003) and are a focus of interest in research on reading difficulties.

1.1 Reading accuracy and reading fluency

There are substantial differences across orthographies regarding their spelling-to-sound consistencies. Languages can be distinguished by rather transparent (one-to-one mappings of graphemes and phonemes; i.e., Italian, German) and rather opaque (one-to-many mappings; i.e., English, Hebrew) orthographies (Spencer, 2010). Grapheme-to-phoneme mapping deficits result in low reading accuracy (Ziegler & Goswami, 2005), which is revealed through high numbers of reading errors and an erroneous pronunciation of grapheme strings (Thaler, Ebner, Wimmer, & Landerl, 2004). Reading accuracy deficits, however, are most pronounced in opaque orthographies with inconsistent grapheme-to-phoneme mappings (Georgiou, Parrila, & Papadopoulos, 2008; Ziegler, Perry, Ma-Wyatt, Ladner, & Schulte-Körne, 2003). In rather transparent orthographies, reading difficulties are mainly characterized by a diminished reading fluency (Landerl & Wimmer, 2008; Wimmer, Mayringer, & Landerl, 1998; Ziegler & Goswami, 2005; Ziegler et al., 2003). Several studies focusing on reading development in German children found that problematic reading achievement was manifested as a major impairment of reading fluency, expressed by very slow and influent word decoding, but not by high numbers of reading errors (Landerl, Wimmer, & Frith, 1997; Wimmer, 1996; Wimmer et al., 1998). This *automatic decoding deficit* (Yap & Van der Leij, 1993) is strongly associated with low reading comprehension scores (Fuchs, Fuchs, Hosp, & Jenkins, 2001; Jenkins & Jewell, 1993) and has been attributed to inefficient word recognition, which may result in reduced attention and working-memory capacities. As a result, fewer resources are available for the reading comprehension process (Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003). Perfetti (1985) proposed in his *verbal-efficiency model* that only efficient and automatized decoding of words can facilitate additional resources. Hence, if an individual is able to gain reading fluency, reading comprehension will improve due to reduced cognitive memory load. In turn, the capacity of working memory extends and connections to long-term memory content are eventually strengthened so that meaning can be directly retrieved (Woltz & Was, 2006, 2007).

1.2 The Acceleration Phenomenon

One specific outcome measure linked to reading fluency is the reading rate (Meyer, Talbot, & Florencio, 1999). According to empirical evidence, the reading rate can be manipulated experimentally (Breznitz & Berman, 2003). An emerging line of research focusing on the manipulation of reading rate demonstrated a counter-intuitive finding: Breznitz (1987) reported that first graders who were pushed to read at a faster reading rate showed better results in reading performance regarding significantly increased reading rate and reading comprehension, compared to their self-paced reading achievement (*Acceleration Phenomenon*; AP). The classical paradigm used by Breznitz (1987) as well as in following AP research studies is based on a cross-sectional, three-block design in which reading rate (in milliseconds) and comprehension (i.e., correctly answered multiple choice questions) are measured to examine AP effects. Participants are instructed to read computerized text in the first (Self-Paced Condition 1) and third (Self-Paced Condition 2) block at their own comfortable self-paced reading rate. In the second block (Accelerated Fading Condition), text is faded out in reading direction at a rate at the upper limit of the participant's reading performance. AP studies showed that reading rates and comprehension scores significantly increased in the second block compared to the first block. However, the reading performance declined to base level in the third block (Breznitz, 1987, 1997a, 1997b; Breznitz & Berman, 2003). This pattern of significant reading improvement through artificial acceleration has been confirmed in numerous studies (for a review, see Breznitz, 2006) and has been demonstrated in children as well as in adults (Breznitz, 1987; Breznitz & Leikin, 2001). Positive effects on reading performance due to the fading manipulation were found in Hebrew (Breznitz, 1987, 1997a), and in other writing systems, such as English (Breznitz, 2006; Breznitz & Leikin, 2001). However, research studies investigating AP effects in more transparent languages (such as German) have not been conducted so far. Furthermore, results indicated that not only normally developing readers but also impaired readers can reach a significantly higher reading rate and better comprehension scores due to the fading manipulation (e.g. Breznitz, 1987; Breznitz 1997a, 1997b).

