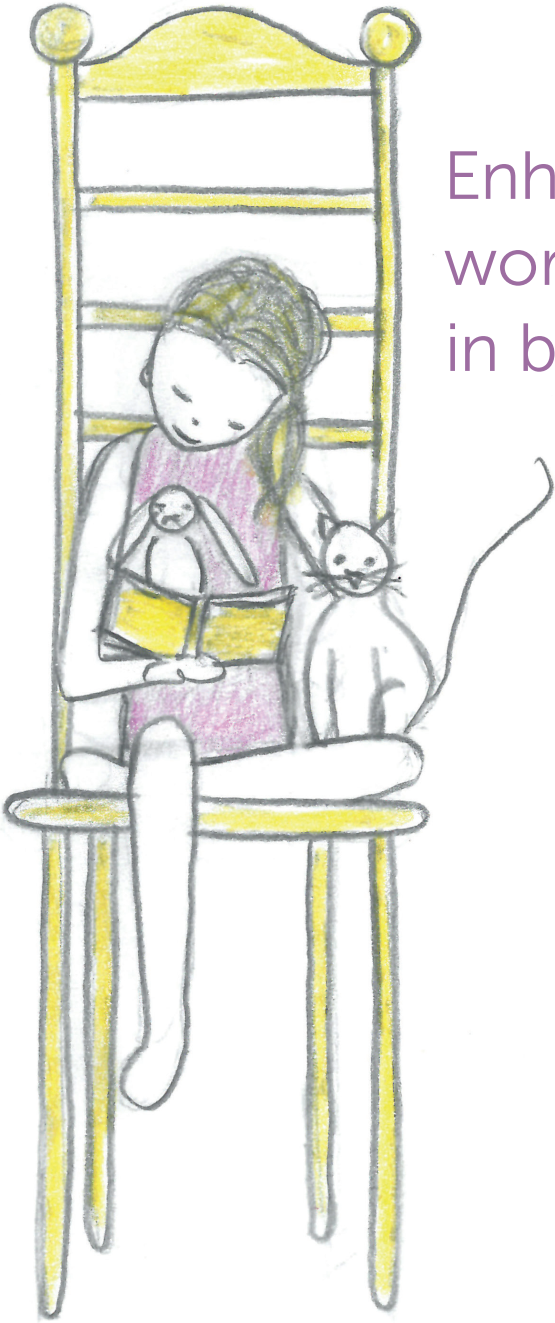

Enhancing word reading fluency in beginning readers

Karly van Gorp

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It always seems impossible until it's done.

~Nelson Mandela.

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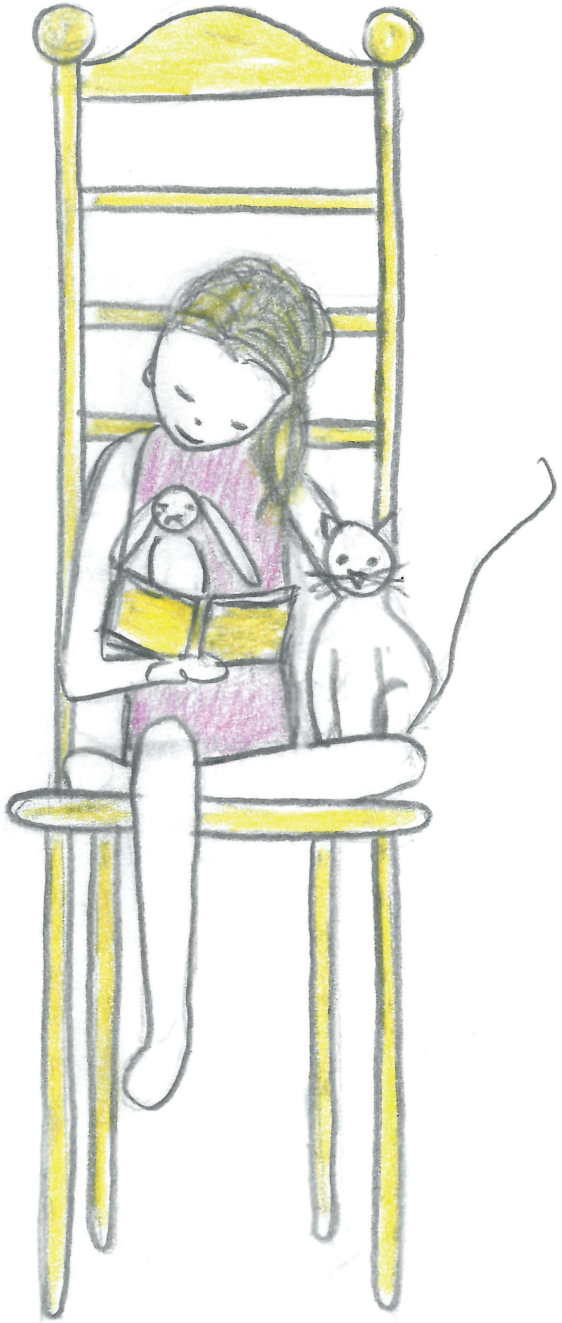

1

General introduction

In contemporary primary education, one of the major goals set out for children is learning to read well. In learning to read, children are being taught letter-sound correspondences that enable them to sound out words. In order to be able to comprehend texts, it is important that their word reading becomes fluent (Torgesen, Rashotte, & Alexander, 2001). If word reading is not fluent, this reading takes so much capacity of working memory that comprehension is severely hampered. Word reading can be considered fluent when it is both accurate and fast (e.g., Wolf & Katzir-Cohen, 2001). For the majority of children, reading fluency develops without any problem. For a substantial group of children, however, reading fluency development is more problematic. For poor readers of opaque orthographies, such as English, the first hurdle is to reach reading accuracy (Aro & Wimmer, 2003). Almost none of the graphemes have a link to a single phoneme and vice versa, which makes it hard to apply grapheme-phoneme-correspondence (GPC) rules. As soon as these poor readers have become accurate, they have to automatize the word decoding process. For poor readers of transparent orthographies, such as Dutch, reaching word reading accuracy is relatively easy. When compared to their normal reading peers, poor readers of transparent orthographies mainly lag behind in word reading speed (Landerl & Wimmer, 2008).

It has been found that children who are behind in reading in the first years of education, remain poor readers throughout elementary school (De Jong & Van der Leij, 2003). In fact, the gap between good and poor readers increases over time, a phenomenon which Stanovich (1986) referred to as the Matthew effect (see also: Bast & Reitsma, 1998; Landerl & Wimmer, 2008). To help children to become more fluent in word reading, it is therefore very important to apply interventions early on in their education. To date, many interventions have succeeded in improving word reading speed of trained items, but it has proven difficult to maintain the increased levels of word reading speed over time and to transfer the outcomes to untrained items (Berends & Reitsma, 2006). In the present dissertation, the focus is therefore on developing an intervention paradigm that aims to have direct, transfer and retention effects on word reading fluency in poor decoders in a transparent orthography.

Word reading models

In experienced readers, there are three different types of information available for each word. For the word CAT the reader has information about how the word is written, which is called *orthographic knowledge.* The three graphemes of the word CAT have distinct orthographic features which makes them easy to recognize and the combination of the three letters represent the written word CAT. The second component is *phonological knowledge;* the word CAT is uttered in speech as /'kæt/.

In this case, there are also three phonemes that correspond to the three graphemes. The third component is *semantic knowledge,* or knowledge about the meaning of a word. While reading the word CAT, not only orthography and phonology are activated, but meaning is activated as well, e.g., the fact that a cat can be defined as a four legged pet with whiskers. These three components are reflected in two of the most common models of word reading. The models are presented here in order to give insight into the complexity of reading words. It is not the aim of this dissertation to compare these theories or to choose a model that is preferred over the other.

DRC model

A classical model of word reading is the dual route cascaded (DRC) model for reading aloud (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001). This model is depicted in Figure 1.1. According to this model there are two different routes of reading words aloud. Both routes start with print and thus orthographic information that is analyzed. During this 'letter analysis', features of letters and entire letters are being identified. After this analysis, two different routes are possible; the lexical route and the non-lexical route. If a word is unfamiliar or even new to the reader, the indirect or non-lexical route is assessed. In this route, GPC rules are applied via the so called 'grapheme-phoneme conversion', in which readers move from a written word to a spoken word in a linear fashion. This is a route that is only suitable for reading regular words, since for irregular words (e.g., *famous*) it is unlikely that applying GPC rules will lead to the correct pronunciation. For reading irregular words and familiar regular words, experienced readers mainly use the direct route (depicted at the left side of the diagram). In this route, there is direct access from the orthographic representation to the orthographic lexicon. From this lexicon, there are links to both the meaning (semantics) and the phonological representation of a word. When reading familiar words such as HOUSE via this direct route, meaning and pronunciation of the word are accessed. This route is more automatic and faster than the indirect route. Moreover, via this route there is feedback from all three levels of representations (depicted by bidirectional arrows in Figure 1.1). For both routes, the final step is the 'phoneme system' from which speech is uttered.

Triangle model

A complementary model for reading words is the parallel distributed processing (PDP) model from Seidenberg and colleagues (Harm & Seidenberg, 1999, 2004; Plaut, McClelland, Seidenberg, & Patterson, 1996; Seidenberg & McClelland, 1989) From this connectionist model, the triangle model can be deducted, which is depicted in Figure 1.2. The triangle model refers to the triangle of orthography, phonology and semantics. Following this model, there are connections between all three components, in both directions. Thus from orthography, there are direct links to semantics and

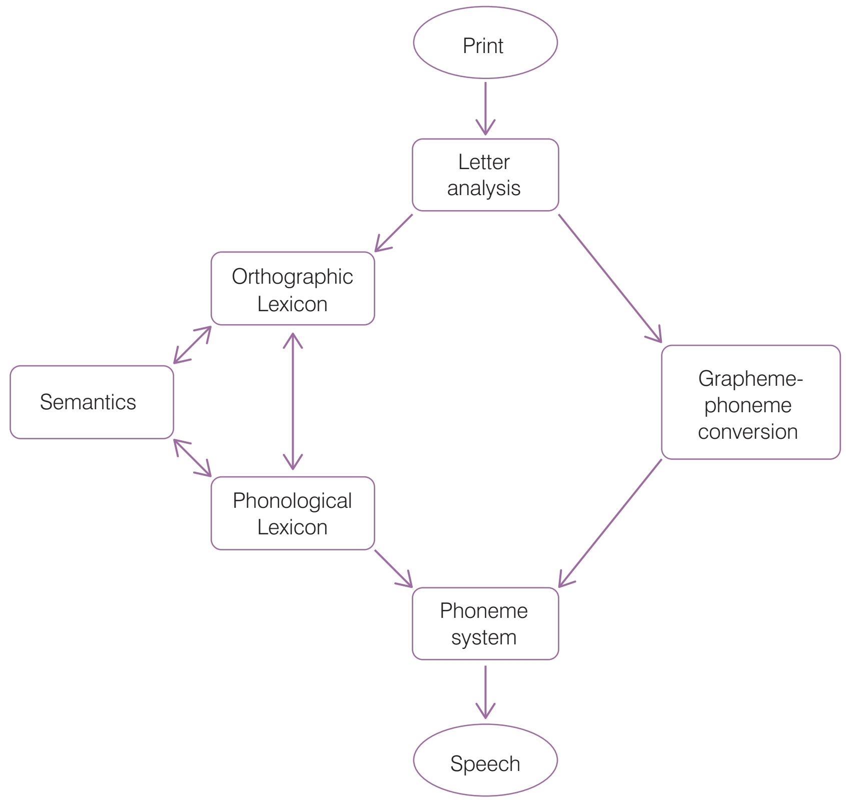

Figure 1.1 DRC Model for Reading Aloud (Coltheart et al., 2001).

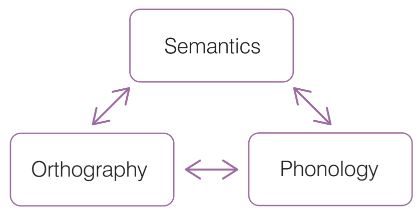

Figure 1.2 Simplified Representation of the Triangle Model (Harm & Seidenberg, 2004).

1

phonology, which in turn also have a link to each other. Due to these different links, a direct and an indirect route from orthography to phonology is possible (see: Coltheart, 2005). When encountering a written word, one can either move directly to phonology and thus speech or one can first access semantics and then move to speech.

Word reading development

Beginning readers have to learn what the relation between orthography and phonology is and this link needs to be trained and strengthened. Since beginning readers are inexperienced, most words can be considered as unfamiliar and as such they need to be read via the indirect route of reading. That children indeed predominantly rely on this indirect route has been shown by the presence of a length effect in lexical decision studies (Acha & Perea, 2008; Martens & De Jong, 2006). These studies showed that beginning readers are sensitive to word length, which is reflected in their decision time needed to make lexical decisions. Intermediate readers are less sensitive to this and experienced readers show no length effect at all, which is also reflected in their response times (Martens & De Jong, 2006). Looking at the DRC model, these findings can be translated to the assumption that beginning readers mostly use the indirect route of reading, which is slow and laborious, whereas experienced reading make use of the direct route for familiar words.

Apart from lexical decision, differences in reading attack strategies could be tracked by means of priming. In priming, a certain prime (e.g., the onset of a word) is presented shortly before the target item. This prime can either help or inhibit the response to the word (in a lexical decision task). If reading is indirect, priming of onsets is likely to be facilitated by such a prime, since reading is from left to right and the onset has been seen already. But if reading is direct, an onset prime is not likely to facilitate reading rate in a fast process such as lexical decision, since reading takes no longer place from left to right.

Phonological recoding and self-teaching

In order to be able to read words, children are assumed to already have passed the stages of acquiring phonological and phonemic awareness and to have obtained (at least partial) letter knowledge. When they have knowledge of graphemes (what letters look like) and phonemes (what letters sound like) they can learn to apply GPC rules. By applying these rules they learn what letters belong to which sounds and vice versa. The task of applying these rules is also referred to as phonological recoding.

It is assumed that this phonological recoding is a self-teaching device (Jorm & Share, 1983; Share, 1995; Share, 2004). Every time a child encounters a word, this word is phonologically recoded, one grapheme at a time. On each encounter with a word, children provide themselves with feedback (e.g., the letters C A T represent the word CAT, which sounds like /ˈkæt/). By applying these rules, orthographic information about the word is stored, which makes it easier to recognize the word the next time. Key features of this self-teaching process are exposure and repetition. Only a few exposures of the same word can be sufficient to store proper orthographic representations of words (e.g. Share, 2004). When representations are stored properly, reading can take place via the direct route, rather than via the indirect route.

Lexical quality hypothesis

As is evident from the depicted models of reading, a lexical representation consists of the three components: orthography, phonology and semantics. The strong orthographic representation as is being formed via phonological recoding alone is not sufficient to be able to identify words rapidly. Alongside orthography and phonology and the link between those two components, the semantics component and the accompanying bidirectional links need to be strengthened during word reading development. According to the lexical quality hypothesis (Perfetti, 1992; Perfetti & Hart, 2002), a lexical representation is of high quality when it is both specific and redundant. The specificity refers to all the representational aspects of a word. With redundancy Perfetti and Hart (2002) refer to the notion that each word can have multiple phonological representations; from spoken language and from orthographic-phonological mapping. If a lexical representation is highly specified and redundant, retrieval is easier and also more reliable (Perfetti & Hart, 2002). Thus, in order to establish a good lexical representation for reading, one must know the meaning of the word, know how a word is pronounced and know how it is written.

Word reading problems

As shortly mentioned before, the main difference between good and poor decoders of transparent orthographies mainly lies in the ability to read words fluently. Whereas good or normal decoders seem to accomplish this fluency with ease, poor readers struggle, in particular with reaching speed (Landerl & Wimmer, 2008). For this reason, the main goal of many word reading interventions in languages with transparent orthographies is to increase word reading speed, without affecting word reading accuracy. From theories on (the development of) word reading it can be deducted that repetition is a key factor, as well as strengthening the link between all three components of a word (i.e., orthography, phonology, and semantics). When a word is read repeatedly, it becomes easier to recognize and name it with speed. However, since it is virtually impossible to repeat all words in order to recognize them fluently, it is important to improve general reading speed in poor readers. This can be done by developing word reading strategies that help them to decode untrained or new words faster as well. The challenge is in finding such strategies.

Repeated reading interventions

A common method to improve word reading speed is repeated word reading. In repeated word reading, a certain set of words and/or pseudowords is read out aloud by the participants repeatedly. This method has not only shown to be effective in enhancing word reading fluency, but also in enhancing sentence and text reading fluency (see: Kuhn & Stahl 2003; Therrien, 2004, Wolf & Katzir-Cohen, 2001).

The main goal of repeated reading interventions is, however, not to only increase the reading speed of the trained items, but to increase the reading speed of untrained items as well. The goal is thus to reach transfer or generalization effects, which proves hard to find (Berends & Reitsma, 2006). Some of repeated reading studies that did seem to effectuate transfer to untrained items have as a common factor that they included direct feedback on the words read during training (Heikkilä, Aro, Närhi, Westerholm, & Ahonen, 2013; Huemer, Aro, Landerl & Lyytinen, 2010; Steenbeek-Planting, Van Bon, & Schreuder, 2012). Also, in a repeated reading intervention with flashcards (pseudowords were represented for a limited duration) in which feedback was provided on the responses, Van den Bosch, Van Bon, and Schreuder (1995) found transfer effects to untrained items. The influence of feedback, however, was not a topic of interest in any of these studies. In the latter example, the limited exposure duration could also have caused the transfer effects, as was found for sentences that were exposed for a limited time (e.g., Breznitz & Berman, 2003). Since it is not sure whether the inclusion of feedback in repeated reading is indeed causing the transfer effects, it is important to further examine the role of feedback.

Computer (assisted) interventions

Nowadays, most repeated reading interventions focusing on improving word reading speed are computer assisted with the stimuli being presented on a computer screen. In order to provide feedback, a tutor or experimenter is sitting next to the participant and indicates whether the participant named the item correctly or not. Based on the input of the tutor, the computer then in turn provides feedback to the participant.

As technology develops in a tremendously high speed, it is obvious that the tutor in the previous example is soon to be replaced by a computer. In order to be able to do this, the computer either has to be able to recognize the speech of the participants (Mostow & Aist, 2013) or different paradigms to enhance reading fluency need to be developed. Methods that do not require speech recognition but do allow for checking whether the child reads the word accurately and also allow for measuring word reading speed are lexical decision and semantic categorization. In lexical decision, participants have to decide whether the presented words are existing words or not. In semantic categorization, participants have to indicate to which of the presented categories a certain word belongs. The computer can provide feedback with regard to correctness and can also provide pre-programmed feedback with regard to the correct pronunciation of the practiced words.

There are numerous benefits of computer interventions, as compared to regular classroom or tutor interventions. First, computer interventions are less costly with regard to both time and money. Second, it has been found that computer interventions can be more effective than regular interventions, which has been ascribed to increased motivation (Saine, Lerkkanen, Ahonen, Tolvanen, & Lyytinen, 2011). Finally, a computer can offer children with limitless amounts of repetition (Segers & Verhoeven, 2005), and repetition is known to be effective in learning and in enhancing word reading speed accordingly (Share, 2004).

The present dissertation

In the present dissertation, the subjects were good and poor experienced and beginning readers of Dutch. Dutch can be classified as a rather transparent orthography (Borgwaldt, Hellwig, & De Groot, 2005; Ziegler et al., 2010). In The Netherlands, children attend kindergarten from the age of four. In the second year of kindergarten, children are informally introduced to the most common graphemes in Dutch. They are not required to know any of these by the end of kindergarten. Moreover, they play games in order to enhance their phonological and phonemic awareness skills. After two years of kindergarten, at the age of six, children start their education in first grade. Here, they receive formal reading instruction and after only six months of instruction they are familiarized with all graphemes of Dutch and they know how to read simple CVC (consonant, vowel, consonant) words. Accurate reading is not the main problem in poor readers of languages with transparent orthographies. These children do however struggle with increasing their reading speed. In the present dissertation it was investigated how good and poor reading children of Dutch develop word reading fluency. Moreover, interventions were developed to help poor decoders to become more fluent.

Aims and research questions

The aim of the present dissertation was to provide insight on how ICT reading interventions can improve word reading speed in poor reading children of an orthographically transparent language. The ultimate goal of the project was to develop a computer intervention designed to help these children in becoming more fluent readers. The computer intervention was assumed to be effective if enhanced word reading speed also transferred to untrained words and if this speed was retained several weeks after the actual intervention took place. In order to create such an intervention, it was investigated in what ways poor readers differed from their good reading peers with regard to decoding skills. It was examined what the effect of repeated reading combined with corrective feedback was. Also, it was examined what methods could be used to enhance word reading fluency in beginning readers. In order to reach this goal of enhancing word reading fluency by means of a computer intervention, the following three research questions were addressed:

1.) What is the role of repetition in combination with feedback in enhancing word reading speed in good and poor beginning readers?
2.) What is the role of priming in enhancing word reading speed in experienced and beginning readers?
3.) Can a computerized intervention in which repetition, feedback, semantics and motivation are incorporated enhance word reading speed of poor reading children?

Outline of dissertation

The present dissertation consists of four research-based articles that have either been published or (re)submitted for publication in international peer-reviewed journals. The dissertation starts with two repeated reading studies in respectively kindergartners and first graders. In *Chapter 2* ("Repeated reading intervention effects in kindergartners with partial letter knowledge", published), the effect of repeated reading of single words and pseudowords in kindergartners is being addressed. In this study, kindergartners repeatedly read a set of words and pseudowords and direct, retention and transfer effects were assessed. This study provided insight in the role of repetition in combination with feedback in good reading beginning readers. *Chapter 3* ("Repeated word reading effects and the role of feedback in good and poor decoders in first grade") used the same paradigm and the same materials as were used in Chapter 2. In this study, the effects of repetition were assessed in good and poor reading first graders. This was examined in order to track differences between the good and the poor readers and to see whether different types of feedback would effectuate larger increases in reading fluency. In *Chapter 4* ("Masked onset priming in lexical decision", accepted for publication.), the effect of orthographic primes on reading accuracy and speed was assessed in adults and second graders. In this chapter, the differences in reading attack strategies used by adults and children were investigated. *Chapter 5* ("Enhancing decoding efficiency in poor readers via a word identification game") describes the effects that are found with the tablet intervention that was developed based on the results of previous chapters in this dissertation. In this intervention, the factors repetition, feedback, priming, semantics and motivation were included. In *Chapter 6,* a general discussion of the dissertation is provided.

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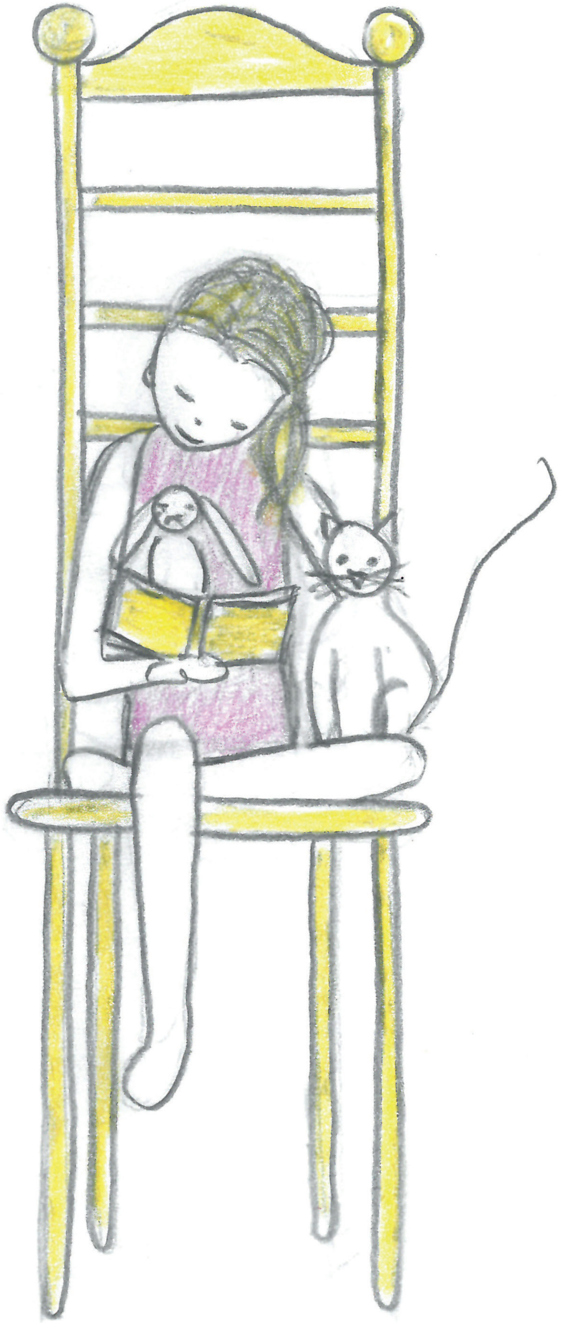

2

Repeated reading intervention effects in kindergartners with partial letter knowledge

This chapter is based on: Van Gorp, K., Segers, E., & Verhoeven, L. (2014).
Repeated reading intervention effects in kindergartners with partial letter knowledge.
International Journal of Disability, Development and Education, 61, 225-239.
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Abstract

The direct, transfer and retention effects of a repeated reading intervention study of single CVC (consonant in the onset and a vowel and consonant in the rime) words in kindergartners with partial letter knowledge were examined. A total of 26 second-year kindergartners participated in this study. Participants were divided over two feedback conditions: one group received feedback on the whole word, and the other group received feedback on the segmented sounds of the word plus the whole word. The intervention lasted 10 sessions, each of which consisted of reading the same 25 CVC words and 25 CVC pseudowords. Prior to and after the intervention, a transfer task was administered, containing 50 other CVC words and pseudowords. Two weeks after training, retention of the trained items was tested. Results showed an increase in reading speed and accuracy during the 10 sessions, with no differences between the two feedback conditions. Also, strong transfer and retention effects were found. The results of this study indicate that a repeated reading intervention in kindergarten, in which pre-readers are brought into a full alphabetic stage, is an effective method to improve reading speed and reading accuracy on trained and untrained words.

Introduction

In a rich print-based environment, children discover written language as a new modality. They learn that words are built up by speech sounds that can be represented by letters. On the basis of an analysis of familiar words involving their constituent sounds and letters, they discover which speech sounds and letters can be mapped onto each other in perspective of word decoding. In emergent word decoding, children are provided with feedback for each attempt they make to phonologically decode words, thus incrementally building up their orthographic representation of specific words (Perfetti, 1992). One can deduce from the self-teaching hypothesis (Share, 1995, 2004) that a few exposures to a word may be sufficient to come to a correct representation of a word. Every encounter helps to decode the word correctly, and enhances the specificity of the underlying representation. However, it turns out to be the case that many children do not succeed in teaching themselves how to decode words as long as letter knowledge is still incomplete. It seems that the self-teaching device in children will then be hampered, since word decoding will often fail and repeated word exposures have minimal chance to occur. In order to find out to what extent the self-teaching mechanism can be activated at an early age, we studied kindergartners with partial letter knowledge who were raised to a task-related full alphabetic stage and provided with repeated exposure of a set of words. In the research on emergent word decoding conducted so far, the exact process of just how children reach increased speed through repeated readings remains undocumented, especially in interaction with different types of feedback.

The development of word decoding can be conceptualised along a continuum that ranges from the slow and laborious reading of words to the rapid and effortless decoding of words (Logan, 1997). Children go through a number of stages along this continuum (Adams, 1990; Ehri, 2005; Frith, 1986). When they have reached the full alphabetic stage, the children can make connections between letters and sounds, which enables them to read words they have never seen before. When words are specified correctly, speed and thus automaticity come into play. Torgesen, Rashotte, and Alexander (2001) showed that the most important factor causing poor reading fluency is a low reading speed in individual words. To acquire a stage of fluent reading, one is thus required to be able to decode words at a high rate. This is underlined in a recent study by Verhoeven and van Leeuwe (2009) in which they found that the development of word decoding is largely a matter of speed. In past decades, there has been great interest in stimulating beginning literacy in kindergartners (National Early Literacy Panel, 2008). Many studies focused on the development of phonological awareness (for example, Byrne, Fielding-Barnsley, & Ashley, 2000), and its longitudinal effects on word decoding in the first grade (see Bus & van IJzendoorn, 1999). However, more recently, there has been a shift towards also paying attention to emergent reading in these young children. Bowyer-Crane et al. (2007) showed the effects of shared storybook reading on kindergartners' decoding skills. In a similar vein, Segers and Verhoeven (2005) found the use of computer interventions to be effective in stimulating early literacy in kindergarten. In line with such findings, Ehri (2012) made the case to stimulate learning to read before the age of six, as this would lengthen the process of learning to decode, which may be especially beneficial for children at risk for dyslexia. De Graaff, Bosman, Hasselman, and Verhoeven (2009) brought kindergartners into a full alphabetic stage, with only partial letter knowledge by means of a computerised instruction. Participants received either systematic or unsystematic phonics instruction. The goal of these phonics instructions was to teach the children how to apply GPC (grapheme phoneme correspondence) rules. Even though both groups showed similar progress in applying these rules, children in the systematic phonics instruction improved more on measures of phonemic awareness, spelling and reading. Next to the focus on beginning literacy, researchers have paid a lot of effort to finding ways to enhance speed of reading in children. As said before, speed is often a problem in poor readers, and so several intervention studies focused on increasing fluency in early readers. Breznitz (1987) studied reading fluency in first-graders by altering the presentation rate of the words in a sentence. In one condition the reading rate was selfpaced, in a second condition the computer presented the words at the slowest reading rate that the participant had performed during the self-paced reading, and the third condition was at the fastest pace. This latter condition led to highest accuracy scores and comprehension scores. She replicated this acceleration phenomenon in several studies (for example, Breznitz, 1997; Breznitz & Leikin, 2001). In yet another reading intervention focusing on fluency, Shaywitz et al. (2004) studied poor and good reading children aged six to nine. They compared two types of one-year interventions with a control group who received no intervention. One of the interventions was experimental and phonologically based (including sound–symbol associations, analysing and synthesizing phonemes and timed reading of words), and the other intervention varied between participating schools and consisted of the remedial reading intervention that was commonly used in those schools. The phonologically based intervention was most successful. However, even though the reading rate and accuracy improved directly after the intervention, the data revealed that poor-reading children did not maintain this level of fluency a year later.

