The use of interventions for promoting reading development among struggling readers

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Abstract

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A challenge for both researchers and practising teachers is to develop, disseminate and implement methods to help all students acquire good reading skills. One way to do this is to conduct intervention studies. Within the framework of this dissertation two such studies are carried out with the purpose of promoting the reading development of children whose reading ability has not yet reached the adequate age level.

The empirical material consists of two studies containing different interventions. These studies form the basis of the four articles included in the dissertation. The overall aim was to analyse the effects of the interventions with regard to both quantitative aspects of pupils' reading abilities as well as the qualitative aspects of interpreting intervention as a method for promoting reading development. The interventions contain training programmes aiming at promoting pupils' reading development. The participants of the first study attended grades 1-4, while in the other study only pupils from grade 2 participated. The first study comprises two different training programmes, one of which was computer-based. In the other study both training programmes were computer-based. One programme focused on phonology, whereas the other was more oriented towards reading comprehension.

Results showed that pupils who received a combination of phonological and comprehension training made greater progress on tests measuring word decoding, phonological ability and reading comprehension than the comparison groups. These results are valid in the short term, i.e. immediately after the end of the intervention, but also in the long term, one year after the intervention was concluded. The results also demonstrate that computer-based intervention in reading training with a strict framework, combined with individually adapted contents may be both effective and motivating and also have a substantial effect on the success of the interventions. The results from one of the studies also showed that it is possible to achieve positive results on pupils' reading skills with interventions that do not contain any homework. The main contribution of this thesis is important for further research and measures for children with reading disabilities.

Keywords: Reading, reading difficulties, interventions, pupils, computer-based training programmes, teachers

List of publications

1. Fälth, L., Svensson, I., & Tjus, T. (2011). The effects of two training programs regarding reading development among children with reading disabilities. *Psychology*, *2*, 173-180.

2. Gustafson, S., Fälth, L., Svensson, I., Tjus, T., & Heimann, M. (2011). Effects of Three Interventions on the reading skills of children with reading disabilities in grade 2. *Journal of Learning Disabilities, 44*, 123-135.

3. Fälth, L., Gustafson, S., Tjus, T., Heimann, M., & Svensson, I. (2013). Computer- assisted interventions targeting reading skills of children with reading disabilities – A longitudinal study. *Dyslexia*, *19*, 37-53.

4. Fälth, L. (2013). *The Need of Variation – Student's and Teachers' Experiences of Participating in a Reading Intervention Study.* Manuscript submitted for publication.

”O mäktiga feer, ge mitt barn i faddergåva inte bara hälsa, skönhet, rikedom och allt det där ni brukar komma stickande med – ge mitt barn ***läshunger****, det ber jag om med brinnande hjärta! Jo, för jag vill så gärna att mitt barn ska få i sin hand nyckeln till det förtrollade landet, där man kan hämta den sällsammaste av all glädje. Så där borde varenda mamma tänka ...”*

ASTRID LINDGREN

FÖRORD

Många har liknat sitt avhandlingsarbete vid en resa. För mig har det varit mera som ett pussel, och då inget sådant där enkelt pussel med knoppar uppe på, där varje bit har sin alldeles givna plats. Mitt pussel har varit, om inte gigantiskt, så i vart fall jättestort. Många bitar föll på plats tidigt och var smidiga att foga samman medan andra har varit svårflirtade och till en början inte verkat passa in alls. Några få bitar blev till och med över och det hör ju inte till vanligheterna när man lägger pussel. Som väl är hade jag redan från start ett par mycket viktiga hörnbitar. En sådan viktig hörnpusselbit har varit min huvudhandledare Idor Svensson – mitt största tack går till dig!

Nästa viktiga pusselbit som funnits med sedan dag 1 är forskningsprojektet COMEGA på vilket stora delar av min avhandling bygger. I COMEGA återfinns (förutom Idor) först och främst min bihandledare Stefan Gustafson (stort tack till dig!) men också Tomas Tjus och Mikael Heimann. Tack alla för gott samarbete! Ett stort tack också till alla elever och lärare som på olika sätt varit delaktiga i avhandlingens interventionsstudier, utan er hade det inte funnits något pussel att lägga.

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Till mina älskade ungar Matilda och Gustav vill jag också säga tack! Det är ju till stor del tack vare er som livet under de här åren har bestått av *så mycket mer* än avhandlingspussel…

Öjaby i mars 2013

1. INTRODUCTION

Today's society makes high demands on reading and writing abilities with "a good reading ability seemingly being a key to success in a working life continuously requiring learning new things, transforming and adapting to new technology and new organizations" (Lundberg, 2010, p. 131). For a substantial number of young people and adults throughout the world, reading is one of the most difficult tasks they face (Mullis, Martin, Kennedy, & Foy, 2007). Of the various learning difficulties school pupils may exhibit, reading failure represents one of the primary challenges that educators have to address in the classroom (Bramlett, Murphy, Johnson, Wallingsford, & Hall, 2002). Because of this, it is important to be well prepared to take appropriate actions for struggling readers. Both knowledge and support can be found in current research on suitable measures to take, but more knowledge is required about what interventions are appropriate and why. This thesis includes two intervention studies which are both about finding suitable tools for promoting the reading development of pupils who have difficulty in this respect. Both studies include computer-based training methods and components which have been shown by earlier research to be important for reading. In these studies the effects of different interventions are compared with regard to different aspects of pupils' reading ability both in the short- and in the long-term perspectives.

Reading and writing are often mentioned together as a coherent concept, e.g. reading and writing ability, reading and writing development, and reading and writing difficulties. In the empirical studies of this thesis the focus is on reading and hence the text is largely limited to reading ability, reading development and reading difficulties.