To explain AP effects, Breznitz (1987) proposed that individuals needed to be pushed to faster reading rates to achieve reading performance gains. In her first explanatory approach, she assumed that improved attention and reduced distractibility might result in the observed reading performance improvements. To test this assumption, she introduced a reading task that utilized pictorial distractors above presented text, which participants were asked to ignore while reading (Breznitz, 1988). To examine whether participating first graders would direct more attention to the reading material if text was faded out, one group of participants read text with text fading and another group without (i.e., control group). Results indicated that participants in the fading group recalled statistically significantly fewer distractors than the readers in the control group. Breznitz (1988) assumed that the fading manipulation may have resulted in reduced distractibility and more focused attention. In a second explanatory approach, Breznitz and Share (1992) investigated possible influences of the fading manipulation on the individuals' working memory capacity. A sample of children in second grade conducted sets of working memory experiments in a fading condition as well as in a self-paced reading condition. In a first working memory task, the participants were asked to repeat each presented sentence in backward and forward order. A second task contained reading material with changes in semantics or wording. Following a target passage, two test passages were simultaneously presented, showing the original and an altered version of the passage. The participants were asked to identify the original passage. In a third task participants were confronted with a single word (*probe*) after reading a passage and were asked to recall the words which had appeared immediately before and after the *probe*. The results revealed statistically significantly faster reading rates and better performance for all working memory tasks in the fading condition compared to the self-paced reading condition. The authors assumed that short-term memory capacity might have been relieved through faster reading rates induced by the fading manipulation. Hence, working memory processing may have been optimized, leading to better performance in the fading condition. A third explanatory approach focused on a possible facilitation of lexical access to words stored in the mental lexicon. In a research study, Breznitz (1987) presented word material that deliberately included orthographic mistakes to test first graders' correction behaviors. Results indicated that the individuals seemed to automatically correct misspelled words when forced to read faster in the fading condition. Statistically significantly faster reading rates in the fading condition were assumed to facilitate the recognition of entire words and thus the direct retrieval of a word's meaning from lexical memory.

Taken together, results from AP studies and explanatory approaches regarding AP effects indicate that the faster reading rate seems to foster word processing. However, the experimental manipulation resulting in faster reading rates in AP studies has not yet been sufficiently explored.

1.3 The present study

Although there is substantial documentation of quantitative reading rate improvements through the fading manipulation (i.e., elementary school children 15–20 % faster than self-paced reading rate, adults 10 % faster than self-paced reading rate; see Breznitz, 1997a; Breznitz & Berman, 2003; Breznitz, DeMarco, Shammi, & Hakerem, 1994), the impact of the fading procedure has not been focused on so far. Fading rates previously applied in AP studies were set at the upper limit of participants' reading performance and most often based on the fastest reading rate for correctly answered items in the first self-paced condition as introduced by Breznitz (1987). However, it is not yet clear whether a fading procedure slower than the self-paced reading rate (i.e., slow fading) could also lead to AP effects. Hence, to test whether slow fading rates can produce AP effects, we conducted an AP study introducing two fading conditions in which text was faded out 40 % slower than the self-paced reading rate and 70 % slower than the self-paced reading rate.[1] We assume that children should read faster in the fading conditions compared to the self-paced conditions, even though the fading rate is slower than the individual self-paced reading rate. Moreover, we propose that this faster reading rate should result in better reading comprehension scores in the fading condition compared to the self-paced reading condition in the three-block experimental design. Exploratory, differences between the two slow fading rates are investigated.

2. Method

2.1 Participants

To identify children with reading difficulties but average IQ scores, 358 children from eight elementary schools in Germany were screened for reading performance and intellectual ability. Children's reading performance was measured by the subtest for text reading comprehension of the standardized scholastic reading achievement test ELFE 1–6 (Lenhard & Schneider, 2006). The reading comprehension subtest consists of 20 items and is accomplished in a restricted time frame (7 minutes). The number of correctly answered items is considered for evaluation; test scores therefore comprise a combined measure of speed and comprehension. For interpretation of individual raw test scores, standardized scores (i.e., percentile ranks based on a norm sample) are provided. Raven's SPM Plus (Raven, 2009) was used to determine children's intellectual ability. The SPM Plus is an untimed power test consisting of 60 diagrammatic puzzles. Each puzzle contains a missing part which has to be identified by choosing from six to eight pieces. Percentile rank charts, based on a German norm sample, were used for interpretation of the total raw scores. Both tests were conducted in a classroom setting.[2] Out of the screening sample, 34 third graders (17 females) with low reading comprehension scores in the ELFE 1–6 subtest for text reading comprehension were identified and participated in the study (mean age = 9.4 years; *SD* = 0.6). Parental informed and written