A more promising way to improve reading fluency is by means of repeated reading (Kuhn & Stahl, 2003). Even though most studies on the effects of repeated reading are on text reading fluency, some studies have focused on the effects of repeated reading of words on word decoding speed. The first of these was conducted by Berends and Reitsma (2006), who found larger reading gains on trained words for second-grade children who read the same word 20 times than for those who read each word only once. There were no transfer effects to new words, regardless of the orthographic relatedness of the items. In a second study, Martens and de Jong (2008) investigated the effects of a four-day intervention programme of repeated reading of words of varying word length in fourth-grade children with dyslexia and in chronologically aged controls. An increase of speed and accuracy from pre-test to post-test was evidenced, but the so-called length effect did not disappear at post-test, suggesting that an increase in speed is not a direct evidence of automaticity. Both these studies measured reading speed at pre-test and post-test, while measurements of all sessions are desired to map the exact process. Only Berends and Reitsma measured the transfer of decoding skills to untrained words and in both studies the retention of the effects on trained words was not taken into account. Finally, children did not receive feedback on their reading attempts, which may have limited the effects.

Differential effects of feedback (whole-word vs. segmented feedback) on reading in children with reading disabilities have been explored by Lovett and colleagues (Lovett, Barron, Forbes, Cuksts, & Steinbach, 1994; Lovett, Warren-Chaplin, Ransby, & Borden, 1990). No difference between the two types of feedback was found, but as the children in these studies also had quite a broad range in rather severe neurological impairments, one cannot simply generalise these results to the normal language-achieving group of children. From an instructional perspective, it is likely that segmented feedback (i.e., "correct, it is pet, p-e-t"), in which the grapheme–phoneme correspondence rules are stressed, is more effective in kindergartners than whole-word feedback (i.e., "correct, it is pet"). In the first grade of elementary school in The Netherlands, children are taught to read by a phonics method in which graphemes are sounded out separately and then pasted together to form a word. Since Dutch is a phonologically transparent language, this method is applicable to the majority of words. The effect of feedback was also examined in a repeated reading study involving syllables instead of words (Huemer, Aro, Landerl, & Lyytinen, 2010). They studied repeated reading of syllables in Finnish poor-reading children, and investigated whether knowledge of trained syllables is transferred to untrained pseudowords containing those syllables. During training they offered feedback on the correctness of the pronounced syllables. In contrast with the repeated reading study of Berends and Reitsma (2006), Huemer et al. did find transfer effects, even for morphologically more complex items. Converging evidence thus shows that repeated readings may help children to improve their reading speed. An open question, however, remains as to how this speed is acquired in early literacy. In the present study, we therefore examined the actual process of forming orthographic word representations in Dutch kindergartners who had received no reading instruction before. We investigated how speed and accuracy of word reading develop as children repeatedly read the same sets of words with short versus extensive feedback. The following research question was examined:

1.) What are the direct, retention and transfer effects of repeated word and pseudoword reading and what is the role of short versus extensive feedback?

To answer this research question, a repeated reading intervention was designed, in which reading latencies and accuracy were measured for all sessions and a transfer and retention task were added, in order to map emergent decoding in kindergartners. We expected gains in both speed and accuracy, and that these gains would be higher in the extensive feedback condition, because in that case the relationship between graphemes and phonemes was emphasised. Even though previous results on transfer effects are inconclusive, we expected to find transfer effects for both conditions (although again higher in the extensive feedback condition), given that beginning readers make use of orthographic analogies (Savage & Stuart, 2001) and the items in our transfer task were created from onsets and rimes of the items in the intervention.

Method

Participants

Participants were 26 monolingual Dutch kindergartners (10 boys, 16 girls) selected from a pool of 59 children. The selection criterion was that children needed to have active knowledge of the 14 graphemes used in the intervention. The children ranged in age between five years, five months and six years, seven months (mean, five years, 11 months; standard deviation [SD], five months). The selected children came from four different classes of three different schools, all in the same region. The kindergarten teachers reported that no formal reading instruction was given in any of the groups. This normally starts in Grade 1, the year following kindergarten. The 26 children were randomly assigned to one of the two feedback conditions. One child was removed from analysis because she did not finish the intervention due to illness.

Materials

Standardised measures

Four standardised tests were administered prior to the reading intervention, the first three taken from the Standardized Screening Test for Children with Specific Language Impairment (Verhoeven, 2005) and the fourth from the Language Test For Children (Verhoeven & Vermeer, 2001). Descriptive statistics of these pre-test measures are represented in Table 2.1. There were no differences between the two groups, for all measures (all F values < 1).

Phonemic awareness. Phonemic awareness was assessed by a phoneme isolation task and a pseudoword repetition task. In the phoneme isolation task, children were asked to indicate the first sounds of each word spoken by the experimenter. This

Table 2.1 Mean Scores for Standardized Measures for Children in the Short Feedback and the Extensive Feedback Condition

	Short Feedback	Extensive Feedback
N	12	13
Phoneme isolation [30]	28.92 (1.31)	28.46 (1.76)
Pseudoword repetition [40]	21.50 (4.89)	20.38 (5.91)
Naming speed [120]	42.83 (6.62)	44.69 (6.01)
Vocabulary [96]	68.92 (8.35)	66.92 (7.76)

Note. Standard deviations are within parenthesis, maximum scores are presented within brackets.

subtest consists of 30 words, varying in length and frequency. In the pseudoword repetition task, children were asked to repeat the pseudoword that was read out aloud by the experimenter. In this manner, 40 pseudowords with increasing length and difficulty were assessed. For both tasks, the total number of correct answers was scored.

Naming speed. Naming speed, as a measure of lexical retrieval, was measured with Rapid Naming: Pictures. Each child was presented with 120 pictures in four rows consisting of five randomly reoccurring objects: a house, a shoe, a comb, a pair of glasses and a duck. The Dutch words for these items are all monosyllabic words (huis, schoen, kam, bril, eend). Children had to name as many of the pictures listed as possible within one minute. The total number of correctly named items after one minute was the final score for this test. We chose to use serial rather than discrete rapid naming, as this was found to be a stronger predictor of word reading fluency in seven year olds (de Jong, 2011).

Passive vocabulary. Passive vocabulary knowledge was measured with the subtest Receptive Vocabulary. In this subtest the experimenter read out a word while participants had to choose out of four pictures the drawing that represented the word given by the experimenter. This test consists of 96 items. If five items in a row were answered incorrectly the test was terminated. All correct items were scored.

Stimuli

The stimuli that were used for this experiment are built up by 14 different graphemes: five vowels and nine consonants. These graphemes were chosen because they allow simple and transparent decoding. From these graphemes 100 items, each consisting of a consonant in the onset and a vowel and consonant in the rime (CVC items), were created. One-half of the items were monosyllabic phonologically transparent CVC words, selected from a database of familiar words for six year olds (Schaerlaekens et al., 1999). Words were selected if they were known by at least 70% of Dutch six year olds. The other half of the items were pseudowords, created by mixing the onsets and rimes from the CVC words.

From these 100 items, two different lists (A and B, see Appendix 1) were created, each consisting of 25 words and 25 pseudowords. Both lists were kept as similar as possible, by using each grapheme equally often in each list. In this way there are, for example, three words and three pseudowords in each list that start with the grapheme "l". Unfortunately, the number of possible words was not sufficient to perfectly match the two lists.

Design

All pre-tests were assessed in a separate session, prior to the intervention. Next, children received 13 separate sessions, each lasting about 20 minutes. In the first session, we offered the children the items of list A. In sessions 2–11 (T1–T10), we administered list B. The 12th session offered list A again, to serve as a transfer task. All 12 sessions, including transfer and intervention, took place within two weeks, with a maximum of two sessions per day. Two weeks after completing the first 12 sessions, the children once again read the words from list B, as a retention task.

Words and pseudowords were offered blocked. Between blocks there was a small break, which could be terminated by the experimenter. The block order changed each session and between subjects. This was done in order to prevent order effects. Within blocks all items were pseudo-automatically randomised each session. Two subsequent words or pseudowords could have maximally one grapheme in a specific position in common. This was done in order to prevent orthographic neighbourhood effects.

Procedure

All sessions took place in quiet rooms inside the schools. We used a Dell Latitude laptop with a 13.3-inch screen for presentation of the items and a Sennheiser headphone/microphone for the sounds and recordings. Single words were presented in the middle of the laptop screen. Black letters on a white screen were used in the font Helvetica with size 28. For all words, each letter was presented in a separate box, making it easier to distinguish the letters. The word was visible during the entire trial and disappeared after the participant read out the word. Prior to each session, the experimenter assessed whether the 14 used graphemes were still actively known by the participants. Then participants were asked whether they were ready to begin reading. Children were asked to read the CVC words out loud. They were free to spell out the word prior to reading the whole word to keep the constraints as limited as possible. After the participants read the word, they received feedback. After the feedback, a fixation cross appeared on the screen and the next word was presented. Throughout the experiment, children were guided by a voice-over character. This character was introduced because the feedback was provided by the computer. After each trial, the experimenter indicated via a button-press whether the child read the word correctly or not. As a result the character told the children whether the word was correct or not. There were four different varieties for the correct feedback (e.g., correct, well done) and for the incorrect feedback (e.g., incorrect, too bad); those different varieties occurred randomly.

In the short feedback condition, the character told whether the word pronounced by the children was correct or not, followed by the pronunciation in the correct way, regardless of the correctness. For the extensive feedback condition, the feedback consisted of the short feedback plus the spelling out of the onset, nucleus and coda, followed by spelling out the whole word. During this spelling out and repetition of the whole word, the boxes containing the letters lit up. For a schematic presentation of the feedback procedure, see Figure 2.1. All participants thus received feedback on all trials during all sessions.

The experimenter rated the answers of the children online by means of an external keyboard. By pressing the key on the keyboard, latencies were also measured. The experiment was programmed in E-prime software, version 2.0 (Psychology Software Tools, Pittsburgh, PA, USA). Each item was individually recorded via the microphone and recorder function in E-prime. All sessions were recorded on an external voice recorder as well. The recordings were used to rate one-half of the items again offline. This was done in order to control for errors of the experimenter and possible biases.

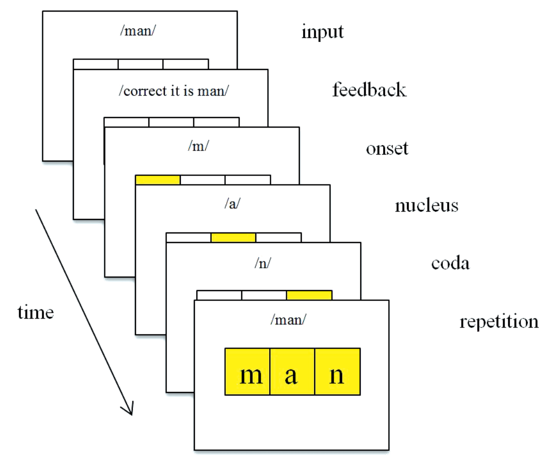

Figure 2.1 Feedback Procedure in Which the First Two Windows Represent the Short Feedback and All Six Windows Represent the Extensive Feedback.

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Cronbach's alpha between the online and offline ratings was 0.76, which indicates that the online ratings for all items could be used.

Data Analysis

For all measurements and items, accuracy and latency scores were measured. In the analyses concerning reading latencies, only correct responses were included. For each child, a mean response time and SD were calculated for both the words and pseudowords. Response times that deviated more than 2.5 SD were considered outliers and were removed from analysis. Incorrect trials and outliers amounted to a total of 15.90% of all items.

For reading latency we measured the offset score instead of the more commonly used onset score. The offset score is the total time that is needed to produce a word, including the naming duration, and has been suggested to be a more reliable measure for reading latencies in children (de Jong & Share, 2007; Huemer et al., 2010; Thaler, Ebner, Wimmer, & Landerl, 2004).

To examine change over time, repeated-measures analyses of variance (ANOVAs) were conducted for the reading latencies. If the assumption of sphericity was not met for the main effect of Time, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity. For reading accuracy the data were not normally distributed, and therefore non-parametric Friedman's ANOVAs were conducted.

Results

Direct effects of the intervention

To examine the effects of the intervention, the mean reading latencies and accuracy scores on words and pseudowords during each of the intervention sessions were calculated. These mean scores are displayed in Figures 2.2 and 2.3. For reading latencies, an ANOVA of repeated measures was performed with Time (T1–T10) and Wordtype (words, pseudowords) as within-subjects factors and Condition (short feedback, extensive feedback) as the between-subjects factor. For accuracy scores, Friedman's ANOVAs were performed for words and pseudowords and for the two different conditions separately, with Time (T1 to T10) as the within-subjects factor. Table 2.2 presents the mean reading latencies for each measurement, with separate values per Condition and Wordtype.

For reading latencies, main effects of Time, $F(3.66,84.14) = 3.35$, $p < 0.02$, $\eta^2_p = 0.13$, and Wordtype were found, $F(1, 23) = 5.15$, $p < 0.04$, $\eta^2_p = 0.18$, showing an increase in speed over time and words to be read slower than pseudowords. No effects for Condition and no interaction effects were found (all F values < 2).

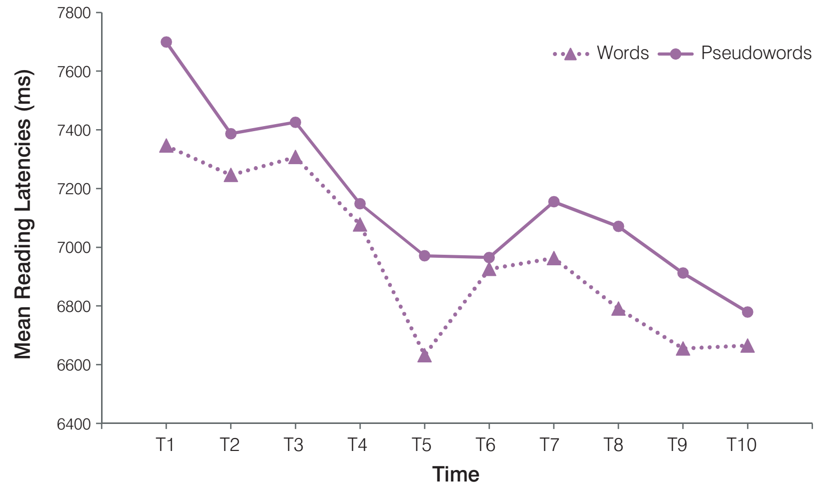

Figure 2.2 Reading Latencies During the Intervention for Pseudowords and Words (N=25).

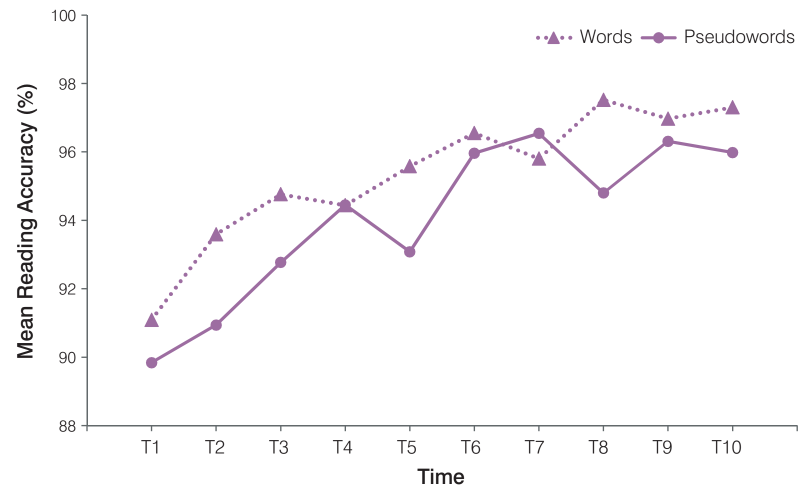

Figure 2.3 Reading Accuracy During the Intervention for Pseudowords and Words (N=25).

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Table 2.2 Mean Reading Latencies in Milliseconds and Standard Deviations for Both Conditions for Each Measurement

		Pre-test	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Post-test	Retention
Short	Words Mean	7846	7934	7935	7465	7187	6616	7369	7048	7161	6817	6791	7215	5926
Feedback	Words SD	1258	1422	1697	1378	1273	1340	1288	1183	1158	2023	1240	1618	1273
(N = 12)	Pseudowords Mean	8414	8122	7757	7758	7580	7151	7098	7391	7497	7307	7228	7160	6034
	Pseudowords SD	1564	1533	1692	1663	1713	956	1458	1348	1323	1521	1240	1413	1580
Extensive	Words Mean	6896	6803	6647	7161	6976	6647	6517	6885	6449	6505	6549	6545	5770
Feedback	Words SD	2198	2000	2157	2351	2453	2254	2007	1821	1732	1859	1721	1425	1861
(N=13)	Pseudowords Mean	6626	7308	7045	7119	6750	6804	6843	6938	6677	6547	6108	6365	5771
	Pseudowords SD	1856	2292	2155	2221	2053	2284	2024	2092	1692	1617	1769	1465	1609

Table 2.3 Mean Reading Accuracies in Percentages and Standard Deviations for Both Conditions for Each Measurement

		Pre-test	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Post-test	Retention
Short	Words Mean	92.35	89.86	91.55	92.92	93.53	96.65	96.14	96.81	96.20	95.82	96.16	98.27	95.84
Feedback	Words SD	5.46	12.75	13.30	9.58	6.16	6.35	8.97	4.64	7.15	10.66	9.33	3.22	7.74
(N = 12)	Pseudowords Mean	91.80	86.97	90.28	93.17	95.76	93.18	96.47	95.94	94.32	94.98	95.78	96.07	93.88
	Pseudowords SD	7.13	12.18	11.12	14.08	5.08	14.08	9.55	5.57	6.84	7.44	8.37	6.35	9.85
Extensive	Words Mean	91.80	92.22	95.47	93.46	95.28	94.29	96.93	94.86	98.73	98.04	98.35	98.07	94.42
Feedback	Words SD	8.40	9.44	4.46	12.72	5.00	8.49	3.85	5.85	1.99	2.75	2.18	2.17	6.22
(N= 13)	Pseudowords Mean	87.91	92.49	91.55	92.40	93.24	92.99	95.48	97.10	95.25	97.53	96.16	94.71	95.81
	Pseudowords SD	14.54	11.32	13.44	8.12	10.12	12.52	5.56	4.20	5.08	3.52	3.77	7.15	4.24

Table 2.3 presents the mean reading accuracy for each measurement, with separate values per Condition and Wordtype. For accuracy, effects for Time were found for the words in the extensive feedback condition, $\chi^2(9) = 23.46$, $p < 0.01$, for words in the short feedback condition, $\chi^2(9) = 31.29$, $p < 0.001$ and for pseudowords in the short feedback condition, $\chi^2(9) = 17.30$, $p < 0.05$. For pseudowords in the extensive feedback condition, no effect for Time was found, $\chi^2(9) = 12.88$, $p = 0.17$. These results indicate that accuracy improves over time for all conditions except the pseudowords in the extensive feedback condition.

Retention effects of the intervention

To measure whether knowledge was retained, the mean accuracy scores and reading latencies of the retention task, administered two weeks after training, were compared with those of the last measurement of training. For reading latencies, an ANOVA of repeated measures was performed with Time (T10, retention) and Wordtype (words, pseudowords) as within-subjects factors and Condition (short feedback, extensive feedback) as the between-subjects factor. For accuracy scores, Friedman's ANOVAs were performed for words and pseudowords and for the two different conditions separately, with Time (T10, retention) as the within-subjects factor.

For reading latencies, a main effect of Time was found, $F(1, 23) = 22.63$, $p < 0.001$, $\eta^2_p = 0.50$. No main effects for Wordtype or Condition and no interaction effects were found (all F values < 2). The main effect of Time indicated that reading latencies were shorter during the retention task than during the final session of the intervention.

For accuracy, an effect of Time for the words in the extensive feedback condition was found, $\chi^2(1) = 5.44$, $p < 0.02$, indicating that accuracy scores decreased for the words in the extensive feedback condition. All other measures were not significant, indicating that accuracy remained stable among words and pseudowords in the short feedback condition and among pseudowords in the extensive feedback condition.

Transfer effects of the intervention

To investigate the transferability of the intervention to the reading of new words, we measured mean accuracy and reading latencies for the transfer task. For reading latencies a repeated-measures ANOVA was performed with Time (pre-test, post-test) and Wordtype (words, pseudowords) as within-subjects factors and Condition (short feedback, extensive feedback) as the between-subjects factor. For accuracy scores, Friedman's ANOVAs were performed for words and pseudowords and for the two different conditions separately, with Time (pre-test, post-test) as the within-subjects factor.

For the reading latencies, only a main effect of Time was found, $F(1, 23) = 4.63$, $p < 0.05$, $\eta^2_p = 0.17$. At post-test, reading times were shorter than at pre-test. For Wordtype no main effects or interaction effects were found, indicating that there were no differences between words and pseudowords (all F values < 2). For Condition we also found no main effect, $F(1, 23) = 3.59$, $p = 0.07$, $\eta^2_p = 0.14$.

Regarding accuracy, there was no effect of Time for the pseudowords in both conditions. For the words, there was an effect of Time in the short feedback condition, $\chi^2(1) = 7.36$, $p < 0.01$, and in the extensive feedback condition, $\chi^2(1) = 4.45$, $p < 0.04$. These results indicate that words were read more accurately on the post-test than on the pre-test, whereas there was no difference in accuracy regarding the pseudowords.

To measure to what extent automaticity is transferred, we compared performance on the transfer words with performance on the trained words at the final Time during the intervention (T10). An ANOVA of repeated measures with Time (T10, post-test) and Wordtype (words, pseudowords) as within-subjects factors and Condition (short feedback, extensive feedback) as the between-subjects factor was performed on the reaction-time data. On the accuracy data we performed Friedman's ANOVAs with Time (T10, post-test) as a within-subjects factor. For reading latencies we found no main or interaction effects, indicating that the untrained items were read equally fast as the trained items. For accuracy we also found no main effect for Time, in any of the conditions. This finding indicates that the transfer items were read equally accurately as the trained items.

Discussion

In the present study, the repeated reading of single CVC words was examined in kindergartners. Reading accuracy and reading speed were measured during 10 repeated readings within two weeks and the results showed positive direct and retention effects: both speed and accuracy improved—and were retained—over time. In the retention task we found a significant but minor decrease for word reading accuracy in the extensive feedback condition. On all other measures, we did not find any differences between the two conditions, indicating that both types of feedback are equally effective.

Throughout the intervention, average accuracy scores were high. Even on the first measurement the average accuracy was 90%. These high accuracy scores are not exceptional in young children learning in a transparent orthography such as Dutch (for example, Martens & de Jong, 2008; Verhoeven & Van Leeuwe, 2009). Based on these high accuracy scores, one might argue to leave them unanalysed. However, due to the large variation among participants and the fact that we did find significant improvements over time, we think that displaying those results is of added value.

With regards to transfer effects, we found a significant improvement from pre-test to post-test of untrained words in both accuracy and speed. Transfer words were read at a similar pace and with the same accuracy level as the trained words in the final session of the intervention. Lovett, Barron, Forbes, Cuksts, and Steinbach (1994) and Berends and Reitsma (2006) did not find such transfer effects to orthographically similar words and pseudowords. Three different factors could explain this difference. The first factor could be the orthographic overlap between the trained items and the transfer items. However, since Berends and Reitsma used both orthographic neighbours and orthographically different words as transfer words and did not find an effect for both types, this does not seem very likely. The second factor could be the inclusion of feedback. Even though there are no differences in terms of reading speed and accuracy between the two feedback conditions during training and transfer, the mere presence of feedback probably causes a difference (Therrien, 2004). A third explanation might lie in the length of the items. We only used short words consisting of three graphemes, which may make transfer easier. Our positive finding on transfer is in line with the interactive analogy model from Goswami (1993). It is also in line with the repeated syllable reading study of Huemer et al. (2010), which also included short items and feedback.

To make sure that we indeed found a transfer effect, rather than a testing effect, we performed additional analyses. For this analysis we combined the two measures (reading latencies and accuracy) together into an inverse efficiency score. This measure was first used by Townsend and Ashby (1978), and with this measure you divide the mean response latency of a participant by the percentage of correct items. The repeated-measures ANOVA revealed that the difference between the first and second measurements of the intervention was smaller than the difference between the first and the second measurements of the transfer, indicating that we indeed found a transfer effect.

With regard to the feedback used in this experimental paradigm, we want to clarify the chosen terminology. The feedback is given not only to correct the children, but also to instruct them as to how all items should be read in a correct, fast-paced manner. On all trials (correct and incorrect), automatised feedback was given. Considering the fact that these children had never received reading instruction, the feedback we provided can also be seen as instruction.

This study can be seen as a first reading intervention for kindergartners by means of feedback. To examine the possibility that the transfer effect is caused by the length of items, a follow-up study taking word length into account would be recommended. In order to disentangle the effects of feedback, a follow-up study should include a condition without any form of feedback. Studying a larger number of participants is also recommendable. In the present study we used a small sample size ($n = 25$), which results in low statistical power. Differences between conditions might have been found if we had used larger groups. For this reason, results of this study should be interpreted with caution.

In sum, the results of this study indicate that a repeated reading intervention with feedback in kindergarten, in which pre-readers are raised to a full alphabetic stage, is an effective method to improve reading speed and reading accuracy on trained and untrained words. The type of feedback did not matter, indicating that children are able to apply the learnt GPC rules to untrained words, regardless of the type of feedback they received, as long as their self-teaching mechanism is stimulated.

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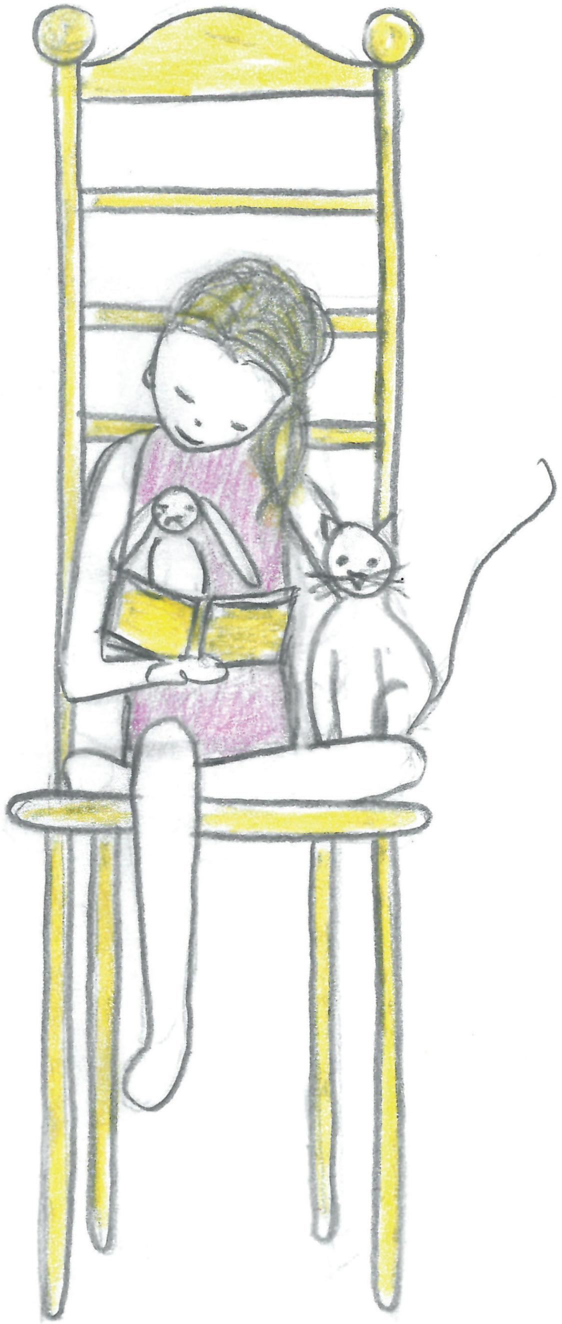
Appendix. Items used in the experiment.

List A		List B	
Words	Pseudowords	Words	Pseudowords
gat	gam	gum	gak
gil	gan	kar	kal
kam	kag	kat	ket
kan	kep	kin	kis
kip	kol	kop	kup
kus	kos	lap	lan
lam	lar	lat	lep
lek	lit	les	lom
lip	lut	lus	lop
mep	mas	man	mar
mes	mel	map	mek
mop	mip	mat	mil
mos	mit	mol	mon
mus	muk	mug	mut
pan	pat	nek	nap
pet	pom	pak	pag
pit	pos	pen	pam
put	puk	pil	pes
rat	ret	pot	pok
rol	rip	rem	rop
rug	rup	rok	rut
sap	sak	sop	sat
sok	san	tas	tan
tak	tep	tik	tis
tor	tos	top	tok



3

Repeated word reading effects and the role of feedback in good and poor decoders in first grade

This chapter is based on: Van Gorp, K., Segers, E., & Verhoeven, L. (resubmitted). Repeated word reading effects and the role of feedback in good and poor decoders in first grade.

Abstract

The direct, retention and transfer effects of repeated word and pseudoword reading were studied in 48 good and 47 poor reading first graders in a pre-test, training, post-test, retention design. First graders (N = 95) read 25 CVC words and 25 CVC pseudowords in ten repeated reading sessions, preceded and followed by a transfer task with a different set of items. Two weeks after training, trained items were assessed again in a retention test. Participants either received phonics feedback, in which each word was spelled out and repeated, word feedback, in which each word was repeated, or no feedback. During the training, both good and poor readers improved in accuracy and speed. The increase in speed was stronger for poor readers than for good readers. The good readers demonstrated a stronger increase for pseudowords than for words. This increase in speed was most prominent in the first four sessions. Two weeks later the levels of accuracy and speed were retained. Furthermore, transfer effects on speed were found for pseudowords in both groups of readers. Good readers performed most accurately during the training when they received no feedback while poor readers performed most accurately with the help of phonics feedback. However, feedback did not differentiate for reading speed or effects after the training. Repeated reading generally improves reading accuracy and speed with the effects being stronger for poor readers and for pseudowords, indicating that repeated reading can be seen as an important trigger for the improvement of decoding skills.