To be able to read one must have reached an insight into how characters represent language and how to recode writing into speech (Tunmer & Greaney, 2010). As reading and reading development are focused on in the empirical studies of the thesis, the next chapter provides the theoretical framework of the relevant concepts. It is a pedagogical challenge for school

teachers to provide all pupils with the tools, e.g. those needed to read new foreign words and gradually learn to read and understand factual texts. This requires a good decoding ability as well as good reading comprehension. The challenge to the teacher involves being able to identify the level of individual pupils' reading development and to face pupils exactly on that level with a view to assisting them to reach an effectively developed reading ability where they take their own initiative to read in order to find out about things or to acquire an experience (Liberg, 2006). In the curriculum of the comprehensive school (Lgr11) it says: "School is responsible for making every pupil after finishing the comprehensive school able to use the Swedish language in speech and writing in a rich and varied way" (Utbildningsdepartementet, 2010a, p. 10). The syllabus for Swedish equally states that "through teaching pupils should be offered the possibility of developing the language for thinking, communicating and learning. The teaching is expected to stimulate the pupils' interest in reading and writing." (Utbildningsdepartementet, 2010b, p. 89). It is not only school that makes high demands on the individual's reading ability. A democratic society is based on the human capacity for taking part of both oral and written information and on giving all individuals the chance to participate and make themselves heard. To feel completely at home in the writing culture characterizing our society today, it is important for children and young people to become good readers and writers.

Most pupils learn to read without much difficulty. Since there are still children who fail to respond well to whole-class provision (Hatcher, Hulme, & Snowling, 2004), it has been argued that such children may require a more individualized approach (Snow, Burns, & Griffin, 1998; Torgesen, Alexander, Wagner, Rashotte, Voeller, & Conway, 2001). The teacher requires knowledge about learning the written language to be able to face and support all pupils in developing their reading and writing ability in a systematic and carefully prepared way (Stanovich, 1986) As reading is not a natural process in the same way as speaking, pupils may require support and guidance to develop their reading ability (Lundberg, 2006). It is especially important that pupils who run the risk of encountering reading and writing difficulties are identified at an early stage and receive help and support in learning to read, so that they are given the same chances as other pupils (Catts & Kamhi, 2005; Høien & Lundberg, 1999; Myrberg, 2007).

The majority of the children who start reading late also remain behind their classmates for several years, and often the gap between poor and strong readers increases successively (Stanovich, 1986). Francis, Shaywitz, Stuebing, Shaywitz and Fletcher (1996), in a longitudinal study following the reading development of American children from preschool to grade nine, demonstrated that 74 % of those who were poor readers in grade 3 were still poor readers in grade 9. Similar results were shown in the Swedish Kronoberg

study (Jacobson & Lundberg, 1995). In this study pupils with reading difficulties in grade 2 were identified, and the results showed that in grade 9 60 % of them still had decoding difficulties, while only 20 % of them caught up with their classmates in word decoding and reading comprehension, for example. Fouganthine (2012) examined the pupils from the Kronoberg study after they had reached maturity. The result showed that all reading-related abilities that were tested at the age of 29 indicated very great differences between the group which had been identified as poor readers in grade 2 and a control group with so-called normal readers. The greatest difference measured concerned phonological ability and spelling. Against this background there is every reason for school to offer support as early as possible to children at risk in order to obviate later failures. Such support that is structured and carefully prepared may take the form of interventions, efforts or measures to promote the development of, for instance, reading and writing. One important task for research on reading difficulties and dyslexia is to propose well-functioning pedagogical measures for individuals with reading and writing difficulties. Within the framework of this thesis two different intervention studies have been conducted to promote children's reading development. These studies are presented in the four articles constituting the thesis (see Ch. 5). The intention of this thesis is to contribute with empirical results that may form the basis for structuring future interventions aiming at promoting a good reading development.

1.1 Aim and research questions

The prerequisites for reading involve being able to decode written text and understand its meaning. As regards pupils with reading difficulties, previous studies have pointed to the importance of early, intensive and systematic efforts. This is the background to the overarching aim of this thesis: to analyze the effects of interventions with regard to the quantitative aspects of pupils' reading abilities as well as the qualitative aspects of interpreting intervention as a method for promoting reading development. For this purpose the following questions have been formulated:

- What effects do the interventions have on pupils' reading abilities?
- How do pupils and teachers perceive their participation in the interventions? What were their experiences of it and how can these experiences shed light on the quantitative results of the interventions?

1.2 Disposition

In Chapters 2, 3 and 4 the theoretical starting points which have formed the basis of the empirical data collection are presented. Chapter 2 is structured so as to put the empirical studies of this thesis in the context of theories about reading and reading development, while Chapter 3 deals with reading difficulties. Chapter 4 contains a discussion of pedagogical measures and interventions for promoting a good reading development in pupils with reading difficulties. Chapter 5 involves methodological aspects of the specific interventions which were made within the framework of this thesis and which resulted in the four articles. That chapter also includes summaries of each article. In the final sixth chapter the results of the studies are presented together with their pedagogical implications and conclusions drawn from the empirical results and theoretical argumentation of the thesis. This is followed by suggestions for further research within this area. Finally, there is a summary in Swedish and references. The four articles included in the thesis are presented in their entirety as Appendices 1-4.

2. READING AND READING DEVELOPMENT

Reading can be defined as the ability to recode text into something that the reader already has command of and that he or she can meaningfully adopt – the spoken language (Tunmer & Greaney, 2010). Even though there are differences between written and spoken language, the language proficiency needed is about the same for acquiring and understanding writing as for speech. It thus includes, for example, localizing individual worlds in the lexical memory, using suitable syntactic sentence structures, finding meaning in individually structured sentences, and being able to build meaningful contexts and identifying the whole (Catts & Kamhi, 2005). To be able to choose the right level of difficulty appropriate for each individual student, a teacher must have access to information on that student's linguistic awareness and reading development. This was of importance for the teachers in our studies, since the participating pupils had reached different levels in their linguistic awareness (see Section 2.2) and reading development (see Section 2.3).

One of the goals of reading is to automatize word decoding in order to focus on understanding the contents of what one reads. Even when one does not immediately understand the meaning of an entirely new word, a visual coupling should be made to the semantic memory without the need to sound the letters (Catts & Kamhi, 2005). A good decoding ability is emphasized in early reading development (Taube, 2007a). If the pupil cannot read the individual words in a text quickly and efficiently, problems with understanding the contents may appear. A large part of the reader's cognitive resources will then be tied up in the decoding process, which impairs the understanding of the text and hence also the learning.