1 Originally, we planned to compare a condition in which text would be faded out at the exact self-paced reading rate with a slow fading condition. However, a systematic presentation error resulted in two slow fading conditions.

2 All children of the eight schools whose parents agreed on their participation were included in the screening. Out of the screening sample, the subgroup of children was identified who scored in the lowest 25th percentile in the standardized reading test but within the norm range of intelligence regarding deductive reasoning. This subsample participated in the present study.

consent was obtained for each child. All participants performed within the range of normal intelligence regarding deductive reasoning measured by the SPM Plus (mean IQ score 90; *SD* = 8.1), but showed a reading performance below average in the ELFE text reading subtest (mean reading percentile rank = 11.4; *SD* = 7.9).

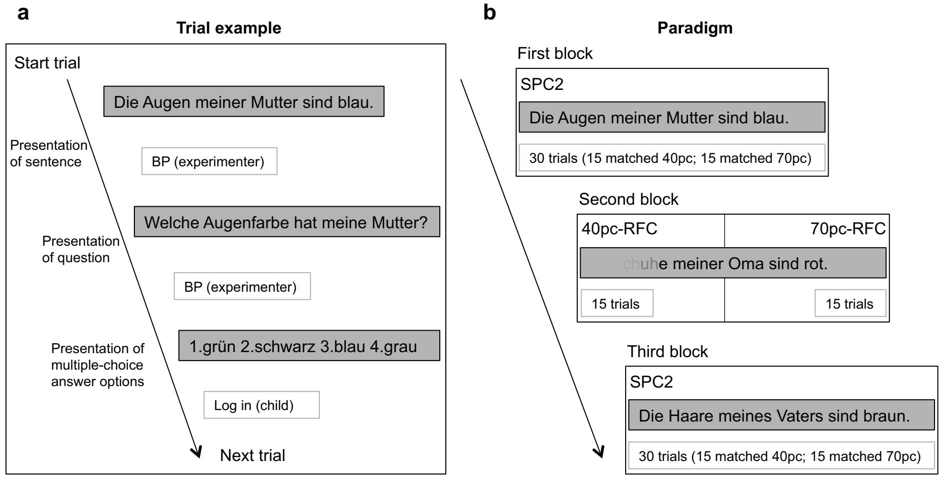
2.2 Materials

A pool of sentences was generated. The material was adjusted to the reading proficiency level of German third grade readers and consisted of sentences, questions and four multiple-choice alternatives. For each sentence, two parallel sentences were generated which were matched regarding two criteria, that is, number of syllables and readability level (defined via *Flesch Reading Ease index*; Flesch, 1948). Overall, 30 sets with three parallel sentences each were generated amounting to a total of 90 sentences. The reading material was implemented as picture files in the experimental program.

2.3 Procedure

Participating children were individually tested in soundproof cabinets installed in mini-busses parked on the school ground. Tasks were presented left-justified central in black print (font type: Arial, letter size: 14 pt.) against a grey background using a 15.4-inch laptop running Presentation® software (Neurobehavioral Systems, Inc.). Each trial started with the presentation of a sentence, followed by a question referring to the sentence and ended with four multiple-choice answer alternatives (see Figure 1). To identify the reading rate per sentence, the children were asked to start reading out loud as soon as the text appeared on the screen. The individual reading rate for each sentence was computerized measured from the point of time the sentence appeared on the screen until the child finished reading the sentence as determined by the experimenter pressing a button. Subsequently, a question referring to the previous sentence was presented on the screen. When the child finished reading out loud the question, the experimenter induced the presentation of the multiple-choice answers by pressing another button. Although voice activated timing might be a more precise technique, Farrington-Flint, Coyne, Stiller, and Heath (2008) pointed out that it is not the best measure when working with children who often talk before and after finishing reading. Therefore, a manual measurement of reading rate was preferred over voice activated timing. The presented multiple-choice answers were labeled with numbers (1, 2, 3, and 4), matching four marked keys on the keyboard and the correct answer was assigned to one of the four numbers. The children were asked to choose one of the answer alternatives and press the corresponding key.