Introduction

It is crucial that orthographic representations are being stored and that word reading becomes automatized, since fluent word reading plays a very important role in text reading fluency (Torgesen, Rashotte, & Alexander, 2001) and comprehension (Perfetti & Stafura, 2014). Every word a child reads needs to be phonologically recoded, and on each attempt the child provides itself with feedback (Perfetti, 1992). By means of this feedback, the orthographic representation of a word becomes incrementally stronger. This process of phonological recoding can be seen as a self-teaching mechanism (cf., Share, 1995; 2004). In poor readers, this self-teaching process is hampered resulting in a delay in reading accuracy and reading speed. One way to overcome these problems is to train these children on repeated word reading (Reitsma, 1983). However, even though repeated reading of words was found to be successful in improving both accuracy and speed of trained items, most studies either did not assess (e.g., Martens & De Jong, 2008), or failed to find transfer effects to untrained items (e.g., Berends & Reitsma, 2006). Moreover, although immediate corrective feedback is claimed to be crucial to obtain transfer effects (Therrien, 2004), the role of feedback on transfer effects of repeated word reading has not yet been investigated. In the present study, we examined the effect of different types of feedback on training, retention, and transfer in a repeated word and pseudoword reading paradigm in good and poor reading first graders.

Repeated reading can be seen as a paradigm in which orthographic learning as a consequence of word repetition occurs in children as young as seven years old (Reitsma, 1983). The word repetition effect has not only been demonstrated with isolated words but also in reading in context. In a study with young children reading novel words embedded in text Share (2004) showed that for most children, a few exposures to an unknown letter string already is sufficient to store orthographic information about this string in their mental lexicon. In third graders, the largest progress in repeated novel word reading was evidenced between the first and second encounter of the word which is in line with the instance theory of automatization of Logan (1988). Once stored, the orthographic information has shown to be retained 30 days (Share, 2004) or even 10 weeks later (Hogaboam & Perfetti, 1978). For poor readers, overlearning seems to be necessary in order to find retention effects (Lemoine, Levy, & Hutchinson, 1993). However, with respect to these poor reading children, it is largely unclear how many exposures to an unknown letter string are needed to come to a stable orthographic representation. After a high level of accuracy is attained, word reading speed can be increased towards automatization. Reaching high levels of accuracy takes more time in opaque languages than in transparent languages, in which readers make fewer errors (Aro & Wimmer, 2003; Seymour, Aro, & Erskine, 2003). For example, the average accuracy level of reading CVC words in

Dutch is just under 90 percent at the end of first grade (Verhoeven & van Leeuwe, 2009).

Following the dual route cascaded (DRC) model of reading (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001), reading novel word strings and pseudowords occurs via the indirect or non-lexical route. In this route, words are decoded letter by letter. Familiar words are read via the direct or lexical route in which word recognition occurs automatically. Martens and De Jong (2008) investigated the influence of repeated reading on direct or indirect reading of words as a function of word length. If orthographic learning would occur after repeated readings, typical length-effects which are thought to reflect letter-by-letter reading rather than direct access would disappear after a series of repetitions. However, they found that after 16 repeated readings without feedback the length effect decreased in typically reading fourth and fifth graders but lasted in typically reading second graders and poor reading fourth and fifth graders. Even though reading speed increased over time, the authors concluded that poor and beginning readers still relied on the indirect route of reading. In a similar study, Suárez-Coalla, Ramos, Álvarez-Cañizo, and Cuetos (2014) showed that the length effect decreased in typically reading Spanish children (aged 7-12) but lasted in dyslexic children.

To date, most repeated-reading studies focused on improving reading speed and accuracy at the sentence or text level (e.g., Chard, Vaughn, & Tyler, 2002; Kuhn & Stahl, 2003; Therrien, 2004). Only a limited number of studies focused on repeated reading of single words (see Wolf & Katzir-Cohen, 2001) and very few studies assessed transfer to untrained items. Lemoine et al (1993) conducted three experiments in which direct, retention and transfer effects were examined in both good and poor readers in grade 3 and poor readers in grade 4. They did find interesting direct and retention effects. With regard to transfer, however, they did not succeed in inducing generalization effects, regardless of the amount of orthographic overlap between trained and untrained items and regardless of the amount of repetitions during training. Thaler et al. (2004) studied the transfer effect of the inclusion of similar onsets in trained and untrained words in poor reading children in grades 2, 3, and 4. The children were presented with 32 training words, with 8 different onsets. Each word was repeatedly read by the participants in an experimental setup with six presentations per session, for up to 25 days. There was only a small transfer to words containing the same onset and no transfer to orthographically unrelated words. In another repeated word reading study, Berends and Reitsma (2006) compared the effects of repeated reading with those of single reading. Half of the participants, who were poor readers, read the same set of 20 words 20 times whereas the other half read 400 different words. Feedback regarding accuracy was given, but only by the presentation of a smiley. At posttest, trained items were read faster by the repeated reading group. For both conditions, there were no transfer effects for untrained items.

A key to find transfer effects might also be the inclusion of feedback (see Therrien, 2004). Corrective feedback, i.e., feedback in which the correct pronunciation is given by the experimenter, was found to be effective in assisted repeated reading of texts (e.g., Young, Bowers, & MacKinnon, 1996). Transfer effects for both accuracy and speed were evidenced in a condition with feedback as opposed to two conditions without feedback and a listening task. In several repeated word reading studies, the role feedback was investigated but none compared a feedback condition to a no feedback condition. Direct feedback regarding accuracy by means of presenting happy and sad smileys as used by Berends and Reitsma (2006) did not result in transfer effects. This can be explained by the fact that even though children provide themselves with feedback on each attempt while reading words (Share, 2004), the accuracy of beginning readers and poor readers in particular is not optimal yet. This is underlined by the finding that reading errors in beginning readers are unstable (Steenbeek-Planting, van Bon, & Schreuder, 2013). Immediate feedback in which the relation between graphemes and phonemes is stressed might thus be effective on these beginning readers. Also, if reading is inaccurate, this type of corrective feedback is likely to be more effective or perhaps even mandatory (Rasinski, Homan, & Biggs, 2009). If there is no feedback, poor readers might consolidate the incorrect pronunciation of a word or might move on to reading the word incorrectly at a high pace rather than reading the word accurately. Therefore, feedback involving correct spelling and pronunciation of words is likely to be most effective in poor readers.

Indeed, two studies that did incorporate immediate corrective feedback evidenced transfer effects after repeated reading of syllables (Huemer, Aro, Landerl, & Lyytinen, 2010), or words and pseudowords (Van Gorp, Segers, & Verhoeven, 2014). The feedback that was used in both studies included information on correctness of the named items, after which the correct pronunciation was proved by either the experimenter or the computer. Huemer et al. (2010) focused on repeated reading of syllables in Finnish speaking children in Grades 4 to 6. For incorrectly read items, feedback was given on correctness. When the child named the syllable incorrectly twice, the tutor pronounced the syllable correctly. In this study, transfer from the syllables to multisyllabic pseudowords containing these items was found. Van Gorp et al. (2014) studied repeated readings of emergent readers (i.e., kindergartners) investigating the effect of different types of feedback. Both word feedback (i.e., feedback on correctness followed by pronunciation of the word) and phonics feedback (i.e., feedback on correctness followed by pronunciation and spelling of the word) turned out to be effective in kindergartners. Both speed and accuracy increased and transfer effects for untrained items were evidenced.

Repeated reading is evidently a good method to increase reading accuracy and speed in poor readers. However, transfer to untrained items is often lacking when no immediate corrective feedback is included. Two repeated reading studies that did include this type of corrective feedback did find transfer effects (i.e., Huemer et al., 2010; Van Gorp et al., 2014). Both studies did not include a condition without feedback, which is needed to ascribe the presence of transfer effects solely to the inclusion of corrective feedback. Furthermore, in the study of Van Gorp et al. (2014) good reading kindergartners were assessed before they had received formal reading education, while in the study of Huemer et al., the mean age of the subjects was 11 years. In the present study we further investigated the role of various forms of feedback (none, word, or phonics) on the growth of reading accuracy and speed in beginning readers. To examine the role of decoding level on the effect of repeated reading, we compared good and poor readers in first grade. Both words and pseudowords were included, to see whether different reading routes (DRC) result in different effects. The study had a pre-test, training, post-test, retention design that allowed us to look at direct and retention effects, and at the effects on trained and untrained items. We measured reading accuracy and speed on ten consecutive sessions within a timeframe of two weeks, followed by a retention test two weeks later. Furthermore, transfer to untrained words and pseudowords was measured via a pre- and posttest directly before and after the training. The research questions were:

1.) What are the direct, retention, and transfer effects of a repeated word reading training with regard to accuracy and speed in good and poor reading first graders?
2.) To what extent does feedback enhance these effects?

With regard to the first research question, our first hypothesis was to find direct, retention, and transfer effects for both accuracy and speed for both groups of readers. Second, we expected poor readers to improve more than good readers, since there is more room for improvement. Regarding the second research question, we expected that feedback would result in larger direct and transfer effects in both types of readers. Moreover, we expected phonics feedback, which stresses the grapheme-phoneme rules, to be most effective for poor readers.

Method

Participants

Participants were 95 monolingual Dutch first graders (51 boys, 44 girls) with a mean age of 6 years and 9 months (SD 4 months, range 73-93 months). Half of the participants (47) were poor readers. They were defined as poor readers in the present study based on a score below the 25th percentile on a standardized isolated word reading task (Three-Minute-Test, Verhoeven, 1995). The other half of the participants (48) was a good reading control group (i.e. above the 75th percentile). The scores on this word reading task represent word reading efficiency, a measure which includes both accuracy and speed. All participants were native speakers of Dutch.

The participating children came from 8 different middle class schools located in the Eastern and Southern regions in The Netherlands. All schools used the same phonics-based reading and spelling method called “Veilig leren lezen” (Learning to read safely, Mommers, Verhoeven, & Van der Linden, 1990). We obtained written consents of the parents of the children, with assurance of anonymity.

The assignment to one of three conditions was random. The differences in group sizes between the conditions was caused by the fact that the data were originally collected for two separate experiments and are yet combined in this study. None of these data have been published before. One experiment examined the difference between phonics feedback and word feedback. Another experiment examined the difference between phonics feedback and no feedback. Therefore, the number of participants in the phonics feedback condition (N = 22) is larger than the number of participants in the word feedback (N = 10) and no feedback (N = 15) conditions.

Materials

Standardized measures

To assess several aspects of reading, standardized measures of all subjects were taken prior to the reading training. Children were assessed on naming speed, phonemic awareness, and receptive vocabulary knowledge. Descriptive statistics for both groups of readers in all three conditions are presented in Table 3.1. In both groups of readers there were no significant differences between the three conditions for all three measures. The good readers were significantly better in pseudoword repetition, $F(1,93) = 13.10$, $p < .001$, and naming speed, $F(1,93) = 19.66$, $p < .001$. The difference between groups for receptive vocabulary was not significant, $F(1,93) = 2.38$, $p = .13$.

Table 3.1 Mean Scores for Standardized Measures for Good and Poor Reading Children in the Phonics, Word, and No Feedback Condition

	Good Readers			Poor Readers		
	Phonics	Word	No	Phonics	Word	No
N	22	14	12	22	10	15
Pseudoword repetition[40]	31.10 (5.22)	28.86 (4.29)	32.92 (6.01)	27.50 (5.56)	26.90 (5.86)	26.93 (4.93)
Naming speed[120]	57.27 (11.41)	56.00 (10.18)	61.08 (10.82)	48.86 (7.83)	45.10 (8.01)	50.93 (11.17)
Passive vocabulary[96]	77.05 (5.77)	78.43 (6.93)	79.83 (4.73)	75.95 (5.03)	77.10 (8.53)	76.33 (4.92)

Note. Standard deviations are within parenthesis, maximum scores are presented within brackets.

3

Pseudoword repetition. This task served as a measure of phonological memory and was taken from the Standardized Screening Test for Children with Specific Language Impairment (Verhoeven, 2005). In this task, participants have to repeat the pseudoword after the experimenter. The experimenter reads out aloud 40 pseudowords consecutively, increasing in length and difficulty. The total number of correctly repeated items was scored.

Naming speed. This task served as a measure of lexical retrieval and was also taken from the Standardized Screening Test for Children with Specific Language Impairment (Verhoeven, 2005). We used the Picture Naming task in which participants are asked to name pictures in a serial naming task. The task consisted of five randomly occurring pictures. Children had to name as many pictures within one minute. The total number of correctly named pictures was scored.

Receptive vocabulary. To measure vocabulary knowledge in the participating children, we administered the Receptive Vocabulary task from the Language Test for Children (Verhoeven & Vermeer, 2001). This task consists of 96 items and 2 practice items. Each item is constructed as follows. The experimenter reads out a word, and the participant has to choose between four pictures which picture illustrates the word read out. If five errors were made in a row, the test was terminated. Only correct answered were summed up and scored.

Stimuli

The stimuli were the same as in the study of Van Gorp, Segers, & Verhoeven (2014). All stimuli were orthographically transparent CVC items. They were created with the use of 14 frequently used graphemes; five short vowels and nine consonants. From these graphemes 100 items were created. Of those items 50 were CVC words selected from a database of words known by 6-year-olds (Schaerlaekens et al., 1999). The selection criterion of words from this list was that they had to be actively known by at least 70% of Dutch 6-year olds. From these 50 words, 50 matching CVC pseudowords were created by scrambling the letters. Words were selected if they were known by at least 70% of Dutch 6-year olds. From these 100 items, two lists labeled A and B were created (see Appendix).

Design

All children were assessed during 14 sessions. Pretests were administered during the first session, which lasted about 30 minutes. All following sessions were reading sessions in which the children were asked to read 25 words and 25 pseudowords. Those sessions took 5-10 minutes, depending on both speed of the participant and condition. In the first reading session, the 50 items of list A were offered as a pre-test. Then we administered list B for 10 consecutive sessions. After these 10 sessions, we offered list A again as a post-test, to measure a potential transfer effect. All these reading sessions took place within a timeframe of two weeks, with a maximum of two sessions per day. Two weeks later, list B was presented to the children once again to measure potential retention effects.

Words and pseudowords were presented in separate blocks. Between the two blocks, there was a small break. Participants could indicate when the second block started. The order of the blocks was counterbalanced between sessions and participants to prevent order effects. Items were pseudo-randomized within these blocks. Items were randomized in such a way that two subsequent items could have maximally one of three positions (CVC) in common in order to prevent orthographic neighborhood effects.

Procedure

All sessions took place within the schools of the participating children, in a room separate from their classroom. We used a laptop for presentation of the items and a headphone/microphone for the auditory feedback and for the recordings of the items read by the participants. Items were presented as black letters in the middle of a white screen. Each letter was presented in a separate box, as illustrated in Figure 3.1. Items remained visible on the screen for an unlimited duration. After the participants read the word, the experimenter indicated whether the item was read correctly or incorrectly and the experiment proceeded to the next item. Depending on the condition the participants were in, they received feedback as initiated by the experimenter's judgment. By pressing button "1" on an external keyboard the experimenter indicated that the item was read correctly, incorrect items were indicated by pressing button "2".

For the children who were in one of the two feedback conditions, a voice-over character providing the feedback was introduced to them prior to the first reading session. In these conditions, children received feedback on both correct and incorrect read items. In the *word feedback condition*, the character told whether the word pronounced by the children was correct or not, followed by the pronunciation in the correct way, regardless of the correctness (i.e.: correct, it is *pet*). For the *phonics feedback condition*, the feedback consisted of the short feedback plus the spelling out of the onset, nucleus and coda, followed by spelling out the whole word (i.e.: incorrect, it is *pet, p-e-t, pet*). During this spelling out and repetition of the whole word, the boxes in which the letters lit up. In the *no feedback condition*, there was no feedback at all. After reading out aloud an item, the experimenter pressed a button (i.e., correct or incorrect) and the experiment continued. For a schematic presentation of the feedback procedure, see Figure 3.1. In the two conditions with feedback, all participants received feedback on all trials during all sessions, thus for both incorrect and correct responses. After the feedback (or directly after the response in the no-feedback condition) a fixation cross appeared on the screen and the next word was presented.

The experimenter rated the answers of the children online by means of an external keyboard. By pressing the key on the keyboard, latencies were measured as well. The experiment was programmed in E-prime software, Version 2.0 (Psychology Software Tools, Pittsburgh, PA). Each item was individually recorded via the microphone and recorder function in E-prime. For back-up purposes, all sessions were recorded on an external voice recorder as well. Since rating speed of the four different experimenters varied quite a lot, all items were re-assessed by means of Praat (Boersma, 2001), resulting in more reliable data. Each individual item was analyzed semi-automatically by Praat resulting in a precise onset-latency (when the participant started pronouncing the item) and offset-latency (when the item was fully pronounced).

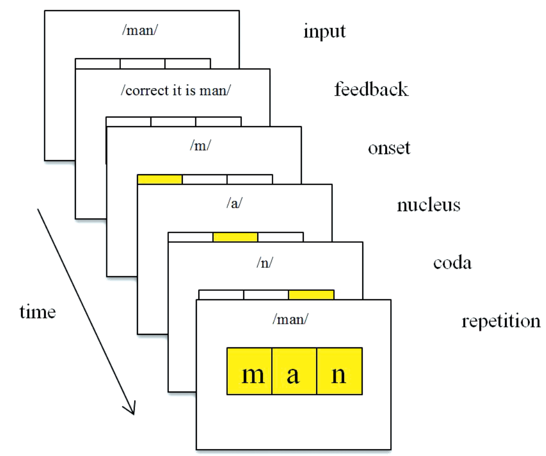


Figure 3.1 Schematic Representation of Procedure (as was used in Chapter 2).
The input reflects the word as represented on the screen. The child reads the word out aloud and the experimenter indicates whether it was correct or not. For the children in the *no feedback condition* the experiment proceeded to the next item. For the children in the *word feedback condition* the second screen appeared, accompanied by auditory feedback stating what the correct representation should be. For the children in the *phonics feedback condition* the other four screens apply as well. After stating the correct representation, the item was spelled out and repeated once more, while graphemes and the word lit up accordingly.

Table 3.2 Mean Offset Reading Accuracy (in Percentage Correct) and Latencies (in Milliseconds) for all Three Conditions for Each Measurement Point for the Poor Readers.

		Pre-test	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Post-test	Retention
Phonics Feedback (N = 22)	Words Accuracy	0.95 (0.06)	0.94 (0.06)	0.93 (0.08)	0.94 (0.06)	0.95 (0.04)	0.95 (0.05)	0.96 (0.05)	0.94 (0.06)	0.94 (0.06)	0.93 (0.10)	0.96 (0.06)	0.93 (0.07)	0.95 (0.06)
	Words Latency	2885 (464)	2871 (708)	2689 (643)	2677 (614)	2624 (616)	2677 (585)	2712 (547)	2579 (602)	2515 (586)	2614 (567)	2642 (521)	2886 (560)	2644 (599)
	Pseudowords Accuracy	0.92 (0.07)	0.90 (0.09)	0.92 (0.08)	0.92 (0.09)	0.93 (0.07)	0.92 (0.07)	0.92 (0.07)	0.92 (0.07)	0.94 (0.06)	0.93 (0.06)	0.93 (0.07)	0.91 (0.07)	0.93 (0.07)
	Pseudowords Latency	3302 (606)	2871 (671)	2964 (665)	2983 (633)	2913 (529)	2922 (648)	2904 (544)	2834 (532)	2733 (612)	2784 (553)	2787 (592)	2971 (632)	2768 (657)
Word Feedback (N = 10)	Words Accuracy	0.92 (0.08)	0.90 (0.12)	0.94 (0.08)	0.86 (0.14)	0.89 (0.10)	0.89 (0.13)	0.90 (0.09)	0.92 (0.08)	0.86 (0.15)	0.85 (0.14)	0.92 (0.08)	0.87 (0.11)	0.92 (0.05)
	Words Latency	3208 (487)	3172 (603)	3017 (610)	2967 (883)	2901 (681)	3040 (798)	2764 (773)	2961 (689)	2753 (595)	2743 (635)	2770 (571)	3166 (710)	2837 (528)
	Pseudowords Accuracy	0.85 (0.09)	0.85 (0.14)	0.87 (0.07)	0.87 (0.08)	0.85 (0.14)	0.83 (0.18)	0.81 (0.18)	0.88 (0.13)	0.88 (0.10)	0.80 (0.17)	0.88 (0.15)	0.84 (0.17)	0.87 (0.10)
	Pseudowords Latency	3676 (232)	3172 (587)	3291 (608)	3211 (736)	3096 (803)	3241 (853)	3275 (740)	3165 (658)	3176 (676)	3117 (790)	3141 (711)	3279 (765)	2945 (575)
No Feedback (N = 15)	Words Accuracy	0.95 (0.06)	0.93 (0.07)	0.91 (0.11)	0.93 (0.06)	0.91 (0.07)	0.94 (0.06)	0.95 (0.05)	0.95 (0.07)	0.94 (0.05)	0.92 (0.15)	0.96 (0.03)	0.95 (0.06)	0.96 (0.04)
	Words Latency	2515 (570)	2535 (658)	2584 (527)	2461 (613)	2289 (570)	2345 (621)	2357 (563)	2224 (537)	2325 (628)	2402 (537)	2299 (528)	2668 (579)	2205 (591)
	Pseudowords Accuracy	0.92 (0.08)	0.90 (0.09)	0.89 (0.09)	0.91 (0.06)	0.90 (0.08)	0.98 (0.07)	0.92 (0.04)	0.92 (0.07)	0.94 (0.07)	0.91 (0.04)	0.94 (0.07)	0.92 (0.08)	0.95 (0.06)
	Pseudowords Latency	2910 (613)	2865 (746)	2806 (693)	2748 (642)	2616 (626)	2709 (632)	2726 (517)	2645 (633)	2713 (677)	2705 (618)	2641 (545)	2907 (572)	2561 (634)

Note. Standard deviations are between parentheses.

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Table 3.3 Mean Offset Reading Accuracy (in Percentage Correct) and Latencies (in Milliseconds) for all Three Conditions for Each Measurement Point for the Good Readers.

		Pre-test	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Post-test	Retention
Phonics Feedback (N = 22)	Words Accuracy	0.99	0.99	0.99	1.00	1.00	1.00	1.00	1.00	0.99	1.00	0.99	0.99	1.00
		(0.02)	(0.02)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)
	Words Latency	1390	1335	1322	1375	1346	1306	1358	1392	1286	1294	1332	1383	1278
		(304)	(200)	(213)	(318)	(235)	(218)	(299)	(272)	(213)	(209)	(289)	(320)	(243)
	Pseudowords Accuracy	0.99	0.98	0.99	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	1.00
		(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)
	Pseudowords Latency	1595	1462	1426	1405	1405	1329	1363	1347	1319	1322	1360	1465	1285
		(358)	(236)	(264)	(304)	(296)	(255)	(219)	(267)	(199)	(263)	(292)	(339)	(236)
Word Feedback (N = 13)	Words Accuracy	0.99	0.98	0.99	1.00	0.99	0.99	0.99	0.99	0.99	0.99	0.99	1.00	1.00
		(0.03)	(0.03)	(0.01)	(0.01)	(0.05)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.00)
	Words Latency	1476	1522	1544	1507	1622	1421	1458	1502	1476	1424	1520	1620	1477
		(269)	(349)	(497)	(455)	(438)	(255)	(317)	(260)	(324)	(261)	(293)	(404)	(297)
	Pseudowords Accuracy	0.98	0.99	0.98	0.97	0.99	0.98	0.97	0.99	0.99	0.99	0.99	0.99	0.99
		(0.03)	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.01)	(0.03)	(0.02)
	Pseudowords Latency	1833	1739	1764	1589	1630	1589	1608	1632	1565	1448	1516	1707	1493
		(487)	(339)	(584)	(440)	(329)	(427)	(351)	(309)	(307)	(227)	(317)	(354)	(201)
No Feedback (N = 12)	Words Accuracy	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99
		(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.02)	(0.02)
	Words Latency	1216	1236	1194	1252	1170	1146	1189	1210	1133	1122	1155	1214	1140
		(159)	(249)	(160)	(250)	(196)	(248)	(179)	(238)	(194)	(244)	(247)	(200)	(211)
	Pseudowords Accuracy	0.99	1.00	0.99	0.99	1.00	0.99	0.99	1.00	1.00	0.99	1.00	0.99	1.00
		(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.00)	(0.00)	(0.02)	(0.00)	(0.02)	(0.01)
	Pseudowords Latency	1330	1262	1246	1223	1255	1205	1235	1213	1238	1176	1161	1253	1208
		(189)	(212)	(162)	(176)	(178)	(178)	(232)	(208)	(215)	(246)	(241)	(202)	(276)

Note. Standard deviations are between parentheses.

Data analysis

For all items, accuracy, onset-latency and offset-latency were measured. In the analyses concerning reading latencies, only correct responses were included. All items with an onset-latency higher than 5000 milliseconds were removed (4.97%). In addition, incorrect responses were removed (another 4.14%). For each child and each session, mean reading latencies and mean accuracy scores for words and pseudowords were calculated.

Four different experimenters performed the data-collection. In order to control for inconsistencies between the experimenters, all individual items were processed semi-automatically in Praat. For each pronounced item, an onset and an offset score, and consequently duration, were determined. In studies using voice-keys the onset time is usually reported, but we chose to report the offset times, since it is likely to be a more reliable measure for reading latencies in children, since it includes naming duration as well (Huemer et al., 2010; de Jong & Share, 2007; Thaler, Ebner, Wimmer, & Landerl, 2004). Therefore we report offset reading latencies in this study.

To examine change over time, repeated measures ANOVA's were conducted. If the assumption of sphericity was not met for the main effect of Time, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity.

Results

In Tables 3.2 and 3.3, mean reading latencies for all measurement points for all three conditions are represented for poor and good readers respectively. For speed we only used the correct responses.

Accuracy

Improvement of accuracy during the training

To assess improvement of reading accuracy during the training, an ANOVA of repeated measures with Time (T1, T2, …, T10) and Word Type (words, pseudowords) as within-subjects factors, and Condition (no feedback, phonics feedback, word feedback) and Reading Level (poor readers, good readers) as between-subjects factors was performed on the mean reading accuracy.

Main effects were found for Time, $F(6.42,551.72) = 2.40$, $p = .02$, $\eta^2_p = .03$, Word Type, $F(1,86) = 41.20$, $p < .001$, $\eta^2_p = .32$, Condition, $F(2,86) = 6.04$, $p < .01$, $\eta^2_p = .12$, and Reading Level, $F(1,86) = 95.49$, $p < .001$, $\eta^2_p = .53$. The main effect for Time was further examined with planned comparisons (Repeated), but between subsequent sessions, no significant differences were found.

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Furthermore, interaction effects of Word Type x Reading Level, $F(1,86) = 19.99$, $p < .001$, $\eta^2_p = .19$ and Condition x Reading Level, $F(2,86) = 4.14$, $p = .02$, $\eta^2_p = .09$ were found. There were no other significant interaction effects. The interaction for Word Type by Reading level shows that the difference in accuracy of reading words versus pseudowords is larger in poor readers than in good readers. To quantify the Condition by Reading level interaction, separate analyses for poor and good readers were performed. For good readers, there was an effect of Condition, $F(2,43) = 3.99$, $p = .03$, $\eta^2_p = .16$. Bonferroni post-hoc analysis showed that good readers have a higher accuracy score at the *no feedback* condition than at the *word feedback* condition ($p = .02$). Between the *phonics feedback* condition and the *word feedback* condition, there was no difference ($p = .20$), neither was there a difference between the *phonics feedback* condition and the *no feedback* condition ($p = .72$). For poor readers there also was an effect of Condition, $F(2,43) = 4.61$, $p = .02$, $\eta^2_p = .18$. Bonferroni post-hoc analysis showed that poor readers had higher accuracy scores at the *phonics feedback* condition than at the *word feedback* condition ($p = .01$). There was no difference between *no feedback* and *phonics feedback* ($p = 1.00$) and the difference between *no feedback* and *word feedback* was marginally significant ($p = .08$). Good readers thus showed the highest accuracy scores in the *no feedback* condition, whereas poor readers benefitted most of the *phonics feedback* condition.

Retention effects of the training on accuracy

To measure if the increased accuracy level was retained two weeks after training, an ANOVA of repeated measures with Time (T1, T10, retention) and Word Type (words, pseudowords) as within-subjects factors and Condition (no feedback, phonics feedback, word feedback) and Reading Level (poor readers, good readers) as between-subjects factors was performed on the mean reading accuracy.

Main effects were found for Time, $F(1.86, 160.07) = 6.50$, $p < .01$, $\eta^2_p = .07$, Word Type, $F(1,86) = 14.23$, $p < .001$, $\eta^2_p = .14$, Condition, $F(2,86) = 4.41$, $p = .02$, $\eta^2_p = .09$, and Reading Level, $F(1,86) = 79.75$, $p < .001$, $\eta^2_p = .48$. There was an interaction effect for Word Type by Reading Level, $F(1,86) = 14.53$, $p < .001$, $\eta^2_p = .15$, indicating that the difference between words and pseudowords was larger in poor than in good readers. No other interaction effects were found (all F's < 1). Planned contrasts (Helmert) revealed that the effect of time between T1 and later was significant, $F(1,86) = 10.86$, $p = .001$, $\eta^2_p = .11$. The difference between T10 and retention was not significant ($F < 1$), indicating that the reached level at T10 was retained two weeks later.

Transfer effects of the training on accuracy

To assess whether the intervention had any transfer effects for accuracy, an ANOVA of repeated measures with Time (transfer1, transfer2) and Word Type (words, pseudowords) as within-subjects factors and Condition (no feedback, phonics feedback, word feedback) and Reading Level (poor readers, good readers) as between-subjects factors was performed on the mean reading accuracy.