2.1 Reading according to the Simple View of Reading (SVR)

The basic notions of what reading is are represented in a model called the Simple View of Reading (SVR) (Gough & Tunmer, 1986; Hoover & Gough, 1990). According to the SVR, the skills and processes that determine reading comprehension are captured by two broad components: decoding and linguistic comprehension. The SVR formula reads:

R (Reading Comprehension) = D (Decoding) × C (Comprehension)

Hence, if the decoding ability is high but language comprehension low, the person in question will not be a good reader. Nor will this pupil be a good reader, if the opposite pattern obtains with a low decoding ability but high language comprehension. This means that pupils with problems of decoding in age-adapted texts or with difficulties in understanding what they read will have problems to acquire the contents of the text (Gough & Tunmer, 1986; Hoover & Gough, 1990). The identification of a simple model of reading has theoretical, educational and diagnostic implications (Chen & Vellutino, 1997; Kendeou, Savage, & van den Broek, 2009; Stuart, Stainthorp, & Snowling, 2008). The model provides a framework within which to understand and conceptualize the phenomenon of reading. It can also guide the structure of directed and suitable early teaching methods and form support in diagnosing reading difficulties. The participants in both the dissertation studies do have a command of word decoding as well as reading comprehension on different levels, and the intention is to improve these abilities through the training they are given by participating in either study.

Since the SVR was first introduced, a large amount of evidence has emerged in its support (e.g. Aaron, Joshi, & Williams, 1999; Joshi & Aaron, 2000; Savage, 2001). On the other hand, the starting point of D and C being two independent components has been criticized, and there are researchers in reading (like Adams, 1990) who maintain that the components interact and largely depend on each other. In a research survey from 2008, Kirby and Savange write that the Simple View of Reading was never thought of as an overarching theory of the cognitive processes involved in reading. The different processes concerning decoding and comprehension can be analysed separately, and their development is directly and indirectly affected by a number of other factors (Vellutino, Tunmer, Jaccard, & Chen, 2007). Heimann and Gustafson (2009) also discuss an expanded model of SVR, emphasising that both decoding and comprehension are affected by various individual factors that are more or less familiar to the teacher: intelligence, perseverance, attentiveness, temperament, motivation and reading habits. The extent to

which the pupil has been exposed to the written language as well as the number of challenging and instructive talks the pupil has taken part in are examples of this. Arguably, however, one of the attractive aspects of the SVR as a broad model for understanding reading is that it places two teachable skills, namely D and C, centre-stage in the classroom. The SVR also reminds us that, in addition to teaching students in decoding, we also need to teach comprehension skills. The second empirical study of this thesis included training programs intended to practise both decoding and reading comprehension, and a good prerequisite for word decoding is that the pupil is linguistically aware (Snowling, 2000). The forthcoming sections deal with opportunities for reading and with different stages in the reading progress.

2.2 Linguistic awareness

Being aware of the language structure and able to shift one's attention from the contents to the form of language and having the ability to step aside from language and reflect on it are the factors usually included in the notion of linguistic awareness. Well-developed linguistic awareness is a good foundation for children to acquire a quick, reliable and gradually automatic decoding ability. It should be possible to analyze the language from a formal point of view without being distracted by the contents. This is a matter of distancing oneself from the meaning, identifying the phonemes and successively becoming aware of how the language is structured. Snowling (2000) defines linguistic awareness on the basis of the subgroups: phonological, syntactic, semantic and pragmatic awareness.

Phonological awareness entails the ability to observe and handle language with respect to its sounds. Language sounds are not produced one by one but merge and interplay, which may make it difficult to distinguish the separate individual phonemes (Lundström-Holmberg & af Trampe, 1987). In the last few decades a great deal of research has focused on the importance of phonological awareness for a successful reading development (Goswami, 1986; Høien, Lundberg, Stanovich & Bjaalid 1995; Lundberg, Frost, & Petersen, 1988; Poskiparta, Niemi, & Vauras, 1999; Vandervelden & Siegel, 1997; Vellutino, Fletcher, Snowling, & Scanlon, 2004). The argument is that in our written language, sounds are systematically related to written symbols, and pupils who have realized that words are formed by a number of non-meaning-carrying units (syllables, endings, phonemes) will more easily discover the systematic relation between sounds and written letters.

Through phonological training a positive effect on reading development can be achieved in all children, but especially in those who run the risk of

developing reading difficulties (Ehri, Nunes, Willows, Valeska Schuster, Yaghoub-Zadeh, & Shanahan, 2001). The Bornholm study (Lundberg, 2010; Lundberg et al., 1988) demonstrated that preschool training of phonological awareness benefits all pupils in their reading and writing development, those with reading problems in particular. This Danish study has been replicated in several other countries with basically the same results (Lundberg, 2010). The relation between phonological awareness and reading ability is a central issue in reading research (Adams, 1990; Snow et al., 1998; Wagner, Torgesen, & Rashotte, 1994). Frost, Madsbjerg, Niedersøe, Olofsson, & Sørensen (2005) highlighted the importance of phonological awareness in the beginning of learning to read, while in the continuing reading development the *semantic awareness* plays a major part. The vocabulary and the acquisition of concepts are a prerequisite for reading comprehension. For children who have difficulties with reading semantic clues play a more important part than for good readers, because contextual clues can compensate children with deficiencies in phonological or orthographical reading (Frost et al., 2005).

Morphological awareness involves an insight into words, word segments and inflections. The awareness of words being often composed of different parts and of the way these build up the meaning of words increases word comprehension and facilitates spelling (Elbro, 2004). To understand the grammar of a language, the internal order of words and patterns of inflection is to be *syntactically aware.* The understanding and knowledge of sentence structure has a positive impact on reading development (Johansson, 2010). Schrauben (2010) also emphasizes the importance of prosody in this development, arguing that reading comprehension is promoted by utilizing punctuation marks and other syntactic clues in combination with prosody. *Pragmatic awareness* influences the way the child becomes aware of how language is used in a social context, which in turn affects text comprehension. Children who have a good pragmatic ability may, for example, adopt the perspective of a listener, answer questions, explain and keep the red thread in a conversation (Gail, 2004).