Figure 1: Details of the experimental procedure: Examples of a trial sequence (a) and the different experimental conditions (b). The arrow represents the course of time



Note. SPC1 = Self-Paced Condition 1; 40pc and 40pc-RFC = 40-percent-Reduced Fading Condition; 70pc and 70pc-RFC = 70-percent-Reduced Fading Condition; SPC2 = Self-Paced Condition 2; BP = Button Press. English translation of example sentences: Die Augen meiner Mutter sind blau. [My mother's eyes are blue.]; Welche Augenfarbe hat meine Mutter? [What is my mother's eye color?]; 1. grün 2. schwarz 3. blau 4. grau [1. green 2. black 3. blue 4. gray]; Die Schuhe meiner Oma sind rot. [My grandmother's shoes are red.]; Die Haare meines Vaters sind braun. [My father's hair is brown.].

2.4 Design

As shown in Figure 1, the sentences were presented to each child in three blocks. The first self-paced block (Self-Paced Condition 1; SPC1) consisted of 30 trials. After 15 trials the children were offered a break. The children were instructed to read the sentences at their own comfortable reading rate. The individual reading rate (in milliseconds) was separately determined for each sentence. Based on the corpus of parallel sentences, the recorded individual reading rate for a given sentence was used to define the fading rate for the respective parallel form of this sentence in the second block. In the second block, sentences were faded out continuously in reading direction. This was operationalized through a bar with the same color as the background (i.e., the bar was invisible), which successively masked the sentence's picture file. That is, the bar steadily moved pixel-by-pixel based on the individual's reading rate for the parallel sentence recorded in the SPC1. Hence, the children would see the sentence once altogether before the bar would start masking the pixels of the sentence file, eventually covering the entire sentence. This block was divided into two fading conditions with 15 trials each. In the 40-percent-Reduced Fading Condition (40pc-RFC), the rate at which the bar covered the pixels of the sentence's picture file was 40 % slower than the self-paced reading rate. In the 70-percent-Reduced Fading Condition (70pc-RFC), the fading rate was 70 % slower than the self-paced reading rate. As there was a break between the fading conditions, the course of events equaled the self-paced conditions in which 2 x 15 trials were accomplished as well. Therefore, the second block was experienced as a single block although two conditions were conducted. The order of the 40pc-RFC and the 70pc-RFC was counter balanced so that half of the participants were presented with 40pc-RFC trials first and subsequently with 70pc-RFC trials and vice versa. In the third block (Self-Paced Condition 2; SPC2), children again read 30 sentences at their own comfortable reading rate in a similar manner as described for the SPC1. The parallel forms of all sentences were presented in each of the three blocks so that all parallel items were presented once in each block. The children were introduced to three practice runs ahead of every block after which remaining questions were answered. Children were instructed before every block and were asked to read as fast and as accurately as possible. Instructions only included the description of the task, but no information about the fading rates. Breaks between blocks were assured and a child-friendly environment was provided. To retain children's motivation, a board game was introduced to track how many trials had been accomplished and how many still had to be completed.