Main effects were found for Word Type, $F(1,87) = 25.19$, $p < .001$, $\eta^2_p = .23$, Condition, $F(2,87) = 4.28$, $p = .02$, $\eta^2_p = .09$, and Reading Level, $F(1,87) = 73.68$, $p < .001$, $\eta^2_p = .46$. There was no main effect for Time ($F(1,87) = 1.90$, p = .17, = $\eta^2_p = .02$) indicating that accuracy did not improve for untrained items. Interaction effects for Word Type x Reading Level, $F(1,87) = 16.64$, $p < .001$, $\eta^2_p = .16$ and Condition x Reading Level, $F(2,87) = 3.67$, $p = .03$, $\eta^2_p = .08$ were found. The interaction Time x Reading Level was approaching significance, $F(1,87) = 2.76$, $p = .10$, $\eta^2_p = .03$. For transfer of accuracy there were no other significant interaction effects. The interaction Word Type x Reading Level shows that the difference between words and pseudowords was larger in poor readers than in good readers. To quantify the Condition x Reading Level interaction, we performed a Repeated Measures ANOVA with Time, Word Type and Condition for good and poor readers separately. For the good readers no effect for Condition (F < 1) was found. For the poor readers there was a significant effect, $F(2,43) = 3.76$, $p = .03$, $\eta^2_p = .15$. Bonferroni post-hoc comparisons revealed that there was no difference between *phonics feedback* and *no feedback* for the group of poor readers ($p = 1.00$). But both *phonics feedback* and *no feedback* resulted in higher accuracy scores than *word feedback* (both pairs: $p = .05$).

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Speed

Improvement of speed during the training

To assess effects of reading speed during the intervention, an ANOVA of repeated measures with Time (T1, T2, …,T10) and Word Type (words, pseudowords) as within-subjects factors and Condition (no feedback, phonics feedback, word feedback) and Reading Level (poor readers, good readers) as between-subjects factors was performed on the mean offset reading latencies.

Main effects were found for Time, $F(5.11,439.42) = 7.74$, $p < .001$, $\eta^2_p = .08$, Word Type, $F(1,86) = 167.92$, $p < .001$, $\eta^2_p = .66$, Condition, $F(2,86) = 7.11$, $p = .001$, $\eta^2_p = .14$, and Reading Level, $F(1,86) = 259.97$, $p < .001$, $\eta^2_p = .75$. Interaction effects for Time x Reading Level, $F(5.11,439.42) = 2.84$, $p = .01$, $\eta^2_p = .03$, Word Type x Reading Level, $F(1,86) = 72.12$, $p < .001$, $\eta^2_p = .46$ and Word Type x Condition, $F(2,86) = 3.35$, $p = .04$, $\eta^2_p = .07$ were found. No other interaction effects were found.

The main effect for Time indicates that speed increased over time. The main effect for Word Type shows that words were read faster than pseudowords. The main effect for Reading Level shows that good readers read faster than poor readers. For the main effect of Condition, Bonferroni post-hoc analysis did not reveal any differences between any pair of feedback conditions.

The Word Type by Condition interaction showed that differences between words and pseudowords were smaller in the *phonics feedback* condition, than in the *no feedback*, and *word feedback* condition. To quantify the other two interaction effects (Time x Reading Level and Word Type x Reading Level) we performed the repeated measures analysis again on poor and good readers and for words and pseudowords separately. In these analyses, Condition was not included, since post-hoc tests revealed no differences between the three conditions. Four separate repeated measures ANOVA's with Time (T1 to T10) as within subject factor were performed. Planned contrasts were used to test at which sessions speed increased and at which sessions speed remained stable. Repeated Contrasts were used to see which sessions differed from its subsequent session and Helmert Contrasts to see how each session differed from all following sessions combined.

Improvement of speed during the training for the good readers

For the good readers we found no effect of Time for words, $F(3.85, 173.18) = 1.93$, $p = .11$, $\eta^2_p = .04$. This is probably caused by the unstable reading times for this group of readers, for this type of items, see also Figure 3.2. For this group of readers an effect of Time for pseudowords was found, $F(4.91, 220.87) = 4.71$, $p < .001$, $\eta^2_p = .10$. Repeated Contrasts reveal that there are only significant increases in reading speed from T2 to T3, $F(1,45) = 4.20$, $p = .05$, $\eta^2_p = .09$, from T4 to T5, $F(1,45) = 4.85$, $p = .03$, $\eta^2_p = .10$ and from T8 to T9, $F(1,45) = 4.93$, $p = .03$, $\eta^2_p = .10$. This progress can be seen in Figure 3.2. The difference between the current session and subsequent sessions is only significant as shown by Helmert Contrasts for T1, $F(1,45) = 13.90$, $p = .001$, $\eta^2_p = .24$, T2, $F(1,45) = 6.48$, $p = .01$, $\eta^2_p = .13$ and T4, $F(1,45) = 8.80$, $p = .01$, $\eta^2_p = .16$.

Improvement of speed during the training for the poor readers

For the poor readers we found an effect of Time for words, $F(6.25, 281.01) = 4.18$, $p < .001$, $\eta^2_p = .09$. See Figure 3.2 for a graph of the mean reading latencies for this group of readers. Repeated Contrasts revealed a significant increase in reading speed from T1 to T2, $F(1,45) = 4.44$, $p = .04$, $\eta^2_p = .09$ and a marginally significant increase in speed from T3 to T4, $F(1,45) = 3.55$, $p = .07$, $\eta^2_p = .07$. As visualised in Figure 3.2 an asymptote for words is reached at T4. This is confirmed by Helmert Contrasts which showed that the difference between T1 and later is significant, $F(1,45) = 17.38$, $p < .001$, $\eta^2_p = .28$, as is the difference between T2 and later, $F(1,45) = 6.37$, $p = .02$, $\eta^2_p = .12$ and the difference between T3 and later, $F(1,45) = 4.21$, $p = .05$, $\eta^2_p = .09$. For pseudowords we also found an effect of Time in the group of poor readers, $F(6.15, 276.53) = 4.90$, $p < .001$, $\eta^2_p = .10$. Here there only was a significant increase in reading speed from T1 to T2 (see Figure 3.2), $F(1,45) = 7.13$, $p = .01$, $\eta^2_p = .14$. As depicted in Figure 3.2 an asymptote for pseudowords is also reached at T4. This was confirmed by Helmert Contrasts that show that the difference between T1 and later is significant, $F(1,45) = 18.44$, $p < .001$, $\eta^2_p = .29$, as is the difference between T2 and later, $F(1,45) = 5.17$, $p = .03$, $\eta^2_p = .10$ and the difference between T3 and later, $F(1,45) = 3.87$, $p = .06$, $\eta^2_p = .08$.

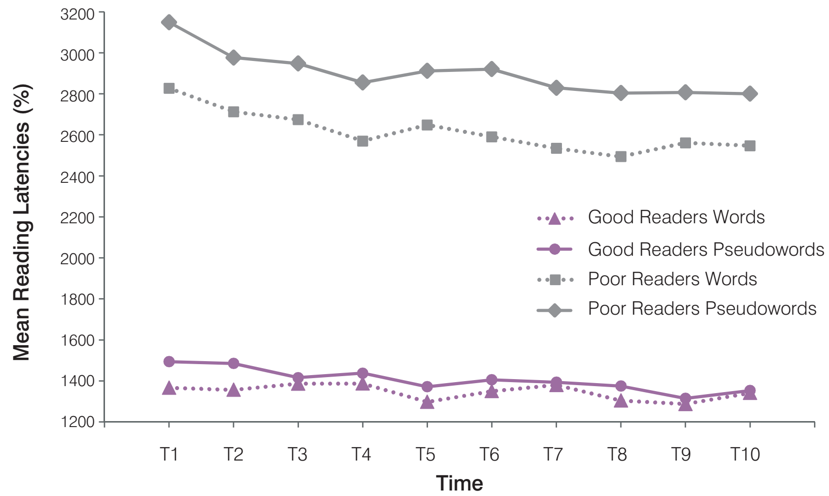

Figure 3.2 Mean Reading Latencies for the Good and Poor Readers.
Scores represent overall mean reading latencies in milliseconds for each consecutive measurement. The dotted line represents reading latencies for words, the solid line represents reading latencies for pseudowords.

Retention effects of the training on speed

To see if the trained speed was retained two weeks later, we performed a repeated measures ANOVA with Time (T1, T10 and retention) and Word Type (words, pseudowords) as within-subjects factors and Condition (no feedback, phonics feedback, word feedback) and Reading Level (poor readers, good readers) as between-subjects factors was performed on the mean offset reading latencies.

Main effects were found for Time, $F(1.62,139.20) = 24.39$, $p < .001$, $\eta^2_p = .22$, Word Type, $F(1,86) = 69.71$, $p < .001$, $\eta^2_p = .45$, Condition, $F(2,86) = 8.04$, $p = .001$, $\eta^2_p = .16$, and Reading Level, $F(1,86) = 277.22$, $p < .001$, $\eta^2_p = .76$. Interaction effects for Time x Reading Level, $F(1.62,139.20) = 7.59$, $p < .01$, $\eta^2_p = .08$ and Word Type x Reading Level, $F(1,86) = 30.48$, $p < .001$, $\eta^2_p = .26$ were found. No other interaction effects were found.

For Time planned comparisons (Helmert) revealed differences between T1 and the two later measurements (T10 and Retention), $F(1,86) = 32.09$, $p < .001$, $\eta^2_p = .27$, indicating a growth in reading speed from T1 to the measurements T10 and Retention. The difference between T10 and Retention was not significant, $F(1,86) = 2.19$, $p = .14$, $\eta^2_p = .03$, indicating that the average reading speed at Retention was similar to the average reading speed at T10. This means that the trained speed was retained two weeks later. The interaction for Time x Reading Level shows that poor readers improve more over time than good readers, which is again caused by the difference from T1 to T10 and Retention. The interaction effect of Word Type x Reading Level showed that the difference between words and pseudowords is larger for poor readers than for good readers.

Transfer effects of the training on speed

To see if there were transfer effects for speed, An ANOVA of repeated measures with Time (transfer1, transfer2) and Word Type (words, pseudowords) as within-subjects factors and Condition (no feedback, phonics feedback, word feedback) and Reading Level (poor readers, good readers) as between-subjects factors was performed on the mean offset reading latencies.

Main effects were found for Time, $F(1,87) = 3.64$, $p = .06$, $\eta^2_p = .04$, Word Type, $F(1,87) = 81.73$, $p < .001$, $\eta^2_p = .48$, Condition, $F(2,87) = 9.43$, $p < .001$, $\eta^2_p = .18$, and Reading Level, $F(1,87) = 358.43$, $p < .001$, $\eta^2_p = .81$. Interaction effects for Time x Word Type, $F(1,87) = 20.85$, $p < .001$, $\eta^2_p = .19$ and Word Type x Reading Level, $F(1,87) = 7.98$, $p < .01$, $\eta^2_p = .08$ were found. No other interaction effects were found. The interaction for Time x Word Type shows that there is a medium size transfer effect for the pseudowords, $F(1,87) = 7.29$, $p < .01$, $\eta^2_p = .08$, whereas there is no transfer effect for the words, $F(1,87) = 0.52$, $p = .47$, $\eta^2_p = .01$. Similarly as for the training, the latter interaction effect shows that the difference between words and pseudowords is smaller in good readers than in poor readers, $F(1,89) = 9.52$, $p < .01$. For the main effect of Condition, Bonferroni post-hoc analysis revealed that children in the *no feedback* condition are faster than the children in the *word feedback* condition ($p = .02$). The difference between *phonics feedback* and *word feedback* ($p = .36$) and the difference between *phonics feedback* and *no feedback* ($p = .30$) was not significant.

To answer the question whether we found a transfer effect here, or orthographic learning or testing effect between the first and the second presentation of the transfer items, we performed another analysis. An ANOVA of repeated measures with Item List (transfer, training), Time (measurement1, measurement2) and Word Type (words, pseudowords) as within-subjects factors and Condition (no feedback, phonics feedback, word feedback) and Reading Level (poor readers, good readers) as between-subjects factors was performed on the mean offset reading latencies.

If transfer indeed occurred, we would find an interaction of Item List x Time, indicating that the increase from Measurement 1 to Measurement 2 for the trained items differed from the increase for transfer items.

The two-way interaction effect for Item List x Time was not significant ($F < 1$), however, there was a significant three-way interaction effect for Item List x Time x Word Type, $F(1,84) = 7.82$, $p < .01$, $\eta^2_p = .09$. Follow up analyses revealed that there was an marginally significant interaction for Item List x Time for the pseudowords, $F(1,84) = 3.34$, $p = .07$, $\eta^2_p = .04$, and an even smaller effect for the words, $F(1,84) = 2.70$, $p = .10$, $\eta^2_p = .03$. The directions of these effects, however, were in opposite direction of each other. For pseudowords the effect of the transfer task was larger from measurement 1 to measurement 2, whereas for the words the effect of the training task was larger. In all these data show us that we did find transfer effects for pseudowords, but no transfer effects for words.

Discussion

The main interest of this study was to investigate the effects of repeated reading and the influence of feedback on these effects in good and poor reading first graders. We found direct effects of the training for good and poor readers, for accuracy and speed. For speed, the effects were stronger in the poor readers than in the good readers. The trained items were read equally accurate and fast during the retention task in both groups of readers. Transfer effects were only found for speed and more specifically, only for pseudowords. The influence of feedback was limited for speed. For accuracy we did find that, for the direct training effects, good reading children were most accurate in the no feedback condition, whereas poor reading children were the most accurate in the phonics feedback condition.

Our first hypothesis was to find direct, retention and transfer effects for accuracy and speed, for both groups of readers and for both types of words. For the training we indeed found *direct and retention effects* for both speed and accuracy. The direct effects of repeated reading are in line with previous research on repeated word reading (e.g., Berends & Reitsma, 2006; Huemer et al., 2010; Martens & De Jong, 2008; Thaler et al., 2004, Van Gorp, Segers, & Verhoeven, 2014). The poor readers did not fall back two weeks after the retention, which indicates that orthographic information has been stored (Hogaboam & Perfetti, 1978; Share, 2004). We found an asymptote for reading speed after only four repetitions. Reading the same items for ten times can thus be seen as overlearning, and perhaps this overlearning of words is effective, also for poor readers (Lemoine et al., 1993). However, it should be noted that we did not assess this effect on the long run, and furthermore, the retention of the transfer effects was not assessed.

Regarding *transfer effects*, we found transfer for speed in pseudowords, both in good and poor beginning readers. According to the dual route model of reading (Coltheart et al., 2001) pseudowords are read via the indirect route. When reading novel words, children and adults also make use of this indirect route of reading. In this indirect route, words are read letter by letter. Our results indicate that repeated reading facilitates this beginning stage of reading. Pseudoword reading can be seen as a pure measure of decoding skill (Gough & Tunmer, 1986). This means that repeated reading of single words leads to improvement of word decoding skill. The high frequent CVC words (e.g.: *cat*) that we used are likely to be encountered by our first graders before. Also, they have stored phonological, orthographic and semantic knowledge of these words, which makes them access these words via the direct route. This could also explain the discrepancy between the present transfer effects and those found in the study of Van Gorp, Segers, & Verhoeven (2014). They studied kindergartners with no previous reading experience. This means that to them, as for pseudowords in our participants, both words and pseudowords were processed as novel words via the indirect route. During the training we found both enhancement via the indirect route for pseudowords and via the direct route for words. The stronger increase in pseudowords and thus the stronger effect on decoding was also found for the good readers during the training.

Our expectation was that poor readers would show larger effects of the training than good readers. For speed, we indeed found a larger growth in poor readers than in good readers. The difference between the good and the poor readers became smaller. This can be explained by the fact that orthographic learning is supposed to occur quickly, after the first few occasions (Logan, 1988; Share, 2004). After that, an asymptote is reached (Hogaboam & Perfetti, 1978, Reitsma, 1983), even though children still increase in reading speed over time (Verhoeven & Van Leeuwe, 2009). Our data support these views; i.e., the largest increase is made from T1 to T2 and an asymptote is reached after four repetitions. This orthographic learning pattern may explain why poor readers were able to catch up with the good readers to some extent, as the good readers may already have reached the asymptote at the beginning of the intervention for words, and not for pseudowords. However, a large gap in reading speed between the two groups remained, for both type of words, indicating that a more elaborate intervention may be necessary for the poor readers (cf. Saine, Lerkkanen, Ahonen, Tolvanen, & Lyytinen, 2011).

The second research question (hypotheses 3 and 4) regarded the effect of feedback. For poor readers, our results show that they are more accurate in the phonics feedback condition, while good readers are more accurate in the no feedback condition. This means that poor readers benefitted from the focus on grapheme-phoneme correspondence rules and the actual process of decoding a word, while good readers are hindered by stressing this indirect route. Effects are small, however, and need to be taken with caution, especially since they do not transfer to untrained items and since they do not interact with time. We assumed that the inclusion of feedback would result in finding transfer effects, following the common factor in the studies of Huemer et al. (2010) (on syllable reading), Van Gorp et al. (2014) (on word reading), and Young et al, (1996) (on text reading). Based on our results, it seems that the inclusion of corrective feedback per se is not necessarily resulting in transfer effects.

A possible explanation for the different findings with regard to transfer of feedback of our study as compared to the study of Huemer et al. (2010) might lie in the need for corrective feedback. This type of feedback is mainly needed if children need correction, thus if errors are being made. In our study, accuracy for the good readers started at 99% and for the poor readers this was around 92%. In the study of Huemer et al. (2010) feedback was given only at incorrect trials, which is likely to be less disturbing. In the study of Van Gorp et al. (2014) inexperienced readers were assessed, and for them the feedback might have had an instructional function as well.

It might also be the case that the inclusion of feedback in the studies by Huemer et al. (2010) and Van Gorp et al. (2014) was not the reason why they found transfer effects. As mentioned above, it could be that in the study of Van Gorp et al. (2014) transfer effects for both words and pseudowords are found because of their reading experience. We assume that repeated reading of words and pseudowords enhances decoding skills and inexperienced readers use decoding via the indirect route for both words and pseudowords. This could have caused the transfer effects in the study of Huemer et al. (2010) as well. In their study children practiced with syllables, and the transfer to multisyllabic pseudowords containing those syllables was measured. It is thus likely that reading occurs via the indirect route during this transfer task. Future research should investigate whether repeated reading of words and or pseudowords indeed only enhances decoding skills, rather than fluent reading skills.

The present study was successful in improving decoding skills in good and poor reading children; however, there were two limitations that lead to suggestions for future research. The first is that we did not monitor motivation, whereas motivation is likely to have influenced the results (Rasinski, 1990). Repeated reading of 50 CVC items for 13 sessions might be boring for these young readers, especially when receiving corrective feedback on each item. Future research in this topic should consider ways to increase the motivation of these children during repeated reading. Thaler et al. (2004) solved this by ending the training for those who reached a certain threshold. Another way to increase motivation, or at lease decrease the chance of boredom or weariness, is to provide feedback only on incorrect trials, as was done in the study by Huemer et al. (2010).

Children who are intrinsically motivated to read seek for challenge (Wigfield & Guthrie, 1997). The second limitation of this study follows up on the motivation aspect and lies in the amount of challenge that was offered to the participants. Repeatedly reading CVC words can be quite boring, especially if you are a good reader. A suggestion for future research is to include more challenge during training. This can be done by using the same paradigm with more complex stimuli. This complexity can be increased by the inclusion of consonant clusters, the inclusion of diphthongs and as a result an increase in word length.

The theoretical implication of this study is that both good and poor reading children increase their accuracy and speed while repeatedly reading words. It seems that repeated reading of words and pseudowords is especially helpful in training pure decoding skills, i.e., reading via de indirect route. This is reflected by the finding that we found transfer only for pseudowords. A practical implication of this study is that repeated reading of words is effective in improving decoding skills in poor and good reading first graders. For poor readers, the inclusion of corrective feedback either from a computer or from a teacher is advisable. Good readers can practice independently, since feedback is not beneficial for them.

In sum we can conclude that repeated reading of single words and pseudowords is effective in both good and poor reading children, since direct, retention and transfer effects were found. The effects were stronger for poor than for good readers and for pseudowords than for words. With regard to feedback, we found that phonics feedback is effective for poor readers' reading accuracy, whereas the accuracy of good readers is the highest without any feedback.

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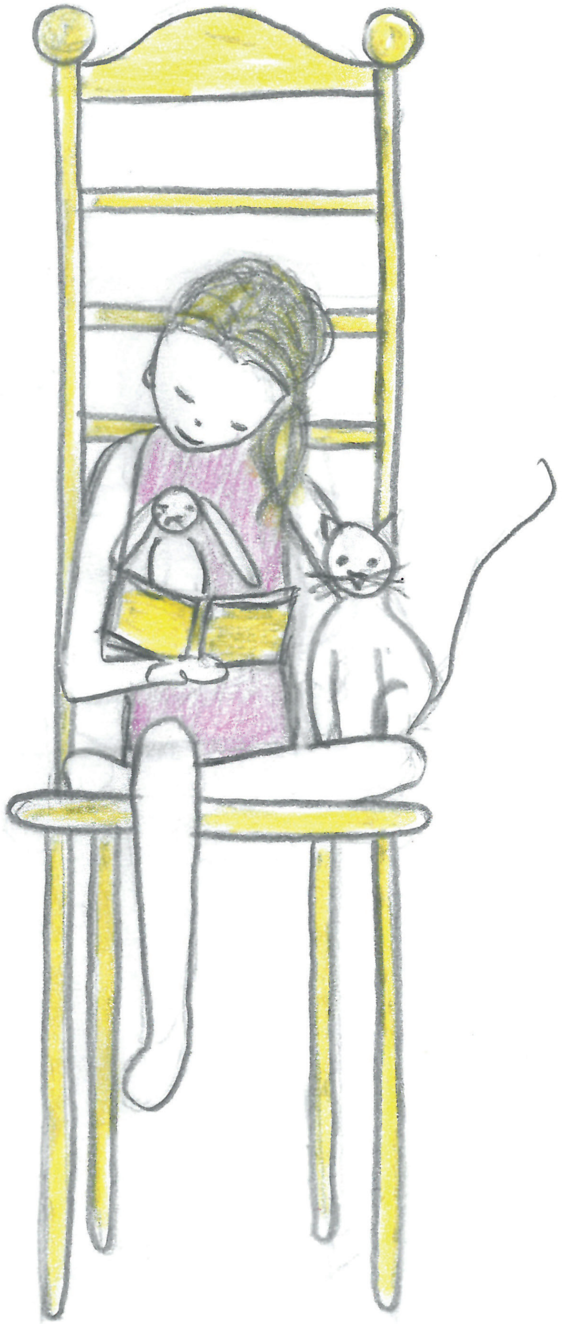
Appendix. Items used in the experiment.

List A		List B	
Words	Pseudowords	Words	Pseudowords
gat	gam	gum	gak
gil	gan	kar	kal
kam	kag	kat	ket
kan	kep	kin	kis
kip	kol	kop	kup
kus	kos	lap	lan
lam	lar	lat	lep
lek	lit	les	lom
lip	lut	lus	lop
mep	mas	man	mar
mes	mel	map	mek
mop	mip	mat	mil
mos	mit	mol	mon
mus	muk	mug	mut
pan	pat	nek	nap
pet	pom	pak	pag
pit	pos	pen	pam
put	puk	pil	pes
rat	ret	pot	pok
rol	rip	rem	rop
rug	rup	rok	rut
sap	sak	sop	sat
sok	san	tas	tan
tak	tep	tik	tis
tor	tos	top	tok



4

Masked onset priming in lexical decision

This chapter is based on: Van Gorp, K., Segers, E., & Verhoeven, L. (Accepted for publication). Masked onset priming in lexical decision.

Abstract

In masked onset priming (MOPE) there is an overlap between prime and target in the onset. This has been shown to lead to faster word recognition of the target in adults in naming tasks but not in lexical decision tasks. To take a developmental stance, the present study investigated MOPE of various onsets in 30 adults and 74 second graders in a lexical decision task. For adults we found no effects for MOPE in lexical decision, which is congruent with the literature. However, results revealed priming effects for the beginning readers: accuracy scores were higher and response times were shorter for both words and pseudowords when there was an overlap of the onset between prime and target. The effects that we found may reflect either sublexical processing or speech planning, leaving it for future research to reach a firm conclusion with regard to underlying processes. Based on our findings, it can tentatively be assumed that beginning readers are susceptible to MOPE in lexical decision because of the fact that their word identification is far from automated.

Introduction

In masked onset priming (MOPE) the onset of a word (i.e., the consonants preceding the first vowel) is presented shortly, prior to the target word (e.g., pl – PLAY). To our knowledge, MOPE is only studied in adults and is thought to reflect either sublexical processing (e.g., Forster & Davis, 1991; Mousikou, Coltheart, Finkbeiner, & Saunders, 2010) or speech planning (e.g., Dimitropoulou, Duñabeitia, & Carreiras, 2010; Kinoshita, 2000; Kinoshita & Woollams, 2002; Schiller, 2008). In adults, MOPE has been shown to facilitate reading latencies and accuracy numerous times in naming studies, but not in lexical decision tasks (e.g., Grainger & Ferrand, 1996). Remarkably, MOPE has not been assessed in children. Beginning readers are known to rely on the indirect route of reading (e.g., Ziegler et al., 2003; Zoccolotti et al., 2005), also in silent reading (e.g., Acha & Perea, 2008; Martens & De Jong, 2006). Therefore, if MOPE reflects sublexical processing, it is likely that MOPE will elicit facilitation in lexical decision in children, but not in adults. In the present study we examined this hypothesis by studying MOPE in a lexical decision task in both experienced and beginning readers.

According to the dual route cascaded (DRC) model by Coltheart, Rastle, Perry, Langdon, and Ziegler (2001), there are two possible routes open to experienced readers (i.e., adults) when encountering written language. In the lexical or direct route, words are read as a whole. From the orthographic representation of the word, both phonology and semantics of that specific word are accessed. In the non-lexical or indirect route, graphemes of a word are processed serially. In natural reading, adults only use this indirect route when reading novel words and non-words (Coltheart et al., 2001).

When performing a lexical decision task, it is often assumed that adults use the direct, lexical route (see: Van den Boer, De Jong, & Haentjens-Van Meeteren, 2012). Adults try to match the written word with words in their lexicon. If they find a match, they respond ‘yes’ and if the item is not found, they respond ‘no’. This is remarkable, as one would expect that pseudowords would be processed via the indirect route. Interestingly, however, there have been studies that did find phonological priming (e.g., vrienk – VRIEND) in lexical decision in adults in French (Carreiras, Ferrand, Grainger, & Perea, 2005) and Dutch (Zeguers, Snellings, Huizenga, & Van der Molen, 2014). Moreover, orthographic priming (e.g., lpay – PLAY) effects have been found in lexical decision in adults in French (Lété & Fayol, 2013) and Spanish (Acha & Perea, 2008). These findings are not in line with the assumption that lexical decision in adults takes place via the direct route alone.

When children are reading naturally, they move from reading words via the indirect route to reading words via the direct route with words being stored in the orthographic mental lexicon (Share, 1995; 2004). In order to map this developing process, Grainger, Lété, Betrand, Dufau, and Ziegler (2012) conducted a lexical decision study in grades 1-5 of elementary school focusing on transposed-letter effects and pseudo-homophone effects in pseudoword targets. As expected, the effect of the pseudo-homophones (which could be misclassified as words) diminished as reading level increased. Also, the effect of the transposed-letter effect first increased and later on diminished (Grainger et al., 2012). In another lexical decision study, Schmalz, Marinus, and Castles (2013) showed that children in grade 3 have regularity effects for unfamiliar but not for familiar words, indicating that they rely on the non-lexical route only for unfamiliar words.

Both studies mentioned above investigated children reading in opaque languages (French and English). In more transparent orthographies like Dutch (Martens & De Jong, 2006) and Spanish (Acha & Perea, 2008), however, a fast transition from indirect to direct word recognition seems less evident. Martens and De Jong (2006) found length effects to be present in 8-year-old normal reading children and in 10-year-old children who were dyslectic. In 10-year-old normal reading children, length effects were absent. Acha and Perea (2008) studied length effects in a lexical decision priming paradigm, using longer words than Martens and De Jong (2006). They found length effects to be present in both 7- and 11-year-old children but not in adults. The results seem to imply that, at least in transparent orthographies, children tend to rely longer on the indirect route and start using the direct route for reading later on.

In contrast to the studies regarding length effects, Van den Boer et al. (2012) proposed that children, like adults, base their lexical decisions on lexical search, rather than on non-lexical processing. They used a lexical suppression task in which the participating Dutch children in grade 2 and 5 were asked to repeat a nonsense word while making lexical decisions, forcing them into using a lexical reading strategy. Van den Boer et al. (2012) did not find any differences between the results in the condition in which Dutch children were performing the lexical decision task with and without lexical suppression, indicating that children do not approach a lexical decision task in a similar way as a naming task. Moreover, the authors found neighbourhood effects to account for differences in response latencies for words, rather than length effects. Taken these findings together, Van den Boer et al. (2012) assumed that children, as adults, adopt a lexical search strategy while making lexical decisions. These effects of neighbourhood-size were stronger in the older children (grade 5) and length effects were still present for the children in grade 2.

Besides lexical decision, priming experiments have been conducted to investigate word attack strategies. Castles, Davis, Cavalot, and Forster (2007) investigated altered letter priming (e.g., *rlay – PLAY*) and transposed letter priming (e.g., *lpay – PLAY)* in a lexical decision task in English speaking children in grade 3 (M_{age} 8;6) and grade 5 (M_{age} 10;5), as well as adults. In grade 3, Castles et al. found priming effects for both prime types. In grade 5, only the altered letter prime induced priming effects, whereas in adults no priming effects were obtained. This suggests that more experienced readers have a more finely tuned lexical recognition mechanism (Castles et al. 2007). Taken together with the findings of Grainger et al. (2012) and Schmalz et al. (2013), there is thus converging evidence that children move from grapheme-by-grapheme decoding to sight-word reading throughout the years.

The study of Castles et al. (2007) has been replicated in French speaking children and adults (Lété & Fayol, 2013) with different results being evidenced. For third graders (M_{age} 8;11), no priming effects were found. For fifth graders (M_{age} 10;10) and dyslexics (M_{age} 13;1), both substitute and transposed letter priming effects were found. For adults, only transposed letter priming effects were found. The finding that this priming effect in French speaking children emerged later than in English speaking children was attributed to the more opaque English orthography which calls for faster tuning of orthographic processing instead of endured phonological decoding (Lété & Fayol, 2013).