2.3 Stages in reading development

It is not possible to completely predict a child's reading development, since it is affected by, e.g., genetic disposition, reading experiences and teaching (Høien & Lundberg, 1999). However, it is important for teachers to know where in the reading progress pupils are supposed to be able to individualize their education. Most children approach reading with a well-established system for how to process speech. The challenge facing teachers is how to make their oral skills benefit their reading, which in turn requires that the

teachers know something about reading development theory (Taube, 2007a). There is a great deal of evidence indicating that a measure of letter-sound knowledge and phoneme awareness is what best predicts the ability to read (Bowey, 2005; Muter, Hulme, Snowling, & Stevenson, 2004). These are skills that depend on a language's phonological system. On the other hand, when it comes to reading, comprehension, vocabulary and grammatical skills are also essential, as well as semantics and grammar, two non-phonological language aspects (Muter et al., 2004). Moreover, beyond the early stages, children have to develop their reading fluency. Even for children who have cracked the reading code it may take time before their reading becomes automatic and the words are correctly and quickly recognized. Reading development is often described as taking place in stages or phases, assuming that everyone passes through the qualitatively disparate steps in a similar way, albeit not at the same rate (Ehri, 1999). There are a number of models describing the reading development process (Chall, 1983; Ehri & McCormick, 1998; Frith, 1985; Høien & Lundberg, 1999; Lundberg, 2010). What is common to these models is that they contain at least three stages or steps: one logographical, one phonological and one orthographic. The first stage entails that words are recognized as units (e.g. that the child knows that is says McDonalds by recognizing forms of written characters without knowing the letters). In the next phase graphemes are linked to phonemes, which mean that the reader has cracked the alphabetical code. In the last stage, the orthographic strategy is used which involves that the child now recognizes the whole, or parts, of words visually (Ehri, 1999). The reason why common words are more quickly recognized than new ones is that well-known words already exist in the reader's orthographic lexicon (Elbro, 2004). In this lexicon all knowledge and experiences of words are stored, one prerequisite for orthographic-morphemic reading being that the child has come across the words so many times that they have become established in the lexicon. Once the child has reached this last stage the resources can be explored for semantic and syntactic clues that can make a text meaningful. Word decoding has now become automatic and takes place without requiring a cognitive effort (Frost et al., 2005).

The reading development does not look the same for all children, because some remain longer in a phase that others left behind quickly, while some shift between the different phases. A reader encountering an unknown word may go back to using earlier strategies. These shifts, according to, e.g. Danielsson (2003), Kullberg (1991) and Share (1995, 1999), indicate that reading development does not happen stepwise but that instead the stages run parallel to each other. Making reading automatic is a process most pupils undergo to the very last years of the comprehensive school (Lundberg, 2010).

2.4 Reading flow and reading comprehension

Wolf and Katzir-Cohen (2001) define reading flow as smooth, friction-free reading consisting of several processes at different levels, where the underlying processes have to reach complete automaticity for achieving total concentration on comprehension. Being able to read fluently is the goal of the pupils participating in the studies included in the thesis, apart from being the primary goal of reading development. This means being able to read a text quickly, correctly and with the appropriate prosody (Schrauben, 2010).

Comprehension is achieved when the reader builds a mental representation, an internal image, founded on a text message and, according to Perfetti, Landi and Oakhill (2005), the comprehension process consists of two main parts: identifying words and activating language processes when words are combined to messages. Primary prerequisites like word decoding ability and word knowledge are necessary for developing a good reading ability (Arnbak, 2010) and, according to Myrberg (2007), vocabulary is the major single factor behind reading comprehension. In a Dutch study Verhoeven, van Leeuwe and Vermeer (2011) found a connection in some pupils between advanced vocabulary and good reading comprehension. The study shows that the attention and time devoted in the early school years to reading pace, word decoding automatization and the use of reading comprehension strategies lay the foundation to a good reading and vocabulary development in the pupil. In order to understand a text readers need to be able to control their reading (Perfetti et al., 2005), which is done by a number of metacognitive processes. Readers who are in good control use different strategies to solve problems of understanding that may turn up in the course of the reading, which is a clear sign that they are absorbed in the text (Nation, 2005). Such a metacognitive attitude has proved to be of importance to reading comprehension (Lundberg, 2010). Research on metacognition emphasizes the importance of the reader being able to use knowledge and strategies on different levels (Arnbak, 2010). Some knowledge may, for instance, be required to concretely understand the facts presented in a text, while making inferences and drawing conclusions from the text demand knowledge of a different type. Keene, Zimmermann, Jakobsson and Fihn (2003) maintain that there are quite a few pupils who are unaware of their own understanding of what they have read. They do not reflect on their own thought process and do not read critically or analytically, nor imaginatively or exploratively. They feel no confidence in what to do when the text becomes difficult to understand and have no idea what they need to know in order to understand a text. To be able to master these abilities readers have to be aware of their own thought processes during their reading and this will make them capable of exploring the text (Nation, 2005). Metacognition in connection with reading activities will be discussed further in Chapter 4.

By automatized word decoding the pupil can concentrate more on comprehension than on reading techniques, which may help developing reading flow and contribute to a positive reading experience. A heightened reading experience may result in increasing the reading pace, with the word decoding ability playing a central part in the continued reading development (Perfetti, 1992; Samuels, 1994). Reading flow cannot be equated with automatization but is more of a bridge between word decoding and reading comprehension (Reichenberg, 2008). This is symbolized by the multiplication sign (x) in the 'simple view of reading' (Gough & Tunmer, 1986), with decoding and comprehension happening simultaneously in fluent reading. With every step that increases decoding (D) or comprehension (C) in the model the total reading ability (R) increases as well.

2.5 The importance of motivation for reading development

Motivation is important to most of our activities (Jenner, 2004), reading being no exception. Several studies have given evidence of the association between children's reading ability and motivation (Baker & Wigfield, 1999; Morgan & Fuchs, 2007). There are also studies showing how motivation may explain why the attainment of reading varies, regardless of cognitive abilities (Anmarkrud & Bråten, 2010; Taboada, Tonks, Wigfield, & Guthrie, 2009) and previous reading ability (Logan, Medford, & Hughes, 2011). This testifies to the importance of both cognitive and motivational factors. There has, consequently, been a strong emphasis on producing and implementing reading programs and interventions that increase children's enjoyment of and motivation for reading, while simultaneously developing their reading abilities.