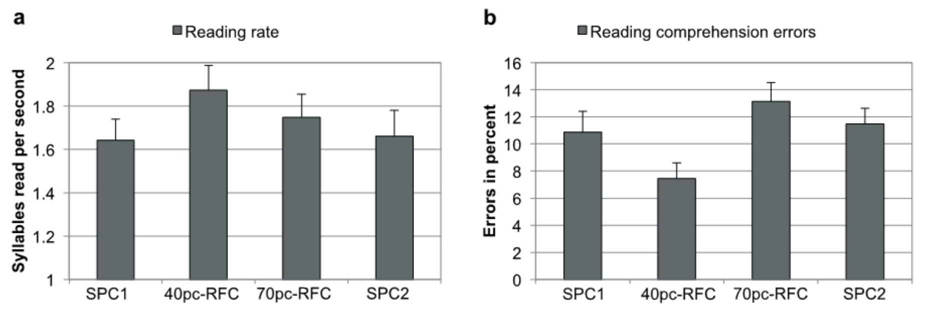
3. Results

Two one-way analyses of variance (ANOVA) with repeated measures (Condition: SPC1, 40pc-RFC, 70pc-RFC, SPC2) were conducted for the dependent variables' reading rate (expressed by number of syllables read per second) and comprehension performance (measured by error percentages). Planned contrasts were performed to compare self-paced scores with the performance in the 40pc-RFC and the 70pc-RFC. The order of 40pc-RFC and 70pc-RFC did not result in sequence effects.

The analysis of reading rate revealed a main effect for Condition, $F(3, 31) = 47.11$, $p < .001$, $\eta_p^2 = .82$. As displayed in Figure 2 and supported by planned contrasts, reading rates in the SPC1 and the SPC2 were comparable, $F(1, 33) = 0.25$, $p > .05$, $\eta_p^2 = .01$, while the reading performance in the 40pc-RFC and the 70pc-RFC differed from both self-paced conditions. Significantly faster reading rates were observable in the 40pc-RFC compared to the SPC1, $F(1, 33) = 66.62$, $p < .001$, $\eta_p^2 = .67$, and SPC2, $F(1, 33) = 84.11$, $p < .001$, $\eta_p^2 = .72$. Comparison of the 70pc-RFC with the SPC1, $F(1, 33) = 15.92$, $p < .001$, $\eta_p^2 = .33$, as well as the 70pc-RFC with the SPC2, $F(1, 33) = 8.44$, $p = .007$, $\eta_p^2 = .20$, also revealed significantly faster reading rates. Furthermore, Fisher's Least Significant Difference (LSD; Fisher, 1935) post hoc pairwise comparisons showed that reading rate in the 40pc-RFC and the 70pc-RFC significantly differed from each other ($p < .001$), indicating faster reading rates in the 40pc-RFC. In comparison to the performance in the SPC1, reading rate was 12.4 % faster in the 40pc-RFC and 6.1 % faster in the 70pc-RFC.

The analysis of reading comprehension error rates revealed a main effect for Condition, $F(3, 31) = 5.83$, $p = .003$, $\eta_p^2 = .36$. As illustrated in Figure 2 and as confirmed by planned contrasts, there were no significant differences regarding comprehension error percentages between the SPC1 and the SPC2, $F(1, 33) = 0.13$, $p > .05$, $\eta_p^2 = .00$. Significantly reduced reading comprehension errors were observable in the 40pc-RFC compared to the SPC1, $F(1, 33) = 4.74$, $p < .05$, $\eta_p^2 = .13$, and the SPC2, $F(1, 33) = 6.64$, $p < .05$, $\eta_p^2 = .17$. LSD post hoc pairwise comparisons showed that comprehension performance in the 40pc-RFC and the 70pc-RFC also significantly differed from each other ($p < .001$), indicating better reading comprehension scores in the 40pc-RFC. Reading comprehension performance in the 70pc-RFC compared to the SPC1, $F(1, 33) = 1.23$, $p = .267$, $\eta_p^2 = .04$, and the SPC2, $F(1, 33) = 1.05$, $p > .05$, $\eta_p^2 = .03$, was comparable.

Figure 2: Results of reading behavior analyses: Reading rate in number of syllables read per second (a) and reading comprehension errors in percent (b) for all experimental conditions



	70pc-RFC	SPC1	SPC2	40pc-RFC
SPC1	$p < .001$	-	*ns*	$p < .001$
SPC2	$p < .001$	*ns*	-	$p < .001$
40pc-RFC	$p < .001$	$p < .001$	$p < .001$	-

	70pc-RFC	SPC1	SPC2	40pc-RFC
SPC1	*ns*	-	*ns*	$p < .05$
SPC2	*ns*	*ns*	-	$p < .05$
40pc-RFC	$p < .001$	$p < .05$	$p < .05$	-