A specific type of priming is masked onset priming (MOPE). Here, the onsets of prime and target items are identical, whereas in the priming experiments mentioned above letters were transposed or altered between prime and target. Onset here is defined as all the consonants preceding the first vowel of the word. In adults, this effect has been evidenced in a paradigm in which the onset of the orthographic word form is primed (for example: *pl – PLAY*) but also in a paradigm with whole word primes with overlapping onsets (e.g., *plough – PLAY*) (Schiller & Kinoshita, 2007). According to the segmental overlap hypothesis (Schiller, 1998) a larger orthographic overlap between prime and target results in a larger priming effect. This hypothesis was adjusted after another series of experiments in Dutch speaking adults by Schiller (2004). He found priming if there was an overlap between segments in the prime and the target, but only if these segments were located at the same location (i.e. in the beginning of the word or string). Thus, if the segments of the onset of the target word were presented in a final position in the pseudoword prime (e.g., lansba – BANAAN), there was segmental overlap but no priming effect. Moreover, the complexity of the onset (i.e. single consonant or consonant cluster) did not have an effect on the size of the priming effect, whereas the amount of overlap (i.e. one or two segments) did. This means that the segmental overlap hypothesis only holds when the position of the segments is at the same place in the prime and the target.

MOPE effects have been found in naming tasks among adults (e.g., Forster & Davis, 1991; Schiller, 2004), but not in silent reading tasks like lexical decision (e.g., Grainger & Ferrand, 1996). While overlap in the onset does not seem to result in priming in lexical decision in adults, phonological overlap in the first syllable rather than the onset was found to induce priming effects in adults in lexical decision (Carreiras et al., 2005). It thus seems that masked onset priming is not purely a phonologically driven effect, because then you would expect similar results for MOPE as for syllable priming.

Throughout the years, there are two possible explanations for the occurrence of the MOPE effect in naming in adults that have been proposed in the literature. The first account is known as the response competition hypothesis (Forster & Davis, 1991) and assumes that for the prime, grapheme-phoneme conversions are made, which is helpful in related prime-target pairs and causing inhibition in unrelated prime-target pairs. This account is supported by the DRC framework (Mousikou et al., 2010). When the target appears, the onset is already activated because it was similar in the prime. While decoding the target item, the onset has already been decoded, which is resulting in a shorter reading time as compared to the same item being preceded by an unrelated onset prime. This can explain why MOPE is only found in naming in adults. For lexical decision, adults rely on the lexical route. The MOPE effect is thought to reflect sublexical processes and is thus not present in lexical decision in adults.

An alternative or additional account for the lack of MOPE in lexical decision and the presence of MOPE in naming in adults was found by Kinoshita (2000). Kinoshita evidenced that the onset priming effect in adults is related to speech planning, which occurs at a later locus than grapheme-phoneme mapping. The assumption that speech planning has a relation with the onset priming effect is underlined numerous times (e.g., Kinoshita & Woollams, 2002; Schiller, 2008). More recently Dimitropoulou et al. (2010) evidenced the onset priming effect in naming tasks to be absent when the primes were unpronounceable. Adults may not use speech planning during silent reading, which might explain the absence of onset priming in lexical decision for this group of readers.

To the best of our knowledge, MOPE has not been studied in children, not in naming tasks nor in lexical decision, while this might reveal relevant information on word reading strategies in children as compared to adults. However, to resume, there is evidence from lexical decision and priming experiments that children in the primary grades make a transition from an indirect to a direct word attack strategy. Moreover, we know that MOPE can be found in adults in naming studies, but there are no reports of this effect in lexical decision studies.

Since according to one type of explanation, MOPE is thought to reflect sublexical processes and beginning readers are thought to predominantly rely on sublexical strategies, in the present study we studied MOPE in experienced and beginning readers of Dutch, an orthographically transparent language. To be able to investigate the effect of differential reading strategies between adults (Experiment 1) and children (Experiment 2), we studied this in lexical decision, a silent reading task. To be able to find differential results between adults and children, we used a lexical decision task. As a comparison with regard to reading strategies, we also studied experienced readers.

To gain more understanding in differences in word reading strategies between children and adults, we conducted a lexical decision experiment with masked onset priming in adults and children, in a 2x2x2x2 design with *Relatedness* (related vs. unrelated), *Target Type* (words vs. pseudowords), *Complexity* (single consonants vs. consonant clusters) and *Prime Type* (part vs. whole word primes) as factors. In this study the following research questions were examined:

1.) Do experienced and beginning readers show MOPE effects (that is a main effect for *Relatedness*) for accuracy and/or speed?
2.) In what way are accuracy and reading speed influenced by *Target Type, Complexity* and *Prime Type* and how do these variables influence the effect of *Relatedness*?

The first research question involved priming. Since we used a lexical decision paradigm, we did not expect to find MOPE effects for the experienced readers. However, we did expect to find MOPE effects in terms of accuracy and speed for beginning readers as evidenced by shorter response times and higher accuracy scores for items with an onset overlap between prime and target in the beginning readers.

The second research question involved lexical factors of target and prime and two-way interactions of these factors with the factor *Relatedness*. For experienced readers, we did not expect to find any interaction effects for *Relatedness.* The hypotheses with regard to interaction effects thus only apply to beginning readers. For *Target Type* we expected to find shorter response times and higher accuracy scores for words than for pseudowords in both experienced and beginning readers, which is known as the lexicality effect. Because we assume that children predominantly rely on the indirect route for reading, no effect of *Target Type* x *Relatedness* is to be expected, since related primes are thought to be equally beneficial in words than in pseudowords.

We also expected to find larger response times for the targets containing consonant clusters than for the items containing no consonant cluster in both experienced and beginning readers (main effect for *Complexity*). Based on the segmental overlap hypothesis (Schiller, 1998; Schiller 2004), we predicted priming effect sizes for items containing consonant clusters to be larger, as evidenced from an interaction effect of *Complexity x Relatedness* in children.

Finally, with regards to *Prime Type* we expected to find no main or interaction effect in experienced readers, if they indeed approach a lexical decision task via the direct route of reading. This would results in no response competition from the prime and thus no main effect for *Prime Type.* For beginning readers we expected to find a main effect for *Prime Type.* We expected whole word primes to yield lower accuracy scores and slower responses than part word primes, due to inhibition of the segments after the onset as was found by Schiller in word and picture naming in adults (2004; 2008). For the same reason, we also expected the part word primes to effectuate larger priming effects than the whole word primes, which would be reflected in a two way interaction of *Prime Type x Relatedness* in the beginning readers.

Experiment 1: Experienced Readers

Method

Participants

A total of 31 undergraduate students from the Radboud University took part in this study in exchange for a financial reward or course credits. All participants were native speakers of Dutch, had normal or corrected-to-normal vision and were right-handed.

Materials and experimental design

All items consisted of a prime and a target and half of the targets were pseudowords. All target words used in the experiment were selected from a database of familiar words for 6-year-olds (Schaerlaekens et al., 1999). The selection criterion for the words was that at least 80% of the Dutch 6-year-olds was familiar to the word (note that our participants in Experiment 2 were 8 years old). We used a 2x2x2x2 design, resulting in 16 different conditions. The first factor was *Relatedness*; primes and targets either had a congruent or an incongruent onset. The other three factors were linguistic factors. The second factor was *Target Type*; targets were either words or pseudowords. The third factor in the design was *Complexity*. Primes and targets contained either a complex onset (i.e., a cluster containing two consonants) or a simple onset (i.e., a single consonant). The complexity of primes and targets was always congruent. The fourth factor in the design was *Prime Type*. Primes were either whole words that were selected from the database (Schaerlaekens et al., 1999) or part word primes, only consisting of an onset.

In total, two lists of 160 items were created. Half of these items were pseudowords, half of these were words. There were 10 items for each of the 16 conditions. The two lists did not differ on *Relatedness,* but rather on *Prime Type.* If a related target was preceded by a part word prime in one of the lists, the same target was preceded by a whole word prime in the other list. All other prime-target pairs were kept constant in both lists. Related and unrelated prime – target combinations were kept constant in terms of length and frequency, making it possible to directly compare those. The two lists with items can be found in the Appendix.

Apparatus and task procedure

The experiment took place in a quiet room. A computer was used for presentation of the stimuli and a keyboard was used for response registration. The experiment was programmed in E-prime 2.0. The items were presented in a black font Helvetica size 28 in the middle of a white screen. An example of a trial is presented in Figure 4.1. Participants were instructed via the computer screen and by the experimenter to only judge the words in capitals with a yes (green button) or no (red button) response. They had to respond 'yes' when the target was an existing Dutch word, and 'no' when the target was a non-existing Dutch word. The red and the green button were on the external QWERTY-keyboard and replaced the buttons 'z' and 'm'. The green button was always on the side of the dominant hand of the participant.

There were two different lists with words; each participant was randomly assigned to one of those lists. The order of items was automatically randomized, to control for order effects. There were 16 practice trials, allowing the participants to get used to the task. After the practice trials, there were 160 trials, which required 80 no-responses and 80 yes-responses. After 40, 80 and 120 trials there was a break. The participants were able to terminate the break by pressing the space-bar. The duration of the experiment was approximately ten minutes.

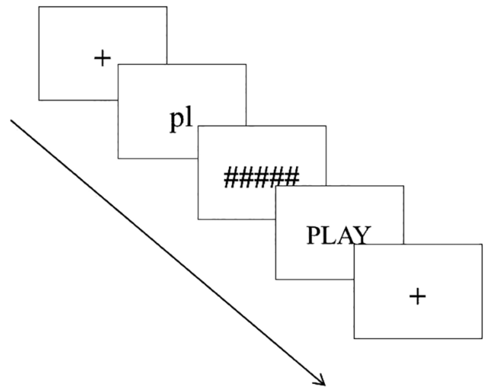


Figure 4.1 Example of one Trial.
Fixation cross for 1500 milliseconds, followed by the prime which was visible for only 80 milliseconds. After the prime the mask (#####) appeared for 500 milliseconds, followed by the target. The target remained on the screen for 800 milliseconds. The response window was 3000 milliseconds. After a response was given then next trial started with a fixation cross.

Data preparation and analysis

For each trial, accuracy and response latency was measured. For both adults and children, a trial was marked as incorrect if 1) the response-time limit was exceeded (more than three seconds), or 2) the answer was incorrect. A total of 8.0% of the items was marked as incorrect. In 1.0% of all the cases, the answer was not provided within 3000 milliseconds. In 4.0% of the cases, participants incorrectly judged a pseudoword as an existing word and in 3.0% of the cases, words were mistaken for pseudowords. Accuracy scores for participants ranged from 85 to 100%.

In the reaction time analysis, only correct items were analyzed (92.0%). One subject was considered an outlier (with response times more than 2 SD above the mean) and was therefore removed from the sample, leaving 30 subjects. We used log transforms for the analysis, since raw reaction times were not normally distributed. Mean response times for all sixteen conditions are presented in Table 4.1.

For both accuracy and response time data we performed two repeated measures ANOVA's A with Accuracy and Reaction Times as the dependent variables and *Relatedness* (related vs. unrelated) *Target Type* (words vs. pseudowords), *Complexity* (simple vs. complex onsets) and *Prime Type* (part words vs. whole words) as within subjects variables. Following our hypotheses, we report main effects and two-way interactions with *Relatedness*. For experienced readers we expected no interaction effects, however, these are reported in order to compare the results of the experienced readers to these of the beginning readers from Experiment 2.

Results

Accuracy scores

With accuracy scores as the dependent variable, we found a main effect for *Relatedness,* $F(1,29) = 13.13$, $p = .001$, $\eta^2_p = .31$. This main effect for *Relatedness*, however, was showing inhibition; related targets were responded to less accurately than unrelated targets. There were no main effects for the other factors, and also no two-way interaction effects with *Relatedness.*

Reaction times

For reaction times there was - as expected - no main effect for *Relatedness,* $F(1,29) = 1.39$, $p = .25$, $\eta^2_p = .05$, indicating that there was no priming. There was a main effect for *Target Type,* $F(1,29) = 128.10$, $p < .001$, $\eta^2_p = .82$, indicating that words were read faster than pseudowords. There was also a main effect for *Complexity,* $F(1,29) = 13.09$, $p = .001$, $\eta^2_p = .31$, indicating that simple targets were responded to faster than complex targets. The effect for *Prime Type* was approaching significance, $F(1,29) = 4.01$, $p = .055$, $\eta^2_p = .12$, indicating that targets that were preceded by whole word primes were responded to faster than targets preceded by part word primes.

There was a two-way interaction effect for *Relatedness* x *Target Type,* $F(1,29) = 4.31$, $p = .05$, $\eta^2_p = .13$. This effect revealed that for pseudowords there was hardly any difference between targets preceded by related or unrelated primes. For words, however, unrelated prime-target pairs were responded to faster than related prime-targets pairs, which reflects *inhibition.* There were no other two-way interaction effects with *Relatedness.*

Experiment 2: Beginning Readers

Method

Participants

A total of 88 children participated in this study (47 boys, 41 girls). The participants ranged in age between 7;4 and 8;7 years (M_{age} = 7;11 years, SD = 0;5). Four children with reading problems were not able to finish the task and were excluded from the analyses. Ten children were not included in the analyses because they were bilingual. The remaining 74 children came from six different grade 2 classes on five different schools, all in the Eastern region in The Netherlands. All schools used the same phonics-based reading instruction program *(Veilig leren lezen; Eng: Learning to read safely).* Two of the participating children were left-handed. None of the remaining children had reading problems (scoring below the 10th percentile), based on performance on a standardized decoding task (Three Minute Test, Verhoeven, 1995).

Materials and experimental design

The same materials and experimental design as in Experiment 1 were used.

Apparatus and task procedure

The experiment took place in quiet rooms in the participating schools. The task procedure was the same as in Experiment 1, with two exceptions. First, for this experiment we used a 13.3 inch laptop and an external keyboard. The settings of the laptop were the same as for the computer in Experiment 1. Also different from Experiment 1, the experimenter checked whether the participants were able to perform the task, based on their accuracy scores of the practice trials.

Data preparation and analysis

In total 29.6% of the items were marked as incorrect. In 10.0% of the cases, the answer was not provided within 3000 milliseconds. In 12.0% of all items, children judged a pseudoword as a correct word and in 7.6% of the cases the children mistakenly pressed 'no' when an existing word was presented on the screen. Accuracy scores of children ranged from 40 to 92%. None of the children were removed from analysis, since accuracy scores correlated with the decoding skills of children, $r = 0.37$, $n = 74$, $p < .01$. If we would remove the poor performing children, we would remove the poorest readers. Accuracy scores of items ranged from 49 to 91% (cf. Castles et al., 2007; Lété & Fayol, 2013). None of the items was removed from analysis. In Table 4.1 the mean accuracy scores and standard deviations for all 16 conditions are presented. Error scores were calculated per participant per condition.

In the reaction time analysis, only correct items were analyzed (70.4%). Outliers had been removed from the data. Outliers were defined per participant as all items

Table 4.1 Mean Accuracy Scores and Response Times in Milliseconds for all Conditions Averaged over Adults (N = 30)

Relatedness	Target Type	Complexity	Prime Type	Example	Mean Acc.(SD)	Net Priming Acc.	Mean RT (SD)	Net Priming RT
Related	Words	Simple	Part	m-MOP	0.95 (0.07)	0.01	581 (62)	- 16
			Whole	kar-KIP	0.92 (0.09)	- 0.04	570 (50)	- 11
		Complex	Part	kn-KNAL	0.93 (0.09)	0.01	588 (50)	5
			Whole	plek-PLAN	0.93 (0.10)	- 0.03	592 (44)	- 13
	Pseudowords	Simple	Part	r-RAAL	0.90 (0.13)	- 0.02	654 (80)	18
			Whole	lik-LEM	0.90 (0.13)	- 0.04	652 (67)	- 1
		Complex	Part	sn-SNUIK	0.90 (0.12)	- 0.06	669 (71)	- 15
			Whole	klep-KLAT	0.91 (0.11)	- 0.02	657 (64)	13
Unrelated	Words	Simple	Part	g-REM	0.94 (0.10)		565 (64)	
			Whole	sop-TAK	0.96 (0.07)		559 (51)	
		Complex	Part	st-GRAM	0.92 (0.07)		593 (58)	
			Whole	kruik-PLAAT	0.96 (0.06)		578 (51)	
	Pseudowords	Simple	Part	m-KERT	0.92 (0.11)		672 (88)	
			Whole	kous-PAAT	0.94 (0.09)		651 (76)	
		Complex	Part	gl-TRAS	0.96 (0.07)		654 (70)	
			Whole	gras-PLEN	0.93 (0.08)		670 (66)	

Table 4.2 Mean Accuracy Scores and Response Times for all Conditions Averaged over Beginning Readers (N = 74)

Relatedness	Target Type	Complexity	Prime Type	Example	Mean Acc. (SD)	Net Priming Acc.	Mean RT (SD)	Net Priming RT
Related	Words	Simple	Part	m-MOP	0.83 (0.14)	0.03	1201 (354)	30
			Whole	kar-KIP	0.79 (0.15)	0.01	1235 (374)	- 31
		Complex	Part	kn-KNAL	0.78 (0.16)	0.08	1265 (407)	7
			Whole	plek-PLAN	0.78 (0.18)	0.05	1259 (392)	41
	Pseudowords	Simple	Part	r-RAAL	0.65 (0.23)	0.01	1395 (404)	52
			Whole	lik-LEM	0.64 (0.23)	0.00	1445 (414)	1
		Complex	Part	sn-SNUIK	0.59 (0.27)	- 0.07	1465 (465)	50
			Whole	klep-KLAT	0.64 (0.26)	0.04	1491 (525)	27
Unrelated	Words	Simple	Part	g-REM	0.80 (0.15)		1231 (382)	
			Whole	sop-TAK	0.78 (0.17)		1204 (380)	
		Complex	Part	st-GRAM	0.70 (0.17)		1272 (391)	
			Whole	kruik-PLAAT	0.73 (0.16)		1300 (405)	
	Pseudowords	Simple	Part	m-KERT	0.65 (0.26)		1447 (476)	
			Whole	kous-PAAT	0.64 (0.23)		1446 (460)	
		Complex	Part	gl-TRAS	0.66 (0.26)		1515 (487)	
			Whole	gras-PLEN	0.60 (0.25)		1518 (454)	

that differed more than two standard deviations from the participants' mean (4.6 %). In some cases (0.004%), a mean response time was missing. For these items (N = 5) we used multiple imputation (see: Schafer & Graham, 2002) to estimate the values of these cases. Raw reaction times were not normally distributed, therefore we calculated the log transforms for all response times. These log transforms are used for the analysis. Mean response times for all sixteen conditions are presented in Table 4.2.

Similar to the first experiment, we performed two repeated measures ANOVA's A with Accuracy and Reaction Times as the dependent variables and *Relatedness* (related vs. unrelated) *Target Type* (words vs. pseudowords), *Complexity* (simple vs. complex onsets) and *Prime Type* (part words vs. whole words) as within subjects variables for both accuracy and response time data. Following our hypotheses, we report main effects and two-way interactions with *Relatedness.*

Results

Accuracy scores

For accuracy we found a main effect for *Relatedness,* $F(1,73) = 4.58$, $p = .04$, $\eta^2_p = .06$, indicating priming effects for accuracy in the beginning readers. Main effects for *Target Type*, $F(1,73) = 39.84$, $p < .001$, $\eta^2_p = .35$ and *Complexity*, $F(1,73) = 20.93$, $p < .001$, $\eta^2_p = .22$ were found, but not for *Prime Type*, ($F < 1$). These main effects were in the direction as expected; words were responded to more accurately than pseudowords and simple items were responded to more accurately than complex items.

There was a two-way interaction for *Relatedness* x *Target Type,* $F(1,73) = 9.49$, $p < .01$, $\eta^2_p = .12$, indicating that for pseudowords there was no overall difference of relatedness; pseudowords were responded to equally accurate when preceded by related or unrelated primes. For words, however, accuracy was higher if those targets were preceded by related primes, as opposed to unrelated primes ($p < .001$). This two-way interaction reveals that for accuracy scores in children, there is only priming for words. Both other two-way interactions were not significant (F's < 1).

Reaction times

With reaction times as the dependent variable, a main effect for *Relatedness,* $F(1,73) = 3.99$, $p < .05$, $\eta^2_p = .05$ was found, indicating priming; targets were responded to faster when they had a related prime than when the prime was unrelated. Apart from the main priming effect, there were main effects for *Target Type*, $F(1,73) = 117.77$, $p < .001$, $\eta^2_p = .62$, and *Complexity*, $F(1,73) = 21.51$, $p < .001$, $\eta^2_p = .23$. The main effect for *Prime Type* was not significant ($F < 2$). The main effects show that related prime target pairs were responded to faster than unrelated pairs, that words were responded to faster than pseudowords, and that items with a single consonant were responded to faster than items with a consonant cluster in the onset. We did not find any significant two-way interactions.

Discussion

In the present study, we studied MOPE effects in lexical decision in adults and second grade children. Our first research question was whether an onset priming effect would be present in adults and children. In line with previous studies with lexical decision MOPE in adults, we found, as expected, no priming effects in adult readers. Interestingly, related primes even seemed to inhibit response accuracy (but not speed). Moreover, for children, we did find priming effects for accuracy and speed, as expected. This means that children responded more accurately and faster to related prime-target pairs than to unrelated prime-target pairs.

We thus found priming for children for related prime-target word pairs with regard to accuracy and speed, and for prime-target pseudoword pairs we only found an effect for response times. The lack of a priming-effect for the pseudowords is probably due to the relatively low accuracy scores, combined with the high variance. Note that a response was also marked as inaccurate when response times exceeded three seconds. Hence, response times can be seen as a more robust measure. That we found priming effects for children and not for adults is as we expected, based on other priming studies (i.e., Castles et al., 2007; Lété & Fayol, 2013). This implies that children and adults use different strategies in lexical decision.

We assumed that children make lexical decisions via the sublexical reading route based on previously observed length effects in lexical decision (e.g., Acha & Perea, 2008; Martens & De Jong, 2006). These length effects are thought to reflect sublexical processing. Following the response competition hypothesis (Forster & Davis, 1991), it is also sublexical processing that causes MOPE effects to occur. Our data support this hypothesis, since we found a MOPE effect for both words and pseudowords in reaction times. Facilitation of previously seen onsets should be found in all items with an overlap, regardless of lexicality. Our accuracy data do not necessarily support the response competition hypothesis, especially with regard to absence of a priming effect in pseudowords. Our latency data also lend support to the other account for MOPE, i.e., speech planning. If MOPE indeed reflects speech planning (e.g., Kinoshita, 2000; Kinoshita & Woollams, 2002), it is likely that it is not found in lexical decision in adults since they do not use speech planning in lexical decision. And the fact that speech planning is likely to induce MOPE in words similarly as in pseudowords also corresponds with our findings. Future research needs to find out whether children do use speech planning in a MOPE lexical decision paradigm in order to be conclusive with regard to the cause of the discrepancy in effects between adults and children.

Our second research question was on the impact of the factors *Target Type* (words vs. pseudowords), *Complexity* (simple vs. complex onsets) and *Prime Type* (whole words vs. part words), and on their influence on the main priming effect of relatedness. For *Target Type* words to be responded to faster than pseudowords in adults, in children we found an effect of *Target Type* in both accuracy and speed. We expected to find main effects for *Target Type* in both groups, based on what is known as the lexicality effect which is present in many studies involving lexical decision (e.g., Martens & De Jong, 2006). In the present study, this lexicality effect with regard to speed is magnified by the configuration of the experiment, in which the 'yes-response' was always made by the dominant hand, as is common in this type of experiments (cf. Lété & Fayol, 2013). In this way, the lexicality effect with regard to speed does not only reflect a faster decision for words, but also a faster response time with the participants' dominant hand.

Target Type also had an influence on *Relatedness.* In adults, this two-way interaction effect was present in the response times. This effect revealed that for pseudowords there was no effect of *Relatedness.* For words, however, response times were slower if there was a related prime preceding the target, and faster if the prime was unrelated, reflecting inhibition. We did not expect to find priming effects for adults, however, we also did not expect inhibition. This effect is likely to be due to lexical competition of the prime, which is often found in priming experiments (cf. Schiller, 2008). In children, there was a two-way interaction effect of *Target Type* x *Relatedness* for the accuracy scores alone. Here, as in the adults, there was no effect of *Relatedness* for the pseudowords. However, for the words, related primes induced higher accuracy scores than unrelated primes in children. The difference between words and pseudowords with regard to enhanced accuracy might, however, reflect lexical processing. Hence, if children rely on their orthographic lexicon, which is likely to be relatively small at the age of 8, and they do not recognize a word, they might incorrectly judge it a pseudoword. .

For *Complexity,* we again found main effects in both adults and children, as expected. The complexity of the onset affected reading speed of adults and both accuracy and speed in children; the targets with complex onsets were more difficult than those with simple onsets. In both adults and children, *Complexity* did not interact with *Relatedness,* which implies that the amount of shared overlap between prime and target did not enhance priming effects. Based on the segmental overlap hypothesis (Schiller 1998; Schiller 2004) this was not to be expected. We predicted *Complexity* to have an effect on *Relatedness* in children since the complex words had a shared overlap of two segments whereas simple words had a shared overlap of one segment. Schiller (2004) did not find an effect of complexity in naming in adults, but they did find and effect for number of shared segments. Perhaps our measure of complexity (which included a measure of shared overlap) was not sensitive enough to elicit differences in the effect of priming. Moreover, we found a main effect for *Complexity* which was not found in naming in adults (Schiller, 2004). Perhaps complex onsets are difficult for beginning readers (e.g., Schreuder & Van Bon, 1989), to the extent that beginning readers do not benefit from the larger segmental overlap.

For *Prime Type,* we found no main or interaction effects in adults, as expected. In children, we found a main effect for *Prime Type* in their response times, as expected. This means that when targets were preceded by whole word primes, they were slower in responding than when targets were preceded by part word primes. For *Prime Type,* there were no interaction effects with *Relatedness* for the beginning readers. We did expect to find inhibition for the whole word primes, since unrelated whole word primes were thought to interfere with the target beyond the onset (Mousikou et al., 2010; Schiller & Kinoshita, 2007). This interference might have happened regardless of relatedness, since we did find main effects for *Prime Type.* Lexical competition of the prime or frequency effects of the prime might have led to slower responses to the target (e.g., Goldinger, Luce, & Pisoni, 1989; Marinus & De Jong, 2010).

At this point, it is important to mention that the present study has some limitations with regard to the chosen priming paradigm. The paradigm is not directly comparable to the classic MOPE paradigm. Contrary to this paradigm, whole and part word primes were not equally salient in the present study, and no forward mask was used. In order to be able to compare part word primes to whole word primes we used this as a between subjects variable. In the stimuli we used monosyllabic words which all consisted of 3-5 letters beginning and ending with a consonant with a maximum of two consonants in a cluster (i.e., CVC, CVVC, CCVC, CVCC, CCVVC or CVVCC). We kept the number of items with single and two consonants in the onset constant. Due to this choice, the length of complex items is longer than the length of simple items, $F(1,158) = 126.69$, $p < .001$. Between all other variables, length was kept constant and thus did not affect the results. As the length effect has shown to be present in children at this age (Martens & De Jong, 2006), it is likely that this has influenced the effects regarding the main effect of *Complexity*. However, our main interest was in the interaction of *Relatedness* x *Complexity,* which is not affected by length.

Due to the choice to use *Prime Type* as the within-items factor, *Relatedness* was assessed between-items. Due to this a direct comparison between our study and other studies assessing MOPE is not possible. Since length and frequency of the targets were kept constant for related and unrelated items, we do believe that based on this study we can draw conclusions with regard to the effect of related primes versus unrelated primes. Moreover, if *Relatedness* would be influenced by the chosen stimuli, this effect would be found in both children and adults, but this was not the case.

The different paradigm, however, does call for caution in comparing the present results directly with results in naming studies with adults. Moreover, we suggest that future research looks into MOPE in naming in children as well, to see what differences there are for children between lexical decision and naming. Another suggestion for future research lies in the potential explanation of speech planning causing the difference in results between adults and children. In order to draw conclusions with regard to speech planning account for the MOPE effect, it needs to be examined whether children use speech planning while making lexical decisions. A way to further explore the presence of speech planning is by performing MOPE in lexical decision and naming combined with EMG (electromyographic speech recognition). In EMG surface electrodes on the face of participants record activation potentials from the articulatory muscles. This technology was developed to recognize silent speech (Schultz & Wand, 2010) and is therefore a useful tool to examine this possible cause for differential results between children and adults.

To conclude, differential effects in adults and children are found with MOPE in lexical decision. Adults do not benefit from onset primes in this paradigm, whereas children do, especially while reading words. These effects underline the different reading strategies as adopted by beginning and experienced readers. The effects that we found are, however, inconclusive with regard to what causes MOPE to occur; is it speech planning or sublexical processing that elicits these priming effects? This remains a question that needs to be answered in future studies regarding this topic. Nonetheless, since related primes seem to enhance reading speed and accuracy in beginning readers, this paradigm could also be used in reading interventions aiming at enhancing word reading efficiency. The observed differences between adults and children pose an interesting challenge for the debate on the origins of MOPE.

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Appendix. Items Used in Experiment.

List A.