Interventions that concentrate on improving reading ability as well as motivation have actually proved to improve children's reading attainment considerably (Guthrie, McRae, & Klauda, 2007). To attain maximum gains it is important, however, to grasp what factors may lie behind the motivation to read. It appeared that the importance of motivation was also obvious in the studies that are made in the context of this thesis.

Taube (2007b) underlines the importance of being aware of the strong effect of success and failure in reading on the pupil's self-image and motivation for continued learning. It is essential to focus on meaningful experiences, to stimulate critical thinking while reading, as well as creative expressions while writing, in order to increase children's motivation (Verhoeven & Snow, 2001). Guthrie and Knowles (2001), stressing the necessity of motivation to produce

committed readers, pinpoint a few prerequisites for motivating reading instruction. They include using meaningful texts based on reality, social cooperation, working with concept themes, instructions for cognitive strategies of thought and supporting pupils in their independent development. Several of the interventions made in the studies included in the thesis involved computer-based training. Alexandersson, Linderoth and Lindö (2000), Enochsson (2004) and Watts and Lloyd (2004) demonstrate that using computers in school promotes motivation. One explanation of this is that pupils are more engaged in activities they find interesting, important and 'real', as can be achieved by computer-based activities. Another reason why using computers, in particular, should be considered 'real' and create motivation among pupils is that they are used by many grownups as a working tool (Fast, 2007).

Jenner (2004) highlights three factors characterizing the motivation process with a bearing on the interpretation of the empirical results of this thesis: First, the goal should lie within the horizon and feel possible to attain. If the goal is too distant, the motivation is not affected in a way that it makes me feel a failure if I have not attained it. It rather creates a feeling that this is nothing for me. Secondly, attainment has a value, if the goal is worth striving for. In this context this might mean that pupils ask themselves whether it is of any use to them whatsoever to be able to read. Thirdly, there is the likelihood of failure, in other words, how pupils estimate their chances to succeed. These factors will recur in the discussion chapter, where they will be related to the empirics of the thesis.

3. READING DIFFICULTIES AND DYSLEXIA

Reading and writing difficulties is an overarching term comprising all problems concerning reading and/or writing, regardless of their cause. Since the empirical studies of this thesis focus on reading difficulties, I have tried in this chapter to concentrate on these as far as possible. The common denominator of the pupils in the two studies is that they have some difficulty with regard to reading. The difficulties may exist at different levels so that some pupils who participate in the studies may supposedly have dyslexia even though we have not taken part of any diagnoses. To describe the participant we have chosen instead to use "reading difficulties", a more overarching term. However, research on dyslexia remains relevant for the field of the thesis, with regard to causes and the expressions of the difficulties, but also in the intervention context.

The complexity of reading difficulties may make it difficult to establish the causes behind them. Initially, the actual learning process, that of being able to interpret the contents of a text into meaningful contexts, is negatively affected either by a) some deficiency in the pupil's speech system, or b) a deficiency in the cognitive process whereby texts are to be coupled to the spoken language system (Tunmer & Greaney, 2010). According to Snowling (2000), the major reasons for reading and writing difficulties are: that the pupil has missed basic reading and writing elements because of non-attendance during the first years of school, that the pupil cannot absorb what is taught due to a lack of cognitive and linguistic maturity, constitutional factors like dyslexia, having a minor brain damage, other neurological deviations, reduced hearing or vision. Another reason might be that the pupil's preparedness for profiting by teaching is low, owing to emotional troubles (Snowling, 2000). As the reasons for the difficulty vary to such extent, it is important to identify them to be able to take the appropriate action.

Along with the increased requirements for reading proficiency, the interest in reading and writing difficulties has grown. A laborious decoding process, requiring too great a mental effort, will thus become a growing stumbling block for acquiring knowledge in school. For good readers decoding happens automatically, and they can therefore concentrate entirely on absorbing the message of the text. The more time and mental effort engaged in decoding and recalling the word the pupil is just reading the less strength is left to comprehend the text. As the difficulty lies in decoding words quickly, the reading comprehension suffers when all energy is wasted on decoding. Deficient reading comprehension is often a secondary symptom caused by bad word decoding (Høien & Lundberg, 1999).

Reading difficulties may, according to e.g. Frith (1997) and Svensson (2003), be viewed on the basis of three different levels: *the biological level* – the structure of the brain and all genes, *the cognitive level* – intelligence, memory and other cognitive abilities and *the manifest level* – the visible signs, i.e. whatever we regard as reading difficulties with all it entails in the form of laborious and stumbling reading, spelling problems, problems with reading comprehension, etc. Svensson (2003) uses the metaphor of a flower pot, where the biological level is symbolized by the root system at the bottom of the pot. Higher up in the soil stratum we find the cognitive level and above the soil, symbolized by a stem and a flower, the manifest level. This model was further developed by Svensson after models by Frith (1997) and Høien and Lundberg (1999). Frith's (1997) is a general explanatory model of dyslexia, where she describes how genetic and environmental factors interact on three different levels: a biological, a cognitive and a behavioural level. It is necessary to keep in mind that all the levels are affected by the environment (Svensson, 2003). Lundberg (2010) makes the same division when describing dyslexia on the basis of the following: *the manifest level,* the way dyslexia expresses itself by uneven and uncertain reading, bad spelling and difficulty in understanding texts, often as a secondary consequence of deficient word decoding and bad reading fluency; *the cognitive level,* where the underlying problems with phonology and working memory are found; and the third level, which concerns the neurobiological *foundation* of dyslexia. The focus in the studies forming part of the thesis is on the manifest level as far as discovering the problems, while later, when appropriate action is to be taken, transferring to the cognitive level.