Note. The standard error is indicated above the bars. Test of significance between conditions is depicted in the tables underneath the bar charts. SPC1 = Self-Paced Condition 1; 40pc-RFC = 40-percent-Reduced Fading Condition; 70pc-RFC = 70-percent-Reduced Fading Condition; SPC2 = Self-Paced Condition 2; *ns* = statistically not significant

4. Discussion

This study explored whether reading improvement in AP studies can also be induced by a slow fading manipulation. Two slow-paced conditions were introduced, one in which text was faded out 40 % slower and one in which text was faded out 70 % slower than the measured individual reading rate (40pc-RFC: 40 % slower than the SPC1; 70pc-RFC: 70 % slower than the SPC1). Data analysis revealed that, compared to the self-paced reading performance, children's reading rates were significantly faster in both slow-fading conditions, with significantly faster rates in the 40pc-RFC than in the 70pc-RFC. Analysis of reading comprehension scores revealed that a significant improvement of reading comprehension in comparison to the self-paced conditions was only observable in the 40pc-RFC.

The present findings suggest that the reading rate increase in AP studies might not be the result of an actual accelerated fading procedure as so far assumed. Since both of the slow-fading conditions in our study produced faster reading rates, it seems that the fading procedure does not have to be applied at a rate at the upper limit of participants' reading performance, but is already effective at slower rates. The data further revealed a difference between the effectiveness of the two implemented fading conditions. Although the fading rate in both fading conditions was considerably slower than the individual self-paced reading rate, both fading conditions led to faster reading rates. It is possible that the mere subjective feeling of time constraint, produced by the fading procedure, caused the participants to read faster. The 40pc-RFC and the 70pc-RFC, however, differed by the degree of reading rate improvement (12.4 % faster in the 40pc-RFC than the SPC1 vs. 6.1 % faster in the 70pc-RFC than the SPC1). We assume that time pressure in the 70pc-RFC was probably experienced to a lesser extent than in the 40pc-RFC. In other words, time constraint may have been experienced more distinctly in the 40pc-RFC, resulting in faster reading rates than in the 70pc-RFC. Interestingly, reading comprehension scores improved significantly only in the 40pc-RFC, but not in the 70pc-RFC. Previous findings demonstrated that time pressure is directly related to reading performance improvement: Walczyk, Kelly, Meche, and Braud (1999), who implemented time pressure through countdown clocks in a sample of undergraduate students, observed that mild time pressure was significantly more effective than no time pressure, leading to faster reading rates and better comprehension scores under mild time constraints. The authors concluded that mild time pressure seems to increase motivation, attention and effort, while readers under no time pressure are probably not optimally challenged. With regard to Breznitz' explanatory approach of a more focused attention (see Breznitz, 1988) through the fading manipulation, it is possible that the experienced time pressure resulted in a reduced distractibility and a shift of attention to the task, at least in the 40pc-RFC. Hence, although participants probably did experience some kind of time constraint in the 70pc-RFC, it might have not sufficed to exert pressure and achieve attention gains to positively affect reading comprehension. To receive more information about the fading rate's influence, methodologically carefully designed studies should focus on implementing different fading rates to investigate possible differential effects.