Prime	Target	Prime	Target	Prime	Target	Prime	Target
g	GIL	g	GAN	n	ROTS	p	MAR
k	KAST	g	GIR	m	GANS	m	PIG
l	LUIS	k	KIS	s	MAAG	s	LIJT
m	MOP	l	LEP	l	POORT	r	NAP
m	MES	m	MUIT	k	PET	n	PAAN
n	NEK	p	POTS	l	RUG	p	RAAN
p	POLS	r	ROM	p	MIER	m	KERT
p	PIJN	g	GES	r	SOK	n	PINS
r	REEP	k	KAL	n	MENS	l	POOM
r	ROOK	r	RAAL	g	REM	g	RAK
gek	GAT	lik	LEM	kam	TOP	punt	KATS
kar	KIP	mus	MEK	gulp	LIFT	reus	LUIN
lap	LES	nat	NES	koel	MUUR	mal	MON
maan	MUIS	peer	POET	soep	RUIT	poot	NEUL
mol	MAP	rijk	ROOL	rust	LAMP	kers	POLT
naam	NEUS	rijp	ROON	kurk	GOLF	neer	PIJG
paal	POES	kalf	KERP	rok	SAP	laag	REEN
put	PIL	lip	LAR	sop	TAK	kous	PAAT
rat	ROL	mat	MUK	tulp	RITS	lat	PUN
riem	ROOS	noot	NAAK	saus	TEEN	tuin	RIES
gr	GROOT	pr	PRIJN	pl	STEP	kn	GRIJM
kn	KNAL	sl	SLOOK	gr	KLEUR	gr	KNAM
st	STOF	sl	SLAM	sp	KNAAP	gr	PLAM
pl	PLAN	sn	SNUIK	st	GRAM	sl	TRAN
pr	PRIJS	gr	GRIEL	pr	KLAAR	pl	GROEL
sl	SLOOT	kl	KLON	pl	KREET	st	PRIS
sl	SLAK	tr	TROP	kn	SPEER	tr	SLOM
sp	SPIN	sl	SLOG	gr	SNOET	pr	STON
st	STUK	kr	SNOEG	kl	STIER	kn	SPOOL
tr	TROM	st	STOR	sm	PLAT	gl	TRAS
groep	GRIJS	graag	GROOL	snor	STAM	plak	STIT
klok	KLAS	klep	KLAT	snot	KLAP	stoep	KRIJN
krijt	KRUIS	kroon	KRUIG	steen	PRUIM	gras	PLEN
spuug	SPEEN	prop	PREM	grap	STEM	kraal	SPOON
prik	PRET	slof	SLIN	stoer	PLEIN	krul	PLEG
slok	SLIM	spel	SPIM	groen	STUUR	stoel	PRUIT
snoer	SNUIT	spijt	SPUIG	klein	SNAAR	troon	SLAAM
spook	SPUIT	ster	STUN	kruik	PLAAT	kras	SPET
stok	STIP	traan	TROEN	pluis	TRAAG	krom	STAG
trein	TROEP	slap	SLON	smal	GROT	smaak	TREIP

Note. Items vary with regard to: Relatedness (related vs. unrelated), Word Type (words vs. pseudowords), Complexity (single letter vs. consonant cluster) and Prime Type (part word vs. whole word).

List B.

Prime	Target	Prime	Target	Prime	Target	Prime	Target
g	GAT	g	GAN	n	ROTS	p	MAR
k	KIP	g	GIR	m	GANS	m	PIG
l	LES	k	KIS	s	MAAG	s	LIJT
m	MUIS	l	LEP	l	POORT	r	NAP
m	MAP	m	MUIT	k	PET	n	PAAN
n	NEUS	p	POTS	l	RUG	p	RAAN
p	POES	r	ROM	p	MIER	m	KERT
p	PIL	g	GES	r	SOK	n	PINS
r	ROL	k	KAL	n	MENS	l	POOM
r	ROOS	r	RAAL	g	REM	g	RAK
gum	GIL	lik	LEM	kam	TOP	punt	KATS
kerk	KAST	mus	MEK	gulp	LIFT	reus	LUIN
lijn	LUIS	nat	NES	koel	MUUR	mal	MON
man	MOP	peer	POET	soep	RUIT	poot	NEUL
mug	MES	rijk	ROOL	rust	LAMP	kers	POLT
nul	NEK	rijp	ROON	kurk	GOLF	neer	PIJG
park	POLS	kalf	KERP	rok	SAP	laag	REEN
poos	PIJN	lip	LAR	sop	TAK	kous	PAAT
raam	REEP	mat	MUK	tulp	RITS	lat	PUN
reis	ROOK	noot	NAAK	saus	TEEN	tuin	RIES
gr	GRIJS	pr	PRIJN	pl	STEP	kn	GRIJM
kl	KLAS	sl	SLOOK	gr	KLEUR	gr	KNAM
kr	KRUIS	sl	SLAM	sp	KNAAP	gr	PLAM
sp	SPEEN	sn	SNUIK	st	GRAM	sl	TRAN
pr	PRET	gr	GRIEL	pr	KLAAR	pl	GROEL
sl	SLIM	kl	KLON	pl	KREET	st	PRIS
sn	SNUIT	tr	TROP	kn	SPEER	tr	SLOM
sp	SPUIT	sl	SLOG	gr	SNOET	pr	STON
st	STIP	kr	SNOEG	kl	STIER	kn	SPOOL
tr	TROEP	st	STOR	sm	PLAT	gl	TRAS
griep	GROOT	graag	GROOL	snor	STAM	plak	STIT
knop	KNAL	klep	KLAT	snot	KLAP	stoep	KRIJN
stap	STOF	kroon	KRUIG	steen	PRUIM	gras	PLEN
plek	PLAN	prop	PREM	grap	STEM	kraal	SPOON
pruik	PRIJS	slof	SLIN	stoer	PLEIN	krul	PLEG
slaap	SLOOT	spel	SPIM	groen	STUUR	stoel	PRUIT
slot	SLAK	spijt	SPUIG	klein	SNAAR	troon	SLAAM
spek	SPIN	ster	STUN	kruik	PLAAT	kras	SPET
stal	STUK	traan	TROEN	pluis	TRAAG	krom	STAG
trap	TROM	slap	SLON	smal	GROT	smaak	TREIP

Note. Items vary with regard to: Relatedness (related vs. unrelated), Word Type (words vs. pseudowords), Complexity (single letter vs. consonant cluster) and Prime Type (part word vs. whole word).

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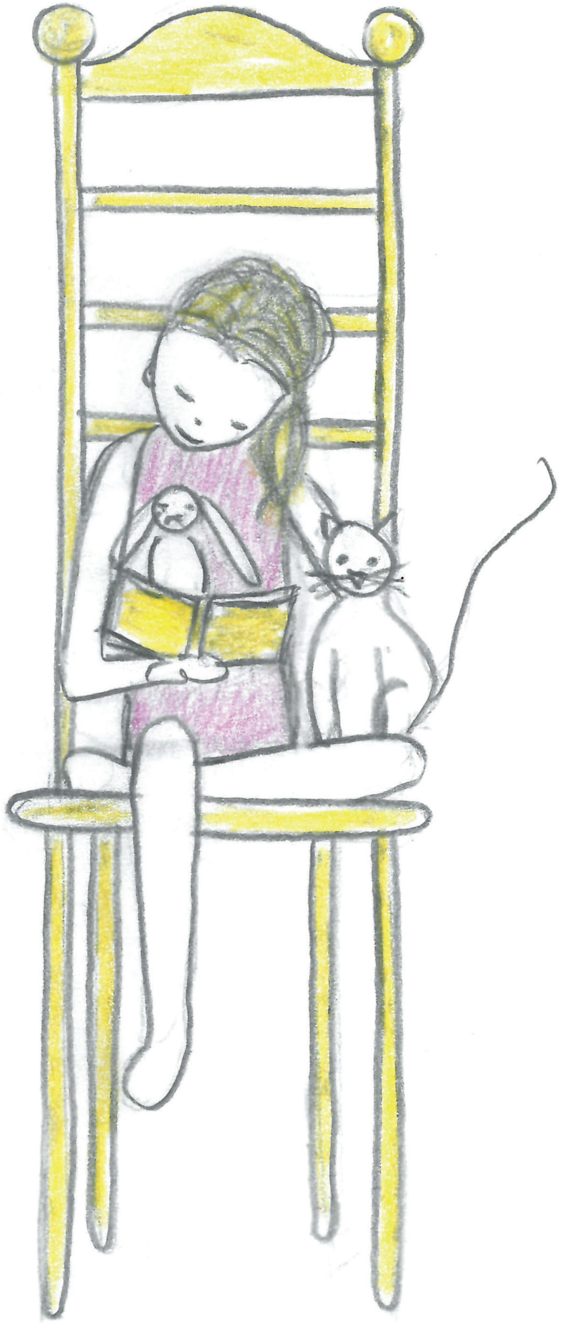

5

Enhancing decoding efficiency in poor readers via a word identification game

This chapter is based on: Van Gorp, K., Segers, E., & Verhoeven, L. (submitted). Enhancing decoding efficiency in poor readers via a word identification game.

Abstract

The effects of a word identification game aimed at enhancing decoding efficiency in poor readers were tested. Following a pretest, posttest, retention design with a waiting control group, 62 poor-reading children in second grade received a five-hour tablet intervention across a period of five weeks. During intervention, participants practiced reading words and pseudowords while doing semantic categorization and lexical decision exercises in a gaming context. Prior to, directly after, and five weeks following the intervention, word decoding efficiency was assessed using a standardized read-aloud test consisting of six lists of untrained words and pseudowords with three levels of difficulty: CVC items, consonant cluster items, and disyllabic items. Significant increases as a result of the brief gaming intervention were found for decoding efficiency on all six word lists. The used motivational game, which included repetition, immediate corrective feedback and a semantics task, elicited transfer and retention effects.

Introduction

A fundamental task for children learning to read is to become fully accurate and fast in word decoding (National Institute of Child Health and Human Development, 2000). Intensive exposure to written language is required to develop this skill. In a meta-analysis, Mol and Bus (2011) indeed showed that print exposure explains a significant portion of the variance in both word decoding and reading comprehension. Poor readers need more exposure to become proficient than normal readers, however (e.g., Ehri & Saltmarsh, 1995). Reading interventions aimed at enhancing word decoding efficiency can offer this required exposure.

Computer-assisted remedial reading interventions with a focus on the repetition of words are one such intervention that might be helpful for enhancing the word decoding efficiency of poor readers (Saine, Lerkkanen, Ahonen, Tolvanen, & Lyytinen, 2011). Repeated reading of words has often been found to increase decoding efficiency for trained items (Therrien, 2004), but transfer to *untrained* words has been difficult to establish (e.g., Berends & Reitsma, 2006b). The ultimate goal of such word reading interventions is nevertheless to improve *general* decoding efficiency and thus to induce transfer effects.

To achieve the goal of word decoding transfer to untrained words, we developed a motivating tablet game that challenges children to make various types of semantic categorizations and thereby practice on word identification. In the present study, we examined the transfer effects to word decoding efficiency of unpracticed items of this word identification game for a group of poor readers in particular. We examined the effects immediately following the intervention and again a few weeks later.

As already mentioned, repeated word reading interventions have been shown to improve decoding efficiency for trained items but not for untrained words (i.e., transfer) (cf. Berends & Reitsma, 2006b). There is growing evidence, however, that repeated reading in *combination* with specific instruction or corrective feedback can elicit the desired transfer effects.

In three studies, the effects were investigated of a repeated reading intervention accompanied by specific instructions on the decoding of onset consonant clusters. Two of the studies showed transfer effects for untrained items containing the trained onset clusters but no transfer effects for untrained items not containing onset clusters (Hintikka, Landerl, Aro, and Lyytinen, 2008; Thaler, Ebner, Wimmer, & Landerl, 2004). The other study involved the same onset cluster training intervention but showed no transfer effect to words containing these onset clusters. (Huemer, Landerl, Aro, & Lyytinen, 2008). The authors suggest that differences in the exact training task or the test and control conditions used in the Huemer et al. study as compared to the Hintikka et al. study may account for the lack of transfer. Alternatively, the limited response time allowed in the study by Hintikka et al. *induced* transfer effects. Being

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required to respond quickly during training may have encouraged participants to also respond faster during testing and thus created transfer effects. Marinus, de Jong, and van der Leij (2012) examined the effects of emphasis on consonant clusters in a speeded repeated reading task to the effects of emphasis on single consonants in a speeded repeated reading task. No transfer effects were found for either of the two experimental conditions, which suggests that the transfer effects found for speeded onset consonant cluster training are not conclusive in reaching transfer effects.

In other research, more stable transfer effects were found for repeated reading tasks including immediate corrective feedback rather than specific instruction. Huemer, Aro, Landerl, and Lyytinen (2010) documented transfer effects for poor readers of Finnish in the fourth to sixth grades when given immediate corrective feedback on a repeated reading of syllables task. The participating children were asked to reread a syllable when initially done inaccurately; after two inaccurate attempts, the correct pronunciation was provided by the tutor. Increased reading speed was found for both trained syllables and untrained pseudowords containing the trained syllables.

In related research, transfer effects were demonstrated for poor reading Dutch children aged 7-10 years were trained on either the set of words incorrectly read in previous trials, or the words that they correctly read in previous trials (Steenbeek-Planting, van Bon, and Schreuder, 2012). Children in both training conditions showed transfer effects for reading efficiency when presented with more complex untrained words and with sentences. In yet another study in which immediate feedback was provided on reading accuracy of syllables, Heikkilä, Aro, Närhi, Westerholm, and Ahonen (2013) found transfer from trained syllables to untrained longer words for Finnish poor reading second and third graders but only for *infrequent* long syllables.

Finally, Van Gorp, Segers, and Verhoeven (2014) found evidence of transfer following a repeated reading intervention with corrective feedback for kindergartners. After 10 repetitions of words followed by immediate feedback on all items, transfer effects for both the accuracy and speed of untrained items were found. Convergence thus exists on the effectiveness of including feedback in repeated reading tasks to foster transfer to untrained items and contexts.

In repeated word reading, the emphasis is predominantly on strengthening the link between orthography and phonology by having participants repeatedly read words aloud. This makes sense as it is known that poor readers are known to struggle with not only orthography and phonology but also the link between the two (cf. Wang, Marinus, Nickels, & Castles, 2014). In addition to the link between orthography and phonology, most current models of adult reading (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Perfetti & Hart, 2002; Plaut, McClelland, Seidenberg, & Patterson, 1996) and children's reading development (Ehri, 2005; Share, 2004) emphasize the importance of semantics.

Experimental studies have shown semantics to play an important role during the early stages of word decoding. Children as young as seven years have been found to extract semantic information directly from orthography (Nation & Cocksey, 2009). And when Duff and Hulme (2012, Experiment 1) examined the role of semantics in the beginning reading of English (children 5 to 6 years), they found highly imageable words to be read more accurately than less imageable words. The children's specific knowledge of these words, moreover, significantly predicted their reading accuracy. Most recently, Wang, Nickels, Nation, and Castles (2013) showed the availability of contextual information to promote the orthographic learning of children aged 6-9 years, particularly for orthographically irregular items. While reading irregular words, that is, it is helpful to know something about the meaning of the target word. And in addition to the facilitation of word decoding, Henderson, Weighall, and Gaskell (2013) found the lexical consolidation of new words to be improved when children 5 to 9 years of age were exposed to the meanings of the target words.

It can thus be concluded on the basis of the preceding and the relevant theories of reading that semantics plays a clear role in the *accuracy* of reading in both children and adults. The effects of semantics on reading *efficiency,* that is, speed and accuracy combined, however, are less clear. To our knowledge, there is only one study of this — that of Berends and Reitsma (2006a) who were interested in improving reading efficiency with the incorporation of semantics into a repeated word-reading task. They compared the reading efficiency of poor readers of Dutch aged 6 to 8 years in conditions with a focus on either the orthography or the semantics of the target words. The children were either asked *Are these two items the same*? and *Is this consonant cluster present in the word?* (for example, about orthographics) or *Do these words belong to the same category?* and *Can you drink it?* (for example, about semantics). The children in the semantic condition outperformed the children in the orthographic condition but generalization to untrained items was not measured, which leaves the question of whether inclusion of semantics facilitated the children's general decoding unanswered.

Based on our review of the relevant research literature, repetition appears to be one key feature for improving the efficiency of children's word decoding. A challenge for most reading interventions is to keep children motivated, however. It is known that motivation in general (Guthrie & Wigfield, 2000) and *intrinsic* motivation in particular (Wigfield & Guthrie, 1997) play a very important role in the process of reading and that the reading motivation of poor readers is generally lower than that of other readers (Polychroni, Koukoura, & Anagnostou, 2006). Guthrie and Wigfield (2000) showed things that interest children in the real world – such as gaming heighten motivation. In addition, computerized reading training has recently been shown to effectively enhance the reading skills of children (e.g., Fälth, Gustafson, Tjus, Heimann, & Svensson, 2013; Heikkilä et al., 2013; Kyle, Kujala, Richardson, Lyytinen, & Goswami, 2013). And computerized reading training has been shown to be even more effective than regular reading training (Saine et al., 2011), and in addition this type of training requires hardly any supervision (Lewandowski, Begeny, & Rogers, 2006).

Feedback was another key feature found in our review of the relevant research literature to improve the efficiency of children's word decoding. And the inclusion of a reward system in games has been similarly shown to promote engagement in game-based reading (Ronimus, Kujala, Tolvanen, & Lyytinen, 2014). A reward system can be considered a form of positive feedback, which has also been cited as crucial for the creation of game "flow" (Kiili, 2005).

We designed a motivational, word identification game to improve the word decoding efficiency of children identified as poor readers of Dutch. Dutch has been classified as having a transparent orthography, which means that poor decoding efficiency is more a matter of decoding speed than decoding accuracy (de Jong & van der Leij, 2003; Landerl & Wimmer, 2008). Repetition and immediate, corrective feedback were incorporated into the game that we designed. For game-based learning to occur, it has been shown that immediate feedback is important (Kiili, 2005). The two elements of repetition and feedback were further included in two different tasks involving semantics, namely a lexical decision task and a semantic categorization task. There are several training tools that include semantic categorization tasks available in English and in Dutch (e.g., *Scrap Cat in Fast ForWord* from Scientific Learning Corporation, 2001; *LeesLadder* from Irausquin, Drent, & Verhoeven, 2010). But, to our knowledge, no studies have investigated the effects of these word identification games on enhancing reading skill.

During training participants practiced with word identification, whereas word decoding was assessed during testing. The transfer task involved six different word lists that varied with regard to word type (words, pseudowords) and complexity (CVC items, cluster items, disyllabic items). A waiting control group received the same intervention as the experimental group but at a later point in time. The children's word decoding efficiency was assessed prior to the intervention, directly following completion of the intervention, and again five weeks later.

Our overriding research question was whether our motivational word identification game which included repetition, feedback and semantics could lead to a significant improvement of word decoding efficiency of untrained items in poor readers. Our first hypothesis was that the intervention would indeed be effective and also elicit transfer effects for decoding efficiency (i.e., increased decoding speed for all six word lists with untrained items). Our second hypothesis was that the intervention effects would maintain and therefore still be present five weeks after completion of the intervention. Our third hypothesis was that the intervention effects would be larger for real words than for pseudowords due to the focus of the game we designed on semantics. Our fourth and final hypothesis was that the transfer effects for the game intervention would be larger for simpler than for more complex items.

Method

Participants

Participants were 64 monolingual Dutch second graders (36 boys, 28 girls) with a mean age of 7 years and 2 months (SD 5 months). All participants were in second grade at the time of the intervention and seven of them had repeated either a year of kindergarten, first grade, or second grade. All participants scored below the 25th percentile on a standardized, isolated, word decoding task (Three-Minute-Test, Verhoeven, 1995).

The participants came from 12 different middle class schools located in the east and south of The Netherlands. All schools were using the same reading instruction method called *Veilig leren lezen* [*Learning to Read Safely*], a method used in 85% of schools in The Netherlands. For this study, a waiting control group design was used in which the waiting control group first served as a control for the experimental group and then received the intervention (see Figure 5.1).

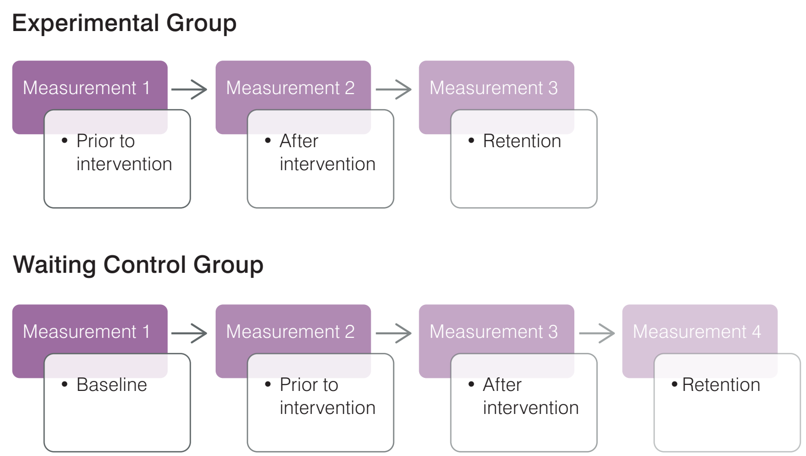

Figure 5.1 Waiting Control Group Design.

For the experimental group, there were three measurement occasions: one prior to the intervention, one directly following the intervention, and one five weeks later. For the waiting control group, there were four measurement occasions; in addition to the three measurements conducted for the experimental group, the waiting control group also had a baseline measurement, which provided a control for assessing the effects of intervention in the experimental group.

The classes with the participating children were pseudo-randomly divided into two groups (i.e., experimental and waiting control). The two groups did not differ on standardized measures related to word decoding skills. Two participants were not able to finish the intervention, leaving 31 participants in each group.

Word decoding task

To assess word decoding efficiency, six word lists were administered. The first list included 150 CVC words; the second included 150 monosyllabic cluster words (CCVC/ CVCC/ CCVCC); the third included 120 disyllabic words. List four, five, and six consisted of CVC, cluster, and disyllabic pseudowords. The lists were taken from the Dutch Standardized Screening Test for Children with Specific Language Impairment (Verhoeven, 2005). For each of the word lists, the participants had one minute to correctly read as many items as possible out aloud. The score per list (i.e., total number of items read correctly in one minute) constituted the reading efficiency score. The word efficiency reading task was administered directly prior to the intervention, directly following the intervention, and five weeks following completion of the intervention to assess retention. For the waiting control group, the task was also administered five weeks prior to the intervention (see: Waiting Control Group Design). The items constituting the word decoding task were different from the items used during the intervention.

Reading race intervention

During the intervention period, the children played the Reading Race computer game, an evidence informed game. This application targets poor readers in grade two and thus the age range of 6 to 8 years. The aim of the application is to increase word decoding efficiency. For an impression of the game, see Figures 5.2a and 5.2b.

Stimuli used in the game. The game stimuli consisted of CVC words, cluster words, and disyllabic words; half-way through the game, parallel types of pseudowords are also offered. The Reading Race application had a total of 731 items (i.e., real words and pseudowords).

All of the target real words were selected from a database of words that 6-year-old children can be expected to know (Schaerlaekens, Kohnstamm, & Lejaegere, 1999). A further selection criterion for the target words was that they had to be known by at least 70% of Dutch 6-year olds. Note that the children participating in this study were all 8 years of age.

In addition to the criterion that the real words had to be familiar to children 6 years of age, the target words also had to belong to one of the *semantic categories* included in the game. As part of the game, the children had to perform a semantic categorization task (e.g., categorize a target word as referring to an *animal* or a piece of *clothing*), a lexical decision task (i.e., identify a target word as a real word or a pseudoword), or both tasks. A sample of the exercises used in the intervention is presented in Figure 5.2a. Eight semantic categories were used in the present study: *food and beverages; nature; animals; people; the human body; in and around the house; traffic and transportation;* and *clothing.*

Level structure of Reading Race. The Reading Race game had a total of 18 levels of play of increasing difficulty. Game difficulty was determined by the type of words offered (i.e., CVC, cluster, or disyllabic) and the number of semantic categories offered to the player to choose from (i.e., two, three, or four). The first nine levels included only real words; the second nine levels included both real words and pseudowords, which changed the task (i.e., required lexical decision instead of semantic categorization) and made the task more complex. After every four levels, the type of vehicle being driven also changed from a submarine to start with, to a car, then to a helicopter, and finally to a rocket. In this manner, children got higher and higher which reflected their progress in the game. For levels 17 and 18, the vehicle remained a rocket. Along with the changing vehicle, the environment changed as well.

For each of the 18 levels of play, the child plays *games* that consist of 24 items. When 2 semantic categories are presented, 12 items from each category were supplied; when 3 semantic categories were presented, 8 items from each category were supplied; and when 4 categories were presented, 6 items from each category were supplied. The categories varied across games but never within a game. Within a specific level of Reading Race, participants played 4, 5, or 6 games. This amount was based on an algorithm that calculates growth in speed of the fourth, fifth, and sixth game relative to the mean speed for the previous games within that level. In this way, children progressed to the next level only after improving their mean reading speed multiple times. For this study, the maximum amount of games within a level was capped at six. Each level started with a practice race [*Oefenrace* in Dutch], which established the baseline for the algorithm of that level.

Across the 18 levels of the race, the format of the presentation for the items varied. There was a standard stimulus presentation, a flashcard stimulus presentation, and a presentation that was preceded by an onset prime. These different presentation formats were included in order to be able to compare conditions within the game but will not be considered further in the present paper.

Playing of the game. Participants were instructed to control the orange vehicle and race against the grey vehicle. The gray vehicle proceeded at the speed of the child's personal average reading rate for the level being played. In this way, the participants were repeatedly challenged to slightly improve their own reading rates.

Players had to categorize the presented items as quickly and accurately as possible by dragging and dropping the items to the correct semantic category. The goal was to be faster than the gray vehicle (own average) in doing this and also collect points and stars along the way. Correct and incorrect answers induced both

A

B

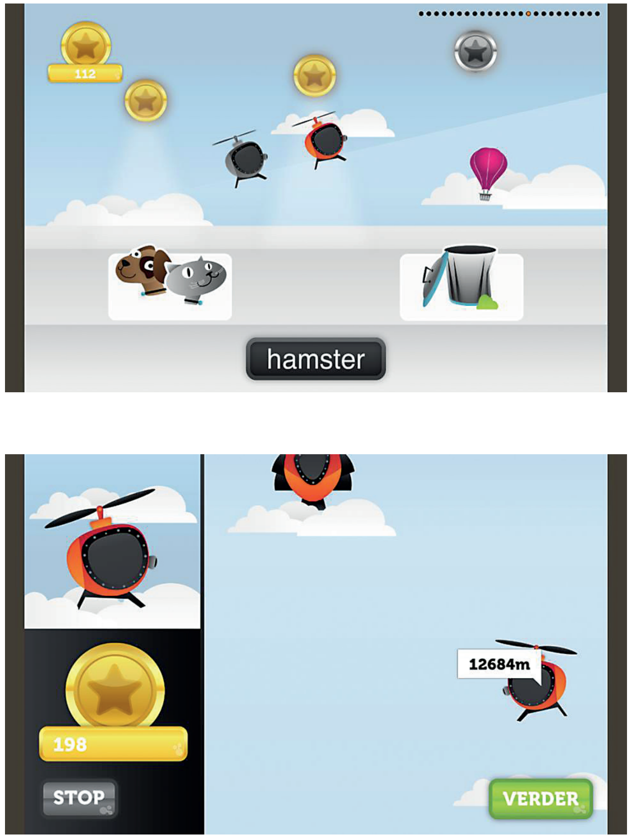

Figure 5.2 The picture above (**A**) is an example of the game.
The word is presented in the black box at the bottom of the screen (*hamster*) and the child has to drag and drop this word into one of the two possible categories (*animals* or *garbage/pseudowords*). When the correct answer is given, the orange vehicle (helicopter) races on (**A**). The speed of the grey vehicle proceeds at the rate of the player's personal average speed. Both points and stars can be earned with the amount related to reading speed. After 24 items, the player sees screen **B**, which visualizes the player's vehicle, how many points have been collected in the game (198), how many points have been collected in total (12684), and which vehicle he/she will become (rocket) after more practice. The player can either stop here or continue (Dutch: *verder*).

visual and auditory feedback. For incorrect responses, the feedback was accompanied by the correct pronunciation of the item. In the case of monosyllabic items, the stimulus was spelled out and read aloud as a whole. In the case of disyllabic items, the stimulus was syllabified and then read aloud as a whole. After the receipt of such feedback, the player had to drag the item to the correct category and could then continue with the game.

When 24 items were correctly dragged and dropped, the children were presented a screen that showed their progress (see Figure 5.2b). In this progress screen, the children could see how many points they scored in the game just completed. This game total was transformed into *meters* and added to the participant's total score, which was also visible. The more *meters* scored, the higher the participant moved up in the race and the higher the type of vehicle controlled, as described above). The participant was also given the option to stop or continue to the next game in the progress screen.

Study procedure

All of the participating children were first administered the pretest measures. During pretesting, all of the children played their first game on the tablet. The experimenter provided instructions and asked the children after doing this if the goal of the game was clear. The teachers in the classes were next instructed on how to use the tablets and to start the game, how often to have the children play, and how long they should have the children play.

The children were expected to play the game four days a week for a duration of 15 minutes across a period of five weeks. This totaled to 5 hours of game play. If the children finished all 18 levels of the race, they could start over again. By doing this, the total number of gameplay hours was kept constant across participants.

Halfway through the intervention, the experimenter visited the schools to check that the intervention was being conducted as instructed. If teachers had questions, they could contact the experimenter throughout the intervention period. After the intervention, it was also checked that the children had practiced as often as instructed. The data stored on the tablets showed all of the children to have practiced 18 times on average (M = 18.40, sd = 4.89).

In addition to pretesting, both directly before and directly following the intervention, the word decoding task was administered by the experimenter. This task was also administered five weeks after the intervention. For the children in the waiting control group, the task was similarly administered five weeks prior to the intervention. When the intervention was completed, both the children and teachers were asked their opinion about the game and task.

Results

In Table 5.1, the mean scores on the six word lists for the two groups of children on the different measurement occasions are displayed. In Figure 5.3, the mean scores of the two groups of children on the six Word Lists are depicted.

Intervention effects for the experimental group

To measure the effect of the intervention for the experimental group, a repeated measures ANOVA was conducted with Measurement (M1, M2), Word Type (Words, Pseudowords), and Complexity (CVC, Cluster, Disyllabic) as within-subjects variables; Group (Experimental, Waiting Control) as the between-subjects variable; and the mean reading efficiency scores of the children as the dependent variable.

A significant three-way interaction of Measurement x Complexity x Group, $F(2,116) = 11.72$, $p < .001$, $\eta^2_p = .17$ was found. This indicates that the number of simple items read correctly in one minute by the participants increased more than the number of complex items and a stronger such effect for the experimental group than for the waiting control group. All of the relevant two-way interactions were significant as well. Measurement x Complexity, $F(2,116) = 39.88$, $p < .001$, $\eta^2_p = .41$, showed the total number of simple items read correctly to increase upon subsequent measurement more than the total number of complex items. Complexity x Group, $F(2,116) = 6.26$, $p < .01$, $\eta^2_p = .10$, showed the experimental group to be stronger on the reading of simple words than the waiting control group. Measurement x Group, $F(1,58) = 36.76$, $p < .001$, $\eta^2_p = .39$, showed the experimental group to generally improve more than the waiting control group.