Reading difficulties do not always entail dyslexia, but dyslexia always entails reading and writing difficulties. To define and diagnose dyslexia is important, not least to receive guidance on what measures are suitable to make (Lyon, Shaywitz, & Shaywitz, 2003). Dyslexia is a much-discussed and sometimes questioned concept. However, a majority of researchers in the field now agree

that phonological difficulties form the underlying reason for dyslexia and that its chief signs are decoding and spelling problems (Elbro, 2004; Lundberg, 2010; Myrberg, 2007; Rack, Snowling, & Olson, 1992; Ramus, 2001; Torgesen, Wagner, & Rashotte, 1994; Vellutino, Scanlon, & Spearing, 1995; Ziegler & Goswami, 2005). There is also research evidence that dyslexia has a neurobiological (Shaywitz et al., 2002) and a genetic (Grigorenko, 2007) background.

Traditionally, dyslexia has been defined as a discrepancy between reading proficiency and intellectual capacity, as measured by standardized intelligence tests (Critchley, 1973). Part of the criticism of the way the discrepancy theory identifies dyslexic individuals is that it has not proved to be reliable in a long-term perspective, nor does it seem helpful in suggesting suitable interventions (Fletcher, Denton, & Francis, 2005; Francis, Madsbjerg, Niedersøe, Olofsson, & Sørensen, 2005; Hatcher & Hulme, 1999; Vellutino, Scanlon, Zhang, & Schatschneider, 2008).

In 2003 the *International Dyslexia Association (IDA)* suggested a definition that specified reduced phonological ability as the main reason for dyslexia:

> *Dyslexia is a specific learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and/or word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and provision of effective classroom instruction. Secondary consequences may include problems in reading comprehension and reduced experience that can impede growth of vocabulary and background knowledge. (Lyon, et al., 2003, p. 2)*

This definition contains information on the reasons for dyslexia, but also on its manifestations. The weakness of the phonological system causes difficulties to achieve word decoding in a quick and efficient way for those with dyslexia.

According to Tunmer and Greaney (2010), there are four components that, taken together, explain dyslexia: the *first* involves permanent/persistent reading and writing difficulties, while the *second* component claims *what it is not* (e.g. severe attention deficit disorder, mental development dysfunction, language dysfunction or emotional dysfunction). The *third* component, perhaps the most interesting one for this thesis, is that no diagnosis should be made before the pupil has undergone evidence-based training in reading and writing (Fuchs & Fuchs, 2006; Rose, 2009; Tunmer & Greaney, 2010). An indication of severity can be provided by how well a child responds to well-

founded intervention. The expected response to interventions fails to come about when the difficulties are to some extent resistant to training (Fuchs & Fuchs, 2006; Tunmer & Greaney, 2010). The effects of the measures and interventions have to be carefully monitored and the pupils have to be observed at an early stage. The *fourth* and last component entails that it is the deficient phonological ability that lies at bottom of difficulties with the written language (Tunmer & Greaney, 2010). However, Tunmer and Greaney (2010) point out that pupils who have been diagnosed with dyslexia according to the above criteria may still make progress and actually do so in their reading ability.

It can be hard to state the existence of dyslexia with certainty. A variation in prevalence is probably due to different definitions containing different criteria and to the chosen study methods (Catts & Kamhi 2005; Svensson, 2011). According to Snowling's 1998 meta-analysis of studies defining dyslexia, there were 4 -7 percent of the pupils who at some point during their reading development fulfilled the criteria for dyslexia. Shaywitz and Shaywitz (2005) concluded on the basis of different studies that the prevalence of dyslexia varied between 5 and 17 percent. Wolff (2005), in a study of Swedish pupils, found that a group corresponding to 7 % of the population at large had dyslexia.

Environmental factors play an important role in connection with reading and writing difficulties (Catts & Kamhi, 2005). The milieu which offers reading and cultural stimulation may have an impact on the pupil's reading development. Effective well-structured teaching and efforts that stimulate reading are important to counteract the genetic inheritance that is negative to reading and can thus offer pupils equally great chances to develop (Elbro, 2004). Unfavourable conditions in school and home environments may, on the other hand, increase the risk of acquiring reading and writing problems in spite of relatively favourable biological conditions (Elbro, 2004; Myrberg, 2003; Svensson, 2011).

4. PEDAGOGICAL WORK THROUGH INTERVENTIONS FOR PROMOTING READING DEVELOPMENT

As previously mentioned, several causes of reading difficulties and dyslexia are well known, but none of them indicates a simple solution. Fortunately, research has shown that reading failure can be prevented for a significant proportion of pupils who experience early difficulties (Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998; Torgesen, 2005). Furthermore, it has been suggested that when intervention is timely for young learners, the trajectory of learning can be altered, resulting in a reduction in the number of pupils requiring special education services in later years (Askew, Kaye, Frasier, Mobasher, Anderson, & Rodríguez, 2002). Children who are offered a well-structured intervention in the form of a pedagogical game with letters and language sounds run less risk of obtaining reading and writing difficulties than other children (Ehri et al., 2001; Elbro & Petersen, 2004; Lundberg et al., 1988; Shaywitz, 2003). In order to acquire a good reading ability it is necessary to practise phonological awareness systematically to go on from developing good decoding strategies to integrating with more comprehension-oriented language strategies. In a study by Frost et al. (2005) it was demonstrated that vocabulary, comprehension and sentence structure are essential for reading development at all ages. In order to acquire reading fluency, phonological and semantic as well as morphological and orthographic abilities have to be integrated into teaching reading.

In spite of current knowledge about the basic elements involved in learning to read, the mainstream approach often fails to support at-risk children adequately in acquiring sufficient letter knowledge to develop fluent and accurate reading and spelling ability (see, e.g., Hatcher et al., 2004). A study by Lovett, Barron and Benson (2003) stress the necessity of direct and systematic efforts and explicit teaching to promote phonological awareness in pupils who run the risk of developing reading and writing difficulties. There

are several studies illustrating that the reading ability of pupils having problems with reading can be improved by intensive, individualized teaching focusing on phonological skills as well as on precision in text reading (Lundberg 1984; Torgesen, 2005; Wolff, 2011). Pupils with reading problems are what the studies included in this thesis are directed towards and the contents of these studies constitute intensive and individualized teaching with some focus on phonological training.