Following Breznitz's working memory explanatory approach (see Breznitz & Share, 1992), we suppose that the faster reading rate, triggered by the fading procedure, may have resulted in reading comprehension improvements due to the optimization of working memory capacity. Based on findings from Baddeley (1981, 1992), we assume that faster rehearsal allows participants to retain a larger amount of information in phonological working memory. We propose, in line with Perfetti (1985), that the faster processing speed due to text fading has an impact on the efficient usage of available working memory capacity. Additionally, and in line with Breznitz (1987) explanatory approach focusing on improved direct fact retrieval, the faster reading rate might have led to a more effective use of reading strategies. As described in previous studies (Farrington-Flint et al., 2008; Lindberg et al., 2011), elementary school children use multiple strategies to decode written text. More or less elaborated strategies exist which differ in effectiveness and processing time, the most effective and fastest strategy being direct fact retrieval (Siegler, 1991). Even though children might theoretically be able to use highly elaborated strategies such as fact retrieval, they often do not actually apply them but rely on less elaborated and error-prone backup strategies (Lindberg et al., 2011). As mentioned above, we assume that participants experienced time pressure more pronouncedly in the 40pc-RFC than in the 70pc-RFC. As a consequence, the fading manipulation in the 40pc-RFC might have produced a stronger feeling of limited processing time. Assuming that the usage of time consuming backup strategies might have been inhibited by the perception of time limitation as experienced in the 40pc-RFC, direct fact retrieval may have been applied more frequently. Hence, the increase of direct fact retrieval usage might have led to better comprehension scores in the 40pc-RFC. In the 70pc-RFC, however, no comprehension enhancements were detectable. We therefore suppose that there may be a speed threshold, which needs to be exceeded in order to significantly profit from faster rehearsal and enhanced fact retrieval. Breznitz reported in previous studies that elementary school aged children enhanced their reading rate by 15–20 % compared to their self-paced reading rate (Breznitz, 1997a; Breznitz & Berman, 2003; Breznitz, DeMarco, Shammi, & Hakerem, 1994). In consideration of Breznitz' findings and our data, we suppose that a reading rate increase by 6.1 %, as detectable in the 70pc-RFC, might have had an insufficient effect. On the contrary, a reading rate increase of 12.4 %, as shown in the 40pc-RFC, seemed to suffice to improve reading comprehension. Prospectively, it would be interesting to investigate if the reading comprehension improvements may even be stronger with higher reading rate gains and if there is a limit to reading rate increase. Future studies should therefore gradually explore different fading rates to illuminate how fast individuals can read until reading performance declines.

With regard to a possible pedagogical applicability, the described findings seem encouraging. The fading manipulation may offer a basis for future reading fluency training programs. Given that reading fluency is one of the major factors associated with reading disabilities especially in rather transparent languages (Wimmer et al., 1998; de Jong & van der Leij, 2003), it seems sensible to directly target the improvement of children's reading rate. Approaches to improving reading fluency and reading comprehension often used repeated reading techniques (i.e., repeated rereading of the same word material combined with feedback and corrections; O'Connor, White, & Swanson, 2007). Results indicated that guided repeated reading positively influenced word recognition, fluency and comprehension (Chard, Vaughn, & Tyler, 2002). *Paired-reading* (Topping, 1995) has been frequently used as a repeated reading intervention. Rosebrock, Rieckmann, Nix, and Gold (2010) for example investigated a sample of German sixth graders following this approach: A student with problematic reading achievement was matched to a better achieving student (tutor). The tandem was asked to read text aloud simultaneously and to repeat this procedure several times. By emulating the reading performance of the tutor, the child with reading difficulties was able to adjust his/her reading performance to a more efficient reading rate. The collected empirical results showed that this adjustment resulted in positive effects regarding significantly improved reading rate and reading comprehension for children with reading difficulties, when reading with a tutor compared to low achieving children reading by themselves. However, training programs using oral reading are most often very time consuming and not well realizable in a classroom setting. In this regard, the *National Reading Panel* (2000) noted that there is a lack of controlled studies for intervention programs integrating independent, silent reading. As the fundamental idea of AP research is to foster silent reading, a reading fluency training approach integrating the fading manipulation would be an economically and ecologically attractive solution to improving reading fluency and reading comprehension in group settings. First attempts to apply the fading manipulation in a training approach recently revealed promising results for adult dyslexics (Breznitz et al., 2013). Further training studies should focus their attention on investigating whether long-lasting training effects can be attained by administering the fading manipulation to dyslexic children.

In sum, text fading represents an effective tool to improve reading rate and comprehension for children with reading difficulties even at slow fading rates. This might be of great pedagogical relevance, as fast fading rates may be too stressful for some children. Since slower fading rates seem to produce reading improvements comparable to accelerated fading, it might be advisable to use slower and more moderate fading rates. However, the fading rate does seem to be influential, as reading comprehension improvements in this study were only observable in the 40pc-RFC. Future studies should focus on the exploration of the impact of reading rate on reading comprehension more closely and gradually manipulate fading rates to investigate their effects on comprehension scores. Possible future training programs could then implement the fading manipulation and adjust it to individual needs and performance levels. Furthermore, the text fading procedure might be an economically and ecologically promising instrument to improve the reading performance of children at risk for developing reading difficulties.

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