A significant two-way interaction of Measurement x Word Type was found as well, $F(1,58) = 27.28$, $p < .001$, $\eta^2_p = .32$. This interaction showed the increase in the number of words read correctly per minute to be stronger than the increase in the number of pseudowords read correctly per minute from M1 to M2. There was also a significant two-way interaction of Word Type x Complexity, $F(2,116) = 55.89$, $p < .001$, $\eta^2_p = .49$, indicating that the difference in decoding efficiency for words versus pseudowords was larger on simple than on complex items. No other interaction effects were found.

Main effects of all four independent variables were found. The effect of Measurement, $F(1,58) = 137.54$, $p < .001$, $\eta^2_p = .70$, showed reading efficiency to be higher on M2 than on M1. The effect of Word Type, $F(1,58) = 213{,}39$, $p < .001$, $\eta^2_p = .79$, showed higher decoding efficiency for words than for pseudowords. The effect of Complexity, $F(2,116) = 643.44$, $p < .001$, $\eta^2_p = .92$, reflected simple items being read more efficiently than complex items. And the effect of Group, $F(1,58) = 6.40$, $p = .01$, $\eta^2_p = .10$, indicated that the experimental group outperformed the waiting control group.

Table 5.1 Mean Number of Items Read per Minute for Six Word Lists on Four Measurement Occasions for Experimental versus Waiting Control Groups (standard deviations in parenthesis)

	CVC Words	Cluster Words	Disyllabic Words	CVC Pseudo	Cluster Pseudo	Disyllabic Pseudo
Measurement 1						
Experimental Group	39.52 (10.99)	25.81 (9.53)	11.94 (5.67)	29.39 (9.20)	16.55 (6.80)	7.39 (3.64)
Waiting Control Group	34.71 (13.71)	21.71 (10.54)	10.10 (5.59)	24.84 (10.12)	13.71 (5.95)	5.97 (3.54)
Measurement 2						
Experimental Group	50.93 (13.24)	33.41 (11.54)	15.62 (6.29)	37.52 (11.54)	20.52 (7.31)	9.97 (4.54)
Waiting Control Group	39.87 (13.99)	25.26 (11.06)	11.65 (6.42)	26.42 (10.76)	15.06 (7.41)	6.74 (4.27)
Measurement 3						
Experimental Group	54.27 (13.74)	36.43 (13.21)	19.00 (9.37)	40.20 (12.18)	23.27 (8.57)	12.83 (4.76)
Waiting Control Group	48.81 (17.47)	31.03 (13.24)	16.03 (8.73)	32.26 (11.64)	19.90 (9.53)	9.87 (5.63)
Measurement 4						
Waiting Control Group	51.58 (18.46)	33.32 (14.61)	18.45 (9.56)	33.87 (15.08)	22.00 (10.08)	11.68 (5.68)

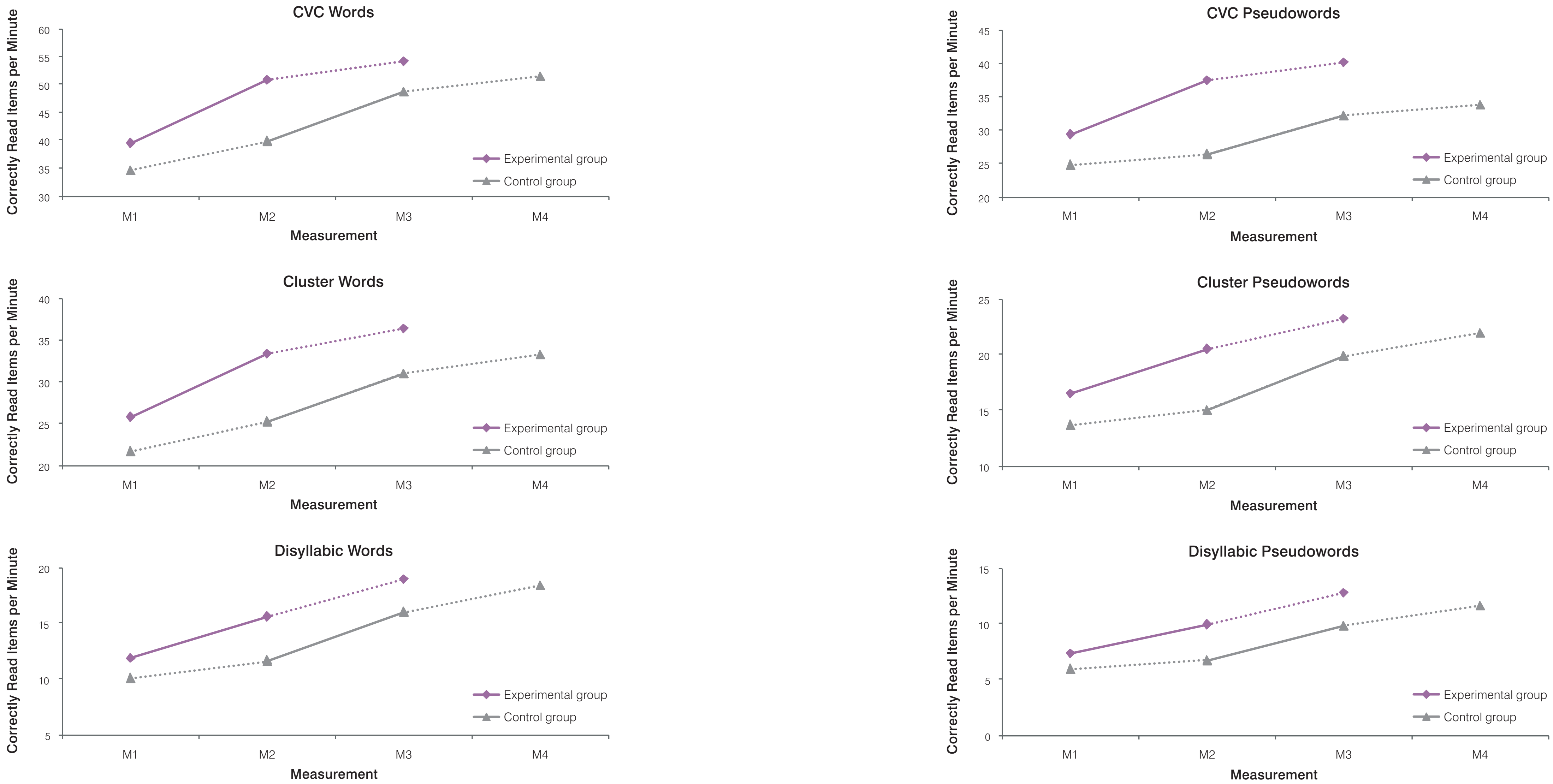

Figure 5.3 Mean Scores for Experimental Versus Control Groups on Six Word Lists. Solid lines represent the period in which the intervention took place. Dotted lines represent the periods before and after the intervention. For the Experimental Group, there were only three measurement occasions (M1 to M3); for the Waiting Control Group, there were four measurement occasions. The number on the y-axis represents the mean number of items read correctly in one minute.

Table 5.2 F-values for Main and Interaction Effects from ANOVAs on Six Word Lists Showing Difference in Growth of Word Decoding Efficiency between Experimental and Waiting Control Groups when Experimental Group received Intervention.

	df	F	p	η^2_p
CVC Words				
Measurement	1,58	115.40	< .001	.67
Group	1,58	5.36	.02	.09
Measurement x Group	1,58	18.77	< .001	.24
Cluster Words				
Measurement	1,58	66.63	< .001	.54
Group	1,58	4.92	.03	.08
Measurement x Group	1,58	9.62	< .01	.14
Disyllabic Words				
Measurement	1,58	29.27	< .001	.34
Group	1,58	3.95	.06	.06
Measurement x Group	1,58	5.53	.02	.09
CVC Pseudowords				
Measurement	1,58	49.59	< .001	.46
Group	1,58	8.47	< .01	.13
Measurement x Group	1,58	24.45	< .001	.30
Cluster Pseudowords				
Measurement	1,58	39.67	< .001	.41
Group	1,58	5.06	.03	.08
Measurement x Group	1,58	12.52	< .01	.18
Disyllabic Pseudowords				
Measurement	1,58	18.80	< .001	.25
Group	1,58	5.40	.02	.09
Measurement x Group	1,58	6.46	.01	.10

In Table 5.2, the statistics for the main effects of Measurement and Group together with the interaction of Measurement x Group are presented for each of the six word lists separately. All of the main and interaction effects were significant. The significant interaction shows the progress of the Experimental Group from M1 to M2 (after intervention) to be larger than the progress of the Control Group (waiting for intervention).

Intervention effects for the waiting control group

To determine if the participants in the Waiting Control Group increased as much as the participants in the Experimental Group after both had received the intervention, we compared their progress from before to after intervention. A repeated measures ANOVA with Measurement (Before Intervention, After Intervention) (M1, M2 for Experimental Group; M2, M3 for Waiting Control Group), Word Type (Words, Pseudowords), and Complexity (CVC, Cluster, Disyllabic) as the within-subjects variables and Group (Experimental, Waiting Control) as the between-subjects variable was performed on the children's mean reading efficiency scores.

Table 5.3 shows large effect sizes for the growth of reading efficiency as a result of the intervention for both groups. We report only the interaction of Measurement x Group because this suggests differences in the progress of the two groups.

A significant three-way interaction of Measurement x Complexity x Group, $F(2,116) = 5.27$, $p = .01$, $\eta^2_p = .08$ was found. Follow-up analyses for each level of Complexity (CVC, cluster, disyllabic) were performed and showed a significant Measurement x Group interaction for the CVC items in particular, $F(1,58) = 5.36$, $p = .02$, $\eta^2_p = .09$: The growth in the Experimental group was larger than that in the Control group. For the cluster items, there was no interaction effect, $F(1,58) = 0.62$, $p = .44$, indicating that the growth of decoding efficiency on the cluster items was equally high for both groups. For the disyllabic items, there was also no interaction effect, $F(1,58) = 0.10$, $p = .75$. There were no other interaction effects for Measurement x Group.

Retention effects for the experimental and waiting control groups

To measure retention of trained reading efficiency five weeks after completion of the intervention, a repeated measures ANOVA with Measurement (After Intervention, Retention) (M2, M3 for Experimental Group; M3, M4 for Waiting Control Group), Word Type (Words, Pseudowords), and Complexity (CVC, Cluster, Disyllabic) as the within-subjects variables and Group (Experimental, Waiting Control) as the between-subjects variable was performed on the mean reading efficiency scores.

A significant three-way interaction of Word Type x Complexity x Group, $F(2,114) = 3.79$, $p = .03$, $\eta^2_p = .06$ was found. Follow-up analyses for each level of Word Type (words, pseudowords) were performed. For words, there was no Complexity x Group interaction, $F(2,114) = 1.65$, $p = .20$. For pseudowords, there was a significant Complexity x Group interaction, $F(2,114) = 4.21$, $p = .02$, $\eta^2_p = .07$. This interaction shows the difference between the two groups to be larger on CVC pseudowords than on Cluster or Disyllabic pseudowords. On average, the children in the Experimental Group correctly read more CVC pseudowords than the children in the Waiting Control Group. No significant interactions with Measurement and Group were found, indicating that the level of retention was similar for the two groups. Also, no other interaction effects were found. Main effects of all three of the within-subject variables

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Table 5.3 F-values and Effect Sizes for Intervention from Repeated Measures ANOVAs on Six Word Lists for both Experimental and Control Groups Separately. Growth Effect Sizes are Large in Both Groups after Receiving Intervention.

	df	F	p	η^2_p	d
CVC Words					
Experimental Group	1,28	106,68	< .001	.79	0.94
Waiting Control Group	1,30	40.45	< .001	.57	0.56
Cluster Words					
Experimental Group	1,28	60.09	< .001	.68	0.72
Waiting Control Group	1,30	22.68	< .001	.43	0.45
Disyllabic Words					
Experimental Group	1,28	25.93	< .001	.48	0.61
Waiting Control Group	1,30	36.13	< .001	.55	0.57
CVC Pseudowords					
Experimental Group	1,28	59.02	< .001	.68	0.78
Waiting Control Group	1,30	43.54	< .001	.59	0.52
Cluster Pseudowords					
Experimental Group	1,28	43.59	< .001	.61	0.56
Waiting Control Group	1,30	44.79	< .001	.60	0.57
Disyllabic Pseudowords					
Experimental Group	1,28	19.04	< .001	.41	0.63
Waiting Control Group	1,30	57.09	< .001	.66	0.63

on retention were found: Measurement, $F(1,57) = 17.78$, $p < .001$, $\eta^2_p = .24$; Word Type, $F(1,57) = 276.14$, $p < .001$, $\eta^2_p = .83$; and Complexity, $F(2,114) = 654.83$, $p < .001$, $\eta^2_p = .92$. The main effect of Measurement shows the reading efficiency of the children to continue to improve even after completion of the training. The main effect of Word Type shows more words than pseudowords to be generally read correctly. The main effect of Complexity shows more simple words to be read correctly than complex words. There was no main effect for Group ($F < 1$), which shows the retention of the two groups to be similar.

Finally, for the Waiting Control Group, the increase in reading efficiency from after the intervention to retention (M3, M4) could be compared to the increase in reading efficiency from prior to the intervention to the start of the intervention (M1, M2). There were no significant differences in the development of the children's word decoding efficiency in these periods, as indicated by the absence of Measurement x Task interaction (M1 to M2, M3 to M4), $F(1, 30) = 1.21$, $p = .84$, $\eta^2_p = .001$.

Discussion

In the present study, we investigated the effectiveness of having poor readers play a word identification game designed to increase word decoding efficiency in second grade. During the training, the children practiced reading words and pseudowords, and making semantic categorizations of the words they read. Word decoding was assessed by asking the children to read six word lists containing untrained words and pseudowords as quickly and accurately both directly before and after the intervention. To measure retention of any training effects, the word decoding task was also administered five weeks following completion of the intervention.

Our overriding research question was whether the motivational game could enhance word decoding efficiency of poor readers of Dutch in second grade. Indeed, the game was effective in reaching transfer effects to untrained items. We found greater improvement of word decoding efficiency on all six word lists when the experimental group was compared to the waiting control group. These intervention effects were retained five weeks later, moreover. The training was effective for both the decoding of words and pseudowords although a greater increase was observed for words than for pseudowords and for simple (i.e., CVC) items than for more complex (i.e., cluster and disyllabic) items. This implies that all our hypotheses were confirmed.

The word identification game used here enhanced reading efficiency in poor readers as reflected by the transfer effects for untrained items presented in a different task (i.e., a read-aloud as opposed to silent reading task). In previous repeated word reading studies, transfer effects have usually been found to be small or limited to specific types of items. In the current study, the transfer effects were large. The large transfer effects reported here can be ascribed to the three factors cited in our review of the literature as important in addition to repeated reading practice: the inclusion of feedback, the use of semantics, and the motivation of the participant. The inclusion of feedback has been shown to be crucial in both other repeated reading studies (e.g., Huemer et al., 2010; van Gorp et al., 2014) and game-based learning studies (Kiili, 2005).

With regard to semantics, Duff and Hulme (2012) found imageability and prior semantic knowledge of words to be important for the accuracy of word reading. Semantic knowledge has also been found to enhance the consolidation of words (Henderson et al., 2013). The items that we used for training purposes were highly imageable, and semantic knowledge of the words was necessary to complete the training task. We know from studies of poor readers that they struggle with the link between phonology and orthography (Bowers & Wolf, 1993) but Nation and Cocksey (2009) showed 7-year-olds to also use access semantics directly from orthography. In the study by Wang et al. (2013), moreover, the importance of semantics was found to be even stronger for irregular reading items. When the link between orthography

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and phonology is weak, that is, semantics may play a bigger role. And when the link between orthography and phonology is weak in children with poor reading skills, it may thus be the case that they will especially benefit from the inclusion of semantics during their training. Our finding of a significant difference in the growth of decoding efficiency for words versus pseudowords may also be explained by the inclusion of semantics, which has no added value for the reading of pseudowords.

Finally, the inclusion of a motivational component in the intervention used in our study may also account for the large reading gains. Computerized reading intervention has been found to be more effective than regular intervention with a tutor (Saine et al., 2011). And motivation and engagement can be assumed to play an important role in the effectiveness of digital training (Killi, 2005; Ronimus et al., 2014). In the present game, the children competed with their "average self", making it possible for them to improve during each game. They were not confronted with the reading speed of peers and therefore only had to try to improve their own speed. When comparing their final scores to those of their peers, moreover, they could accumulate just as many points as those who were better readers. This experience of winning can help children stay motivated (Kiili, 2005). And indeed, all of the children participating in our study reported really having fun and enjoying the intervention. The use of a computer tablet also provides a safe learning environment in the sense that no one is present to notice any mistakes that are made and make the children therefore feel uneasy. In all we can conclude that the motivational game that we used in this intervention study was effective at enhancing decoding efficiency.

There are several directions for future research to take in light of the present findings. Future research might try to unravel the combination of feedback, semantics, and motivation in order to be able to pinpoint which components or combination of components are responsible for the elicited transfer effects. In the present study, this was not possible. In future research, possible individual differences in the intervention effects and retention effects might also be taken into consideration. Children may respond differently to digital interventions and some be more resistant to interventions than others. Whether or not this was the case in the present study cannot be determined, but individual variation in responsivity to reading interventions along the lines of the one used in the present study should be studied in the future.

Our results have promising implications for both education and the development of training interventions. Children with poor reading skills were shown to be able to independently improve their word decoding skills by simply playing a word identification game for a total of five hours spread across a period of five weeks. No parent, teacher, or experimenter sat next to the children during their training. Teachers do not have time these days to help the children in their classes individually, which means that solutions must be sought like using a tablet for practice and interventions as in the present study. In sum, we can conclude that the motivating word identification game used in the present study improved the word decoding efficiency of poor second-grade readers. Large effects of the intervention for both simple and complex words but also pseudowords were found. The children enjoyed the game and did not see it as training but as gaming. And the game can be played without adult supervision, which makes it more attractive for both home and classroom use than many other reading interventions.

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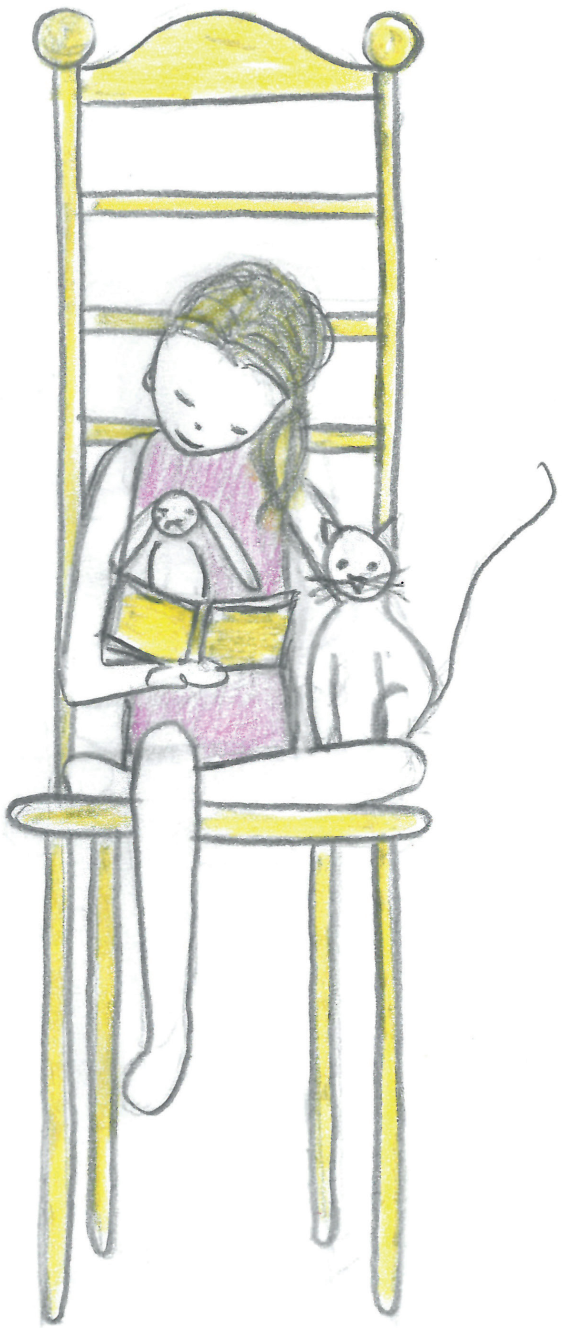

6

General discussion

The aim of the present dissertation was to provide insight into how word reading fluency in beginning poor readers of Dutch can be enhanced by means of computer reading interventions. The first research question was what the role of repetition in combination with feedback would be in increasing word reading fluency. The second research question was whether priming could enhance reading fluency in beginning readers. The third and final research question was to what extent reading fluency could be enhanced by means of a computer reading intervention in which repetition, feedback, priming, speed, semantics and motivation were included. In this chapter, the answers to these questions will be discussed in light of word reading theories, followed by limitations and suggestions for future research and implications for educational practice.

The effect of repetition and feedback

Research on the improvement of word reading fluency has shown that repetition, and in particular repeated word reading, is effective in improving the speed of reading of trained words (Kuhn & Stahl 2003; Therrien, 2004; Wolf & Katzir-Cohen, 2001). When looking at developmental models of reading, it is clear that repetition is key in improving word reading fluency. During of repeated practice, children can provide themselves with feedback and by doing so they strengthen the lexical representations of the learned words. To make word reading efficient, it is important that the improved reading fluency on trained items also transfers to untrained items. To date, most repeated reading interventions have not succeeded in reaching this goal (Berends & Reitsma, 2006). This could be due to the fact that these studies did not include corrective feedback. Indeed, most of the repeated reading studies that reported transfer effects (Heikkilä, Aro, Närhi, Westerholm, & Ahonen, 2013, Huemer, Aro, Landerl & Lyytinen, 2010; Steenbeek-Planting, Van Bon, & Schreuder, 2012) did include immediate corrective feedback. Even though these trainings all incorporated immediate feedback, none of them investigated the specific effects of the inclusion of feedback. From research on what makes computerized interventions effective in general, it is known that feedback plays a crucial role (Kiili, 2005). Based on these lines of evidence, it was thus likely that the incorporation of feedback in a computerized repeated word reading intervention would be beneficial for the learners.

The effect of repetition combined with feedback was examined in Chapter 2 and Chapter 3. In Chapter 2, two types of feedback were compared. Half of the participants received short corrective feedback (e.g., 'correct, cat') and the other half of the participants received extensive corrective feedback (e.g., 'correct, cat, c-a-t, cat'). Participants were kindergartners with partial alphabetic knowledge who knew how to read words. Twenty-five words and 25 pseudowords were read repeatedly during 10 sessions. Children received feedback on all responses, regardless of the correctness. Prior to and immediately following the training reading speed and accuracy of untrained items were measured. Two weeks following the training, retention of the trained items was measured. It was shown that repeated word reading combined with feedback is indeed effective. On top of direct and retention effects, transfer effects to untrained items were established. There were no differences between the two conditions of feedback, indicating that the extensiveness of feedback (with or without spelling out the word) did not matter in this group of readers.

In Chapter 3, it was examined what the contribution of feedback was to these positive effects. Here the effects of short and extensive feedback were compared to no feedback in good reading (i.e., 25% best scoring on a standardized decoding task) and poor reading (i.e., 25% lowest scoring) first graders. The used paradigm was the same as in Chapter 2. In line with the results of Chapter 2, direct and retention effects were found for both good and poor readers. Transfer was only found for pseudowords, while in Chapter 2 transfer was also found for words. A possible explanation could be that the words used for the transfer task were too simple and already stored in the orthographic lexicons of the participants. It can be assumed that these known, transparent words are read via the direct route, leaving little room to improve. Transfer to pseudowords does, however, indicate that the participants have become better at phonological recoding and therefore at reading via the indirect route. As in Chapter 2, the condition (short feedback, extensive feedback, no feedback) and thus the amount of feedback had no differential effect on reading speed. However, during the intervention, good readers performed most accurate without feedback and poor readers performed most accurate with extensive feedback. This indicates that the inclusion of immediate extensive feedback is effective at enhancing word reading accuracy in poor readers. Word reading fluency can be seen as a product of reading speed and accuracy, hence it can be concluded that reading efficiency in poor readers was highest when they received extensive feedback.

The present dissertation thus evidenced in two studies that transfer effects can be established by implementing repeated reading interventions. Feedback, and in particular feedback that includes processes that take place in the non-lexical route of reading, is helpful in enhancing word reading accuracy in poor beginning readers.

The effect of priming

Next to the effect of repetition and feedback, the effect of phonological priming in beginning readers was examined. Priming has been found to reduce response or reading times and increase accuracy for the target items in children before. These effects have, for instance, been found for altered letter priming (rlay – PLAY) and transposed letter priming (lpay – PLAY). There is evidence that these priming effects enhance word reading in beginning readers of both opaque (Castles, Davis, Cavalot, & Forster, 2007) and more transparent (Lété & Fayol, 2013) orthographies. This suggests that beginning readers are susceptible for these very subtle cues that enhance word reading.

In Chapter 4, onset priming with whole word primes (e.g., trick – TRAIN) and part word primes (e.g., tr – TRAIN) was examined in a lexical decision task. The results of experienced, adult readers were compared to those of beginning readers in second grade. In previous studies on onset priming during silent reading, no priming effect for the experienced readers was found (e.g., Grainger & Ferrand, 1996). This is likely due to the fact that onset priming either reflects indirect processing or speech planning. Experienced readers do neither of these during silent reading, whereas children presumably do. And indeed, in Chapter 4 onset priming for beginning readers, and not for experienced readers, was evidenced; priming effects in terms of increased speed and increased accuracy levels were reached for the beginning readers. The effect was larger when the target was preceded by only an onset consonant cluster (such as tr - TRAIN) as compared to whole words containing the same onset consonant clusters (trick - TRAIN). This difference is probably due to lexical competition in the latter prime type.

These data revealed that onset priming is effective in beginning readers in that they responded more accurately and faster when words were preceded by a prime containing a similar onset. These results implicate that beginning readers make use of the presented primes which in turn results in faster and more accurate reading. Primes may help the children to apply a ‘from left to right’ reading strategy, which corresponds with the indirect route of reading. It can next be hypothesized that onset primes will also help to enhance word reading efficiency in a classroom-based reading fluency intervention using word repetition and feedback (as was used in Chapters 2 and 3).

Reading fluency intervention

The ultimate goal of the present dissertation was to find out to what extent reading fluency could be enhanced by means of a computer reading intervention. The studies described above give a firm basis for a blueprint of a potentially successful intervention game to strengthen the connections between orthography, phonology and semantics in order to enhance word reading fluency. Such a game would need three components: repetition, immediate corrective feedback, and onset priming. As is shown in both the dual route cascaded (DRC) model of reading aloud (Coltheart, Rastle, Langdon, Perry, & Ziegler, 2001) and the triangle model (e.g., Plaut, McClelland, Seidenberg, &

Patterson, 1996) and as is also evident from the lexical quality hypothesis (Perfetti, 1992; Perfetti & Hart, 2002), representations are stronger the more orthography, phonology and semantics are integrated. Speed is not only an outcome variable, but also a factor that could contribute to enhanced word reading speed. Breznitz and Berman (2003) found that if reading speed was increased externally, forcing the children to read at a faster pace than their preferred pace, this resulted in an increase of accuracy and comprehension. Another critical factor in enhancing word reading fluency is motivation. Research by Kiili (2005) has shown that motivation improves the flow of the game and thus adds to the effectiveness of game-based interventions. Motivation may be a crucial factor, especially in reading fluency interventions for poor readers. Repeated reading can be quite boring, and the motivation of poor readers to decode isolated words can expected to be low (Polychroni, Koukoura, & Anagnostou, 2006). In developing a game aimed at enhancing word reading fluency in poor beginning readers, it is thus key that these children keep on being motivated.

In the intervention as described in Chapter 5, children practiced with reading words while making decisions on the semantics of the word. These semantic decisions either were lexical decision tasks ("Is it and existing word or not"), semantic categorization tasks ("Is the word an animal or a part of the human body?") or a combination of these two tasks. Speed was increased externally since children were encouraged to increase their own reading pace time after time in order to win the game. Motivation was kept high by providing children with rewards, motivational comments, and adaptive exercises.

During the game, children practiced with categorizing words and pseudowords. The items differed in their complexity, from CVC items to disyllabic items. The number of categories to choose from also differed, from 2 to 4. Children practiced 4 times a week for 15 minutes for the duration of five weeks. During a session of 15 minutes, children could play several games. After each game of 24 items, they could see their progress. Prior to and directly following the intervention, as well as five weeks following the intervention, transfer was assessed. The transfer task was different from training with regard to two aspects: first, only untrained items were assessed, second, decoding efficiency rather than word identification skills were assessed. By means of a waiting-control-group design, all 62 subjects practiced with the game. For both groups of subjects large transfer effects on all six different word lists were established after only five hours of practice. These effects were also retained five weeks following the training. Considering the large transfer to a different task and to different items it can be concluded that the use of repetition, feedback and priming in a motivational context in the present game was effective at enhancing decoding efficiency in poor beginning readers.

Basic principles for enhancing word reading fluency

To date, teachers and scientists are struggling to find effective methods to enhance reading fluency in poor reading children. As was stated in the introduction of this dissertation, word reading can be considered fluent when it is both accurate and fast (Wolf & Katzir-Cohen, 2001). Poor readers struggle to reach this word reading fluency, which ultimately also affects their reading comprehension. It is thus crucial that poor word reading fluency gets enhanced. In previous research, it has become clear that it is rather easy to enhance word reading fluency of trained items but more difficult to find methods that, in addition to trained words, enhance word reading fluency of untrained items as well. In the studies of the present dissertation, it was evidenced, however, that this overall reading fluency can be enhanced, even in poor beginning readers. In Figure 6.1, it is depicted which components are likely to have contributed to this enhanced reading fluency. These components are discussed in more detail below.