The metacognitive ability of pupils is another important factor in reading development (Andreassen & Bråten, 2011; Myrberg, 2003; Pressley & Ghatala, 1990). This ability may in turn help pupils to learn what mental strategies lead to success or failure in their reading development. Well-developed metacognitive thinking enables them to change and develop their reading. The teacher has the important task of stimulating pupils' metacognition by, for example, encouraging them to ask themselves how they think and what they could do differently to achieve better results. *Characteristic of a pupil who reads well is not that she or he always understands, but that she/he can decide for herself/himself when she/he does not understand* (Myrberg, 2003, p. 38). As for metacognition, Palincsar and Ransom (1988) write that it is through talks and observations that the teacher can find out how pupils experience their own reading and to what extent they are aware that people may have different aims with their reading and that these different aims make them read in different ways. See also Section 2.4 for further reasoning about metacognition.

4.1 Intervention studies to promote reading development

A challenge to both researchers and teachers is to develop, disseminate and test methods that can help pupils to acquire a better reading ability (Torgesen et al., 2001). One way to do this is to conduct intervention studies. Preventive intervention has been shown to be more efficient than remedial intervention (Torgesen & Hudson, 2006; Tunmer & Greaney, 2008). However, despite this knowledge, there are pupils who will be in need of remedial instruction when they get older, either because they did not obtain the right kind of reading instruction, or because of the severity of their problems. All the participants in the studies included in this thesis have reading difficulties of some kind after spending one or several years in school. The focus is therefore on remedial rather than preventive intervention. Such intervention may take different shapes with regard to length, intensity or contents. A large number of intervention studies about reading have been performed (e.g. Ball &

Blachman, 1991; Elbro & Petersen, 2004; Foorman et al., 1998; Hatcher, Hulme, & Ellis, 1994; Wolff, 2011). Below, some intervention studies are described briefly, while others with greater relevance to the present thesis (computer-based interventions, interventions involving one-to-one teaching and those applying Reading Recovery) are described in greater detail. Several intervention studies have applied Reading Recovery, or a modification of it, in intervention contexts (e.g. Center, Wheldall, Freeman, Outhred, & McNaught, 1995; Invernizzi, Rosemary, Juel, & Richards, 1997). Within the framework of this thesis, Study 1 exemplifies a modified version of Reading Recovery, described in Fälth, Svensson and Tjus (2011). In Section 5.3.1 an account is made of this program for training reading, first as a general method for reading instruction and subsequently as intervention.

To be regarded as well-founded, the intervention has to be based on theories of how to develop a specific ability and how to promote this ability among those who struggle to be in command of it. In reading contexts this means that it is important to have a clear view of what type of difficulty a pupil faces and what is its basis, so as to be able to plan for a suitable pedagogical intervention (Snowling & Hulme 2011). As mentioned above, for many pupils with reading problems, especially those with dyslexia, reading involves problems with decoding strings of letters that form words. Consequently, effective interventions for pupils with such problems focus on the systematic training of word decoding and on the link between letters and language sounds (Hatcher et al., 1994; Shaywitz, 2003; Torgesen et al., 2001). For many children, poor decoding skills pose a bottleneck to understanding, and for them an intervention aimed at promoting the development of word-level decoding skills is entirely appropriate.

In contrast to problems with word decoding, which may appear in dyslexia, some pupils are good at learning to decode but have a vague understanding of what they read. Such ‘poor comprehenders’ may have difficulties with grammar, for example, or with finding coherence, making inferences or drawing conclusions from what they have read (Cain, 2010; Nation, 2005). The different profiles for dyslexia and ‘poor comprehenders’ indicate that these varieties of reading difficulty require different pedagogical measures. For a pupil with comprehension problems efforts may be directed towards developing vocabulary and semantic knowledge (Snowling & Hulme, 2011). There is evidence from longitudinal studies that comprehension difficulties originate in semantic, grammatical and lexical processes outside phonology (Catts, Adlof, & Weismer, 2006; Nation, Cooksey, Taylor, & Bishop, 2010). There have so far been no studies of how to identify such pupils in terms of Response to intervention, RTI (Snowling & Hulme, 2011), i.e. how the difficulties appear after training with a valid intervention. The concept of RTI is further defined in Section 4.2. In both the intervention studies made within

the framework of this thesis an attempt is made to include a training program aiming at strengthening reading comprehension skills among the pupils.

Generally speaking, several intervention studies within the field of reading illustrate, as mentioned above, that phonological training has a positive effect on pupils' reading capacity (e.g. Ehri et al., 2001; Elbro & Petersen, 2004; Hatcher et al., 1994; Torgesen, Wagner, Rashotte, Herron, & Lindamood, 2010; Vellutino, Scanlon, & Tanzman, 1998). There are also studies showing greater intervention effects if phonology is linked to orthography in a systematic way (Castles & Coltheart, 2004; Ehri et al., 2001; Iverson & Tunmer, 1993). So far, the focus has been on the contents of an intervention, but the form or the arrangement of interventions is also of importance. Results from different studies of interventions suggest that they should be systematic (Kjeldsen, Niemi, & Olofsson, 2003) and intensive (Denton, Fletcher, Anthony, & Francis, 2006). With regard to their intensity, there are studies showing that it is better to concentrate the training to a limited period rather than smearing the same amount of training over longer time periods (Bus & van Izendoorn, 1999; Ehri et al., 2001).

A study by Lovett, Borden, DeLuca, Lacrerenza, Benson and Brackstone (1994) forms the basis of several subsequent intervention studies. In this study two different interventions focusing on promoting the acquisition of unknown words are evaluated. The first group received phonological training, including straightforward teaching of letter-sound relations. The other intervention group was taught word identification strategies intended for more orthographic reading whose focus was not on single sounds and letters but on larger orthographic units and strategies for how to read these. There was also a control group receiving the regular teaching offered by the school. Both intervention groups made progress in relation to the control group, but the results also show differences between the intervention groups. The first group, which had received phonological training, showed better results on nonsense word reading, while the other intervention group was better at reading irregularly spelled words. Lovett, Steinbach and Frijters followed this up (2000) by implementing teaching that combined the methods used in the previous study. This combined training turned out to be more effective than either method separately. In line with this, Study 2 of this thesis includes an intervention group receiving a combination of two different methods for training reading, while the two other groups practise each method separately.