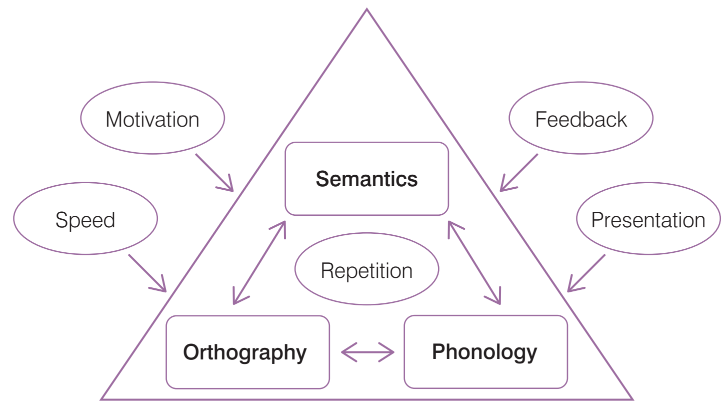

Figure 6.1 Basic Principles for Enhancing Word Reading Fluency.

At the bottom of Figure 6.1, the components of orthography and phonology are depicted. These two components together constitute word decoding. Word reading can be simplified as the recognition of different graphemes (orthography), which need to be translated to different phonemes (phonology). According to the double deficit hypothesis (Wolf & Bowers, 1999), both phonological awareness and naming speed can be affected in poor readers. Hence, to enhance word reading fluency in this group of readers, the emphasis needs to be not only on the separate components (orthography and phonology) but also on the link between them.

In the same triangle at the bottom of Figure 6.1, the third component of a word is represented: semantics. A word not only has a written and a spoken form, but it also has a meaning. This third component is also present in current models of word reading such as those of Coltheart et al. (2001) and Plaut et al. (1996). Semantics is a very important aspect of reading. One could see the two components orthography and phonology together as word decoding and orthography, phonology and semantics together as word identification. And this word identification in turn can be seen as the path to comprehension; the ultimate goal of reading. In Chapter 5, it was evidenced that a paradigm in which this word identification was practiced, general word decoding skills were increased. The inclusion of semantics is likely to have strengthened the lexical quality of the trained items. Perhaps the participants have learned to use the direct link from orthography to semantics to get to phonology, which in turn has led to more efficient decoding. In the present dissertation it was not examined what the exact role of semantics was in the intervention, however, contemporary models of word reading underline the importance of this third component of word reading.

As depicted in Figure 6.1, there are also multiple factors outside the triangle of word reading that enhance word reading fluency. The first of these factors is repetition; a factor which increases the strength of the link between phonology and orthography. Share (2004) has shown that in good beginning readers four encounters of a written word can be sufficient to automatize the link between orthography and phonology. That is, if a written word is being encountered for the fourth time, children can directly access the phonological representation. In the dual route model of reading (Coltheart et al., 2001) this can be depicted as moving from the indirect route to the direct route of reading. In poor readers four repetitions are not sufficient to reach this automaticity. Nonetheless, repetition is effective in reaching higher reading speed and accuracy in this group of readers, as was evidenced in Chapters 2, 3 and 5.

The second factor that can influence training of word reading is motivation, which is likely to interact with several of the other factors. Since repetition is required, in particular for poor readers, reading interventions can be quite laborious and thus boring. Therefore, it is important that participants are being engaged to participate. However, it is known that reading motivation in poor readers is lower than in their peers (Polychroni et al., 2006). Also, it is assumed that reading motivation and poor reading skill affect each other bi-directionally (Morgan & Fuchs, 2007).

Thus, on the one hand, poor readers struggle with low intrinsic reading motivation. On the other hand, however, research has shown that computerized interventions can provide external motivation (e.g., Saine, Lerkkanen, Ahonen, Tolvanen, & Lyytinen, 2011). Saine et al. found computerized intervention aiming at improving letter and word recognition to be more effective than regular classroom interventions without the help of a computer. Kiili (2005), however, stated correctly that just the help of a computer is not enough to motivate children who have grown up using computers.

He found that effective game-based interventions have three important features: a reward system, positive feedback, and increasing difficulty. In Chapters 2 and 3, children received positive feedback on all correct responses and at the end of each block of 25 items (words or pseudowords). Moreover, they received a sticker as reward after each session. The difficulty in these interventions did not increase. In Chapter 3, the good readers indicated that the intervention was indeed 'boring'. In Chapter 5 we incorporated all the factors as suggested by Kiili (2005) in an app; children received points for correct answers and they could collect stars if they were relatively faster than during previous games. Moreover, the items within games were of similar difficulty, but the levels increased in difficulty in order to continuously challenge the participants. Even though it was not possible to disentangle the contribution of external motivation to the app studied in Chapter 5 from other contributors, it is likely to have added to the obtained effects and hence is found to be effective at enhancing word reading fluency.

The third factor is the form of presentation of the word, which mainly affects orthography and hence the link between orthography and phonology. From remedial practice it is known that flashcard training is effective at improving word reading fluency. In this type of exercise, a word is written on a card and each card is presented for a short period of time (usually a second). The child then has to name the word as soon as possible. This type of exercise has also been computerized and this has been shown to improve comprehension (Tan & Nicholson, 1997) and to transfer the increased reading speed to untrained items (Van den Bosch, van Bon, Schreuder, 1995). Presenting the target word for a limited amount of time can thus help to increase decoding fluency. Another method that has been shown to effectively increase word reading speed and accuracy in this thesis was onset priming in Chapter 4. In addition to a regular presentation, items in the app in Chapter 5 were alternatively presented in a flashcard or priming manner. It is likely that these presentation forms have added to the effect of enhanced word decoding efficiency.

A fourth factor that is likely to have a positive effect on the enhancement of reading fluency is speed. Here, speed is not referred to as an outcome measure but as an independent variable, as suggested by Breznitz and Berman (2003). By forcing the participants to answer within a limited time frame, or to read a word within a limited time frame, speed as an outcome measure is affected by speed as an independent variable. This was shown in a self-paced reading paradigm in which sentences needed to be read at a faster pace than the preferred pace (Breznitz & Berman). This increased reading pace did not only lead to lower error scores, but also to better comprehension of texts. In single word reading, flashcard methods have also revealed that the externally influenced response limit enhanced word reading fluency. In the app in Chapter 5, children were encouraged to read at an increasingly higher pace, in order to receive points, stars and level up.

The fifth and final factor that can enhance word reading fluency is feedback, which has been a prominent factor in this dissertation. In Chapter 2 feedback was on the link between orthography and phonology; after each word was named by the participant, the word was repeated by the computer and for half of the subjects spelled out in addition to repetition. In Chapter 3 it was examined whether it was indeed the feedback that was effective at enhancing word reading fluency on top of the effectiveness of repetition. It was shown that poor reading children responded more accurately when they received extensive feedback; i.e., feedback that spelled out the words. In Chapter 5 this extensive feedback was also included in the app, but only for incorrect responses. For correct responses, there was visual and auditory feedback to indicate correctness of the response. Feedback has been shown to be one of the components that enhance game flow (Kiili, 2005). The data of this thesis support this finding. Moreover, it can tentatively be assumed that proper and extensive feedback can help to strengthen the link between orthography and phonology and –as a result- enhance word reading fluency.

To sum up, the factors as depicted in Figure 6.1 all contribute to enhancing word reading fluency. A final point that has not been mentioned yet is the duration of interventions. Compared to most interventions aiming at enhancing reading skills in primary education, the interventions used in this thesis were relatively short (compare: Cheung & Slavin, 2013). The interventions in Chapter 2 and 3 lasted for 2 weeks and consisted of 10 sessions of approximately 10 minutes each. The intervention in Chapter 5 lasted for 5 weeks and consisted of 20 sessions of approximately 15 minutes each. The latter implies that a very small investment of only 5 hours can lead to a quite substantive increase in reading efficiency in beginning readers. It has been noticed before that good interventions do not need to take a lot of time (Nicolson, Fawcett, Moss, Nicolson, & Reason, 1999). Our data support this finding. More importantly, in the intervention of Chapter 5 the participants practiced without any help of a teacher or tutor.

Limitations and future directions

The research in the present dissertation has some limitations. The first limitation is that this dissertation has focused on the group effects of the interventions and priming experiments. The effects of individual differences have not been taken into account. This means that it has not been examined what the influence was of relevant child factors such as phonological awareness, vocabulary size, working memory capacity, naming speed, and speed of processing on the study outcomes. Since these individual differences were not taken into account, it cannot be concluded what factors caused participants to respond to the intervention. When these interventions will be used in practice, it is important to know for which children these interventions are likely to be successful and for whom these are not. Steenbeek-Planting et al., (2012) found, for instance, that some children benefit more from repeated reading of correctly read words, whereas others benefit more from repeated reading of words they read incorrectly? in previous occasions. Also, Torgesen (2000) found that word reading interventions had the least effect in children who had relatively low phonological skills at the start of the intervention. Torgesen also found that low socio-economic status and low attention as rated by teachers of children with low phonological skills resulted in lower benefits from reading interventions. In future research, it could be investigated which type of children respond to the intervention and which children do not.

A second limitation is that in this dissertation extended long-term effects have not been examined. Although in the intervention studies, retention measures were administered, the time between intervention and retention measurement was relatively short. In Chapters 2 and 3 retention was measured two weeks after the intervention, which lasted two weeks as well. Retention in Chapter 5 was measured five weeks after the intervention, which lasted five weeks as well. Even though it can be concluded that the effects last for several weeks after the interventions, it remains unclear what the effects are six months or a year later. Examining long-term effects would be particularly interesting for studies investigating the effects in poor readers. Since in Chapter 5 a large increase in reading fluency was evidenced, it would be interesting to see how this enhanced reading fluency develops over time. In the past, only few brief reading interventions have shown lasting effects (Cheung & Slavin, 2013). Moreover, it would be interesting to see if and how this increased reading speed transfers to reading sentences and texts and how this affects reading comprehension. These potential follow-up studies can be seen as interesting topics for future research.

Conclusions and practical implications

Based on the research presented in this thesis, it can be concluded that word reading fluency in beginning readers can be enhanced by repeated reading of words and pseudowords in combination with immediate corrective feedback. This combination was found to be effective in kindergartners, in good and poor reading first graders and in poor reading second graders. Based on the studies in Chapters 2 to 5, it was tried to come up with guidelines for interventions to be effective at enhancing word reading fluency.

For remedial practice, there is evidence that repeated reading of words is effective in enhancing word reading fluency in beginning readers. For poor readers, it is, however, important that they receive extensive immediate feedback, i.e., auditory feedback in which the relations between graphemes and phonemes are stressed. In Chapter 5, a motivating game which included repeated reading and semantic categorization was successful in enhancing word reading fluency in poor reading second graders. The fact that children practiced independently implies that a motivating game which is programmed to provide the children with the necessary feedback is able to enhance word reading fluency without the help of a parent, teacher, or tutor. But in order to be able to track the progress of these children, a teacher or tutor should either administer word decoding tasks to the children or track children's progress via the game itself. This also fits very well with adaptive learning in which children in classrooms learn individually and adaptive to their learning level. In this dissertation, it has been shown that word reading fluency can be enhanced, even in poor beginning readers. This is important since higher-order reading skills rely on this basic ability. The present thesis showed that word reading fluency can be enhanced by means of speeded semantic categorization of words while using repetition combined with proper feedback. It seems best to enhance this reading fluency early on, so that children benefit from it throughout their entire school career. Since reading motivation in poor readers is low, it is crucial that the intervention program is focused at keeping them motivated as well as at training them for the desired skill. In word reading fluency intervention, motivation can be kept high by including a reward system, by providing feedback and by offering increasingly difficult exercises.

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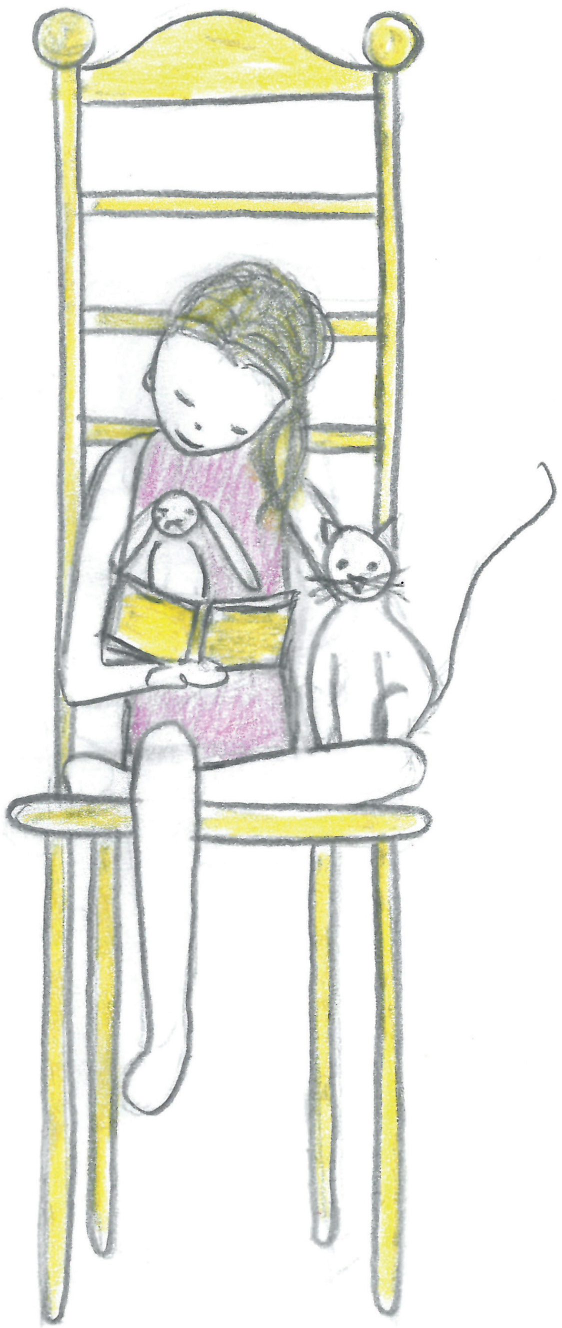

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Dankwoord

Curriculum Vitae

Samenvatting

Een van de belangrijkste vaardigheden die kinderen leren in het basisonderwijs is lezen. Aan het leren lezen van woorden wordt daarom ook veel aandacht besteed in de lagere groepen. In de hogere groepen is het belangrijk dat kinderen al goed woorden kunnen lezen om zo teksten te kunnen begrijpen. Zodra kinderen weten dat gesproken woorden uit klanken bestaan en geschreven woorden uit letters, kunnen ze leren hoe ze deze letters en klanken aan elkaar kunnen koppelen. In het begin gaat dit proces langzaam en lezen kinderen letter voor letter. In het Nederlands hebben de meeste letters maar een klank, uitzonderingen hierop zijn bijvoorbeeld de klinkers die lang of kort kunnen klinken en de letter *d* die aan het einde van het woord *hond* anders klinkt dan aan het begin van het woord *dier.* In bijvoorbeeld het Engels is deze relatie tussen letters en klanken aanzienlijk minder eenduidig. Zo lijken de woorden *though* en *tough* qua schrijfwijze erg veel op elkaar, maar wat betreft uitspraak (ðo en *təf*) helemaal niet. Omdat het in het Nederlands wel (relatief) eenduidig is, hebben de meeste kinderen weinig moeite met het **accuraat** leren lezen. Toch is er al direct vanaf groep 3 een grote variatie in leesvaardigheid tussen de leerlingen waar te nemen. Deze variatie komt met name door het verschil in **leessnelheid.** Dit verschil wordt waarschijnlijk veroorzaakt doordat **zwakke lezers** moeite hebben met het **automatiseren** van woorden lezen. Daar waar **goede lezers** na een aantal herhalingen van een woord overgaan van letter-voor-letter lezen naar het direct herkennen van woorden, blijven zwakke lezers vaak steken bij het letter-voor-letter lezen. Het spreekt voor zich dat dit tijdrovend is en op den duur ook ten koste gaat van leesbegrip. Het verschil tussen goede en zwakke lezers wordt bovendien in de loop der jaren steeds groter. Daarom is het van belang om met methodes te komen die deze zwakke lezers helpen bij het snel en accuraat lezen. In dit proefschrift is onderzocht hoe beginnende zwakke lezers geholpen kunnen worden bij het automatiseren. De volgende drie onderzoeksvragen stonden centraal:

1.) In hoeverre kan de leessnelheid van goede en zwakke beginnende lezers verbeterd worden door middel van herhaald lezen in combinatie met feedback?
2.) In hoeverre kan de leessnelheid van goede en zwakke beginnende lezers verbeterd worden door middel van priming van de eerste letters van een woord?
3.) In hoeverre kan een motiverende game, die gebruik maakt van herhaling, feedback en semantiek effectief ingezet worden om de leessnelheid van zwakke lezers te verbeteren?

Het effect van herhaald lezen en feedback op de leessnelheid

Uit eerdere onderzoeken is gebleken dat het herhaaldelijk aanbieden van een set woorden er voor zorgt dat zwakke lezers deze woorden sneller gaan lezen. Deze verbetering was echter vaak alleen specifiek voor die getrainde set woorden en niet voor het lezen van ongetrainde woorden. Een aantal studies liet deze **transfer** naar ongetrainde woorden wel zien. Een van de overeenkomsten binnen die studies was dat er naast herhaald lezen ook gebruik werd gemaakt van feedback, al dan niet door een computer gegeven. In hoofdstuk 2 van dit proefschrift is onderzocht of herhaald lezen in combinatie met feedback zou kunnen resulteren in het verbeteren van leessnelheid (en tevens ook de accuratesse) van ongetrainde woorden van goede lezers uit groep 2. Deze goede lezers waren als dusdanig bestempeld omdat zij al letterkennis hadden (wat geen onderdeel is van de lesstof in groep 2) en wisten hoe ze woorden moesten lezen. Deze kinderen kregen een training waarbij ze een vaste set met 50 woorden tien keer te lezen kregen. De set met woorden bestond voor de helft uit drieletterige Nederlandse woorden (zoals *kat*) en voor de helft uit drieletterige niet-bestaande woorden, ofwel **pseudowoorden** (zoals *lon*). Voor en na deze training werd het transfer effect gemeten door 50 woorden en pseudowoorden aan te bieden die niet tijdens de training werden getoond. In hoofdstuk 2 werd gekeken naar het verschil tussen korte feedback (waarbij alleen goed/fout werd aangegeven, gevolgd door de correcte benoeming van het woord) en uitgebreide feedback (waarbij het woord ook nog eens letter-voor-letter verklankt werd, terwijl de letters op het scherm oplichtten). Er werd tussen de condities geen verschil gevonden; het type feedback leidde niet tot andere resultaten. Wel werd er voor beide condities een transfer effect gevonden voor ongetrainde woorden; deze werden na de training sneller en meer accuraat gelezen dan daarvoor. De getrainde woorden werden bovendien ook twee weken na de training nog snel en accuraat gelezen.

In hoofdstuk 3 werd een onderzoek met dezelfde opzet uitgevoerd, maar dit keer bij zowel goede als zwakke lezers uit groep 3. Deze lezers waren als goed en zwak gedefinieerd op basis van een gestandaardiseerde woordleestaak. De goede lezers waren de 25% best presterende lezers en de zwakke lezers waren de 25% zwakst presterende lezers. Omdat uit hoofdstuk 2 niet bleek of feedback er inderdaad voor had gezorgd dat er transfer effecten waren, was er in hoofdstuk 3 een controlegroep die geen feedback ontving tijdens de training. Ook in deze studie werd gevonden dat de leerlingen (zowel goed als zwak) na 10 keer trainen de geoefende woorden sneller en meer accuraat gingen lezen. Dit leesniveau hielden de leerlingen opnieuw vast twee weken na de training. De transfer naar ongetrainde woorden werd echter alleen gevonden voor pseudowoorden. Waarschijnlijk werden deze effecten niet gevonden voor woorden omdat deze drieletterige woorden al te vaak gelezen waren door de leerlingen voor aanvang van de training, waardoor er geen of weinig verbetering mogelijk was. Dat betekent dat herhaald lezen met name effectief is voor nieuwe of onbekende woorden. In deze studie bleek bovendien dat het al dan niet ontvangen van feedback tijdens de training geen effect had op de leessnelheid van de leerlingen. Dit betekent dus dat feedback geen positief, maar ook geen negatief effect heeft op de leerwinst van de (zwakke) beginnende lezers.

Het effect van priming op de leessnelheid

Bij **priming** krijgt de lezer kort voordat hij of zij een woord gaat lezen wat informatie over het woord. Dit kan bijvoorbeeld op het gebied van betekenis zijn, waarbij iemand eerst het woord *dier* te lezen krijgt en daarna het woord *kat*. Dit kan echter ook fonologisch zijn, waarbij iemand eerst wat informatie krijgt over de klanken waaruit een woord is opgebouwd. Deze informatie, of prime, wordt slechts een fractie van een seconde aangeboden. Onset priming is een voorbeeld van fonologische priming en hierbij ontvangt de lezer al kort informatie over de **onset** van een woord. Deze onset bestaat uit, simpelgezegd, alle letters die vooraf gaan aan de eerste klinker van een woord. Voor het woord *kok* is de onset dus de letter *k* en voor het woord *klok* is de onset het medeklinkercluster *kl*. Deze prime kan congruent zijn (zoals *kl* voor *klok*) maar ook incongruent (zoals *kl* voor *groep*). Omdat de lezer in het geval van een congruente prime al informatie heeft over het woord, is deze over het algemeen sneller met lezen dan wanneer er een incongruente prime vooraf gaat aan het woord. Dit verschil in snelheid noemt men het priming effect. Omdat beginnende lezers woorden van links naar rechts lezen (letter-voor-letter) zou het logisch zijn dat zij sneller gaan lezen met onset primes. Dit effect was echter bij kinderen nog niet onderzocht.

Dit effect van onset priming bij beginnende lezers is bestudeerd in hoofdstuk 4. Kinderen uit groep 4 kregen woorden en pseudowoorden te lezen die werden voorafgegaan door een onset prime. De taak voor de kinderen was om op de groene knop te drukken als ze een woord lazen en op de rode knop te drukken als ze een pseudowoord lazen. Uit de resultaten van deze studie bleek dat de kinderen inderdaad sneller waren in het beoordelen van woorden en pseudowoorden wanneer deze voorafgegaan waren door een congruente prime dan wanneer deze voorafgegaan waren door een incongruente prime. Het maakte hierbij niet uit of de prime alleen een onset was (*kl* voor *klok*) of een heel woord met dezelfde onset (*kluis* voor *klok*). In deze studie werden kinderen uit groep 4 vergeleken met volwassenen. Voor volwassenen werkt dit priming-effect niet, net als in eerdere studies was aangetoond, maar voor kinderen wel. Dit komt waarschijnlijk doordat kinderen nog een strategie hanteren waarbij ze van links naar rechts (letter-voor-letter) lezen, terwijl volwassenen het woordlezen al geautomatiseerd hebben en woorden als een geheel herkennen. Een andere verklaring kan zijn dat de kinderen deze woorden nog verklanken (waardoor een overlap in klank een voordeel biedt) terwijl volwassenen dat niet of in mindere mate doen. Ongeacht de achterliggende reden kan er op basis van hoofdstuk 4 gesteld worden dat beginnende lezers baat hebben bij onset priming.

De effectiviteit van een motiverende game

Voor het lezen van woorden zijn niet alleen de schrijfwijze en de klank, die tot op dit punt met name beschreven werden, van belang. Er is nog een derde component die bij het lezen van woorden hoort, namelijk betekenis ofwel semantiek. Wanneer er een volledige **representatie** in de hersenen is opgeslagen van een woord, dan bevat deze representatie informatie over de **orthografie** (hoe ziet een geschreven woord er uit?), de **fonologie** (hoe klinkt een woord als ik of iemand anders het uitspreekt?) en de **semantiek** (wat betekent een woord?). De interventies en experimenten in de hoofdstukken 2, 3 en 4 berustten volledig op orthografie en fonologie en de link daartussen, en maakten geen of weinig gebruik van de semantiek. Dat is ook terug te zien in de praktijk van leestrainingen, waar herhaaldelijk het hardop voorlezen van woorden wordt geoefend. Dit wordt gedaan omdat zwakke lezers moeite hebben met het versnellen van het koppelen van klanken en letters. Het snel lezen van woorden heeft echter weinig toegevoegde waarde wanneer het kind niet begrijpt wat hij of zij leest.

In hoofdstuk 5 was er om die reden ook aandacht voor semantiek. In een leuke en motiverende app, genaamd Leesrace, gingen zwak lezende kinderen uit groep 4 bepalen tot welke categorie het gelezen woord behoorde. De app was motiverend omdat het echt een game was; de spelers konden winnen of verliezen, er konden punten worden behaald en het werd steeds moeilijker naarmate de lezer sneller werd. In de game werden ook de succesvolle componenten uit de andere hoofdstukken toegevoegd; namelijk het herhaald lezen en priming. Omdat de game zonder hulp van een ouder of leerkracht gespeeld werd, werd er ook gebruik gemaakt van feedback om zo de leerlingen te sturen. In de game volgde er een positief of negatief geluid na de semantische beslissing. Na een foutieve beslissing werd het woord ook letter-voor-letter voorgezegd en daarna als geheel uitgesproken. Nadat de leerlingen gedurende 5 weken een uur per dag hadden gespeeld met de app, werd de leesvaardigheid op ongetrainde woorden getoetst. Er werden grote transfereffecten gevonden, zowel voor woorden als voor pseudowoorden. Zo gingen de kinderen bijvoorbeeld op het lezen van eenvoudige woorden van 40 woorden per minuut naar 50 woorden per minuut wat een groei van 25% weergeeft. Op basis van de resultaten van deze interventie kan er dus gesteld worden dat het trainen van leessnelheid met behulp van een motiverende game effectief is.

Conclusies en implicaties voor de onderwijspraktijk

De studies in dit proefschrift tonen aan dat het mogelijk is om de leessnelheid van beginnende lezers te vergroten, zonder dat het ten koste gaat van de accuratesse. Herhaald lezen is inderdaad een krachtige methode om de leessnelheid te vergroten. Door dit herhaald lezen gaan beginnende lezers van letter-voor-letter lezen naar meer automatisch lezen. Het is gebleken dat het toevoegen van feedback aan deze herhaald lezen training noch een positief noch een negatief effect heeft op het verbeteren van de leesvaardigheid. Herhaald lezen heeft niet alleen een effect op het vergroten van de snelheid van getrainde woorden, maar ook op die van (nieuwe) ongetrainde woorden. Juist omdat beginnende lezers nog van links naar rechts lezen heeft het aanbieden van een onset prime waarschijnlijk ook een effect, zoals is aangetoond in dit proefschrift. De effecten van de laatste studie toonden aan dat kinderen door het spelen van een motiverende game - gericht op het verbeteren van leesvaardigheid - aanzienlijk sneller zijn gaan lezen.

Voor de praktijk betekent dit dat het goed zou zijn als leerkrachten de techniek van herhaald lezen toepassen. Door middel van het herhalen van een woord, wordt dit woord steeds beter opgeslagen, waarna het uiteindelijk geautomatiseerd kan worden. Oefeningen die gebruik maken van het concept van herhaald lezen, zoals bijvoorbeeld flitsen en 'voor-koor-lezen', zijn dus erg zinvol. Een andere effectieve techniek om de leesvaardigheid te vergroten is onset priming. Een manier waarop dat in de klas ingezet kan worden is bijvoorbeeld door het gebruik van wisselrijtjes waarbij de onset telkens gelijk blijft. Een wisselrijtje met de klank *kl* zou bijvoorbeeld de woorden *klok, klein, kleur, kluis, klim, klei* kunnen bevatten. Hierdoor wordt de klank *kl* geprimed en door de herhaling wordt die klank-letter koppeling ook geautomatiseerd. Het is echter belangrijk dat bij het snel lezen van woorden ook aandacht gegeven wordt aan de betekenis van de woorden, zoals in het vijfde hoofdstuk van dit proefschrift is gedaan. Een andere praktische implicatie is het product Leesrace. Deze game is gebaseerd op wetenschappelijk onderzoek (onder andere H2, 3 en 4) en is ook effectief gebleken (H5). De game kan eenvoudig ingezet worden in de klas en daarbuiten. Kinderen kunnen zelfstandig met de game oefenen, ze vinden het leuk en de resultaten zijn veelbelovend. Door het inzetten van bovenstaande technieken kunnen leerkrachten de beginnende lezers, met name de zwakke beginnende lezers, helpen om een flinke sprong te maken. Wanneer de leerlingen eenmaal vlot woorden kunnen lezen is er een goede basis gelegd om aan het begrijpen van teksten te beginnen.

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Curriculum Vitae

Karly van Gorp is op 30 maart 1985 geboren in Sint-Oedenrode. Na het behalen van haar gymnasium diploma op Bernrode in Heeswijk-Dinther is ze in 2004 naar Nijmegen gegaan. Op de Radboud Universiteit heeft ze haar bachelordiploma Nederlandse Taal en Cultuur behaald in 2007. Al tijdens die bachelor bleek dat Karly vooral interesse had in hoe taal in de hersenen werkt. Ze volgde in haar laatste jaar van de bachelor een minor psycholinguïstiek en ze volgde het Honours programma. Haar bachelorscriptie was op het gebied van taal en hersenen en deze schreef ze bij het Max Planck Instituut, waar zij op dat moment ook student-assistent was.

Na haar bachelor bleef Karly in Nijmegen om daar de research master Cognitive Neuroscience te volgen, met als specialisatie psycholinguïstiek. Ze behaalde haar masterdiploma in 2010. In januari 2011 startte ze met haar promotieproject bij het Behavioural Science Institute te Nijmegen. Naast haar proefschrift leverde dit project ook een mooie toepassing op voor de praktijk. Samen met softwarebedrijf QLVR te Utrecht ontwikkelde Karly de Leesrace, een game die zwakke beginnende lezers helpt met het vlot lezen van woorden.

Inmiddels werkt Karly als postdoctoraal onderzoeker bij het Behavioural Science Institute in Nijmegen aan een aantal verschillende projecten. In deze projecten is een belangrijke rol weggelegd voor taal en leren enerzijds en voor ICT en games anderzijds.