The empirical studies in this thesis consist of different reading training methods: Reading Recovery, phonological training (Comphot) and reading comprehension training (Omega-IS). For more details about each training program see Section 5.3.1 – 5.3.3. All teaching takes place in a one-to-one situation between one pupil and one teacher. In a metastudy by Scammaca,

Vaughn, Roberts, Wanzek and Torgesen (2007) an effective intervention for first-year pupils was shown, comprising the explicit teaching of phonological awareness and decoding as well as exercises in reading whole texts and in reading comprehension. Furthermore it was shown that one-to-one tutoring or teaching in small groups was preferable. The importance of one-to-one tutoring is emphasized in several studies (Ehri et al., 2001; Ross & Begeny, 2011; Torgesen et al., 2001; Wolff, 2011) as is the case in our studies.

An often quoted intervention study by Torgesen et al. (2001) comprised sixty pupils with specific reading difficulties. They were divided into two groups and were set to work with two different reading programs. The teaching was conducted on a one-to-one basis and lasted 2 x 50 minutes every day for eight weeks. Both programs entailed training in phonological awareness and word decoding with a variation in focus. In one program, ADD = Auditory Discrimination in Depth, the focus lay on teaching the pupils to listen to the sounds of the words and to observe and feel where in the mouth words were formed. This meant reading at a more articulatory level. In the other program, EP = Embedded Phonics, the pupils were immediately taught decoding strategies, while phonological awareness was stimulated by various writing and spelling exercises. Here the focus was on reading and understanding texts. The results showed that the pupils in both groups had made substantial progress. In spite of the different directions, the programs were equally effective in improving the pupils' reading ability. These positive general effects indicate that the details of the contents may not be as important as ascertaining that the programs have a phonological basis, are systematically structured and sufficiently intensive. It was also demonstrated that these pupils, who used to be found in the five lowest percentages in the class with regard to reading ability, almost reached the earlier average of the class. Even though they were not subsequently given any extra support they continued to develop positively, so that in a follow-up study conducted one year after the completion of the project, it emerged that 40 % of these pupils no longer required special needs teaching (Torgesen et al., 2001). The second study of the present thesis included a phonological training program and, also in line with Torgesen et al. (2001), we included follow-up testing and then examined how many pupils still required special needs teaching.

4.1.1 Computer-based interventions

In both studies conducted within the framework of this thesis, computer-based reading training programs were used for the purpose of developing the reading ability of children who are struggling readers. Previous studies have demonstrated that computer-based reading training can be effective for those running the risk of developing such difficulties (e.g. Magnan & Ecalle, 2006, Nicolson, Fawcett, & Nicolson, 2000, Regtvoort & van der Leij, 2007; Saine,

Lerkkanen, Ahonen, Tolvanen, & Lyytinen, 2011). Even for pupils whose difficulties in reading have been confirmed, computer-based training programs have turned out to be useful as a way of teaching reading (e.g. Jiménez et al., 2007; van Daal & Reitsma, 2000 and Wise, Ring, & Olson, 1999).

The motivation factor plays an important role in connection with intervention studies, because the training has to be experienced as stimulating and meaningful (Baker & Wigfield, 1999; Guthrie, Wigfield, & Perencevich, 2004). To increase the motivation for training reading in the pupil it is, according to Moreno (2006), essential to discuss and explain why and how the different elements of the training are necessary. Several intervention studies illustrate that computer-based training in itself may increase the motivation, not least for pupils who are used to working with computers. Another advantage of computer support is that it increases pupils' activities and concentration and thus gives those with reading problems the much needed benefit of 'more time on task', (Fast, 2007; Johansson, 1992; Olson & Wise, 1992; Riis, 1991). According to Riis (1991), teaching time is used more efficiently with computer support, and the pupils also seemed satisfied with such computerized drills. They also appreciated the opportunity offered by computer-based training to work in their own pace without being corrected by teachers (Riis, 1991). In a study by van Daal and Reitsma (2000) pupils with both reading and writing difficulties as well as motivation problems displayed a more task-oriented work method when training spelling with computers as compared to receiving similar teaching (without computers) in the classroom. It was also demonstrated in this study that computerized training improved pupils' spelling, with 'more time on task' pinpointed as a contributing factor.

One of the programs (Comphot) employed in Study 2 of this thesis is altogether phonologically oriented. This agrees with the results of a study by Saine et al. (2011), indicating that pupils running the risk of developing reading and writing difficulties are helped by computer-based phonological training to reach the same level in decoding and spelling as the control group. Yet another computer-based intervention study by Gustafson, Ferreira and Rönnberg (2007) demonstrates that phonological ability as well as variations in word decoding ability should be considered when designing efforts to train reading. This study was carried out with pupils in the second and third years of school who had reading problems. Computer programs of two different types were created: one with phonological and one with orthographic exercises. One difference was that the phonological program largely contained auditive exercises, while the orthographic one primarily consisted of different exercises involving written words and letters. The results demonstrated that pupils with pronounced phonological problems made greater progress in reading after receiving phonological training than those with the same difficulties who received orthographic training. It was also shown that pupils who initially had

pronounced orthographic problems were better helped by orthographic than by phonological training.

4.1.2 Factors to consider regarding intervention studies in reading instruction contexts

Unfortunately, there is still a dearth of evidence-based interventions in education as well as a paucity of knowledge of 'what works' and for whom (Snowling & Hulme, 2011). High demands are made on the implementation of a well-founded intervention. Troia (1999) highlights over 30 different criteria that in his view should be considered in connection with intervention studies. They include, for instance, the importance of random sampling, the existence of a control group, distinct accounts of the number of individuals, gender distribution, participants' age and a clear description of the contents of the intervention. Some aspects of relevance to this thesis are described below. One aspect with regard to sampling is to capture the group one intends to study. If the aim is to study the effects of different methods of reading training for pupils with specific reading and writing difficulties, it is relevant for the result that the sample consists of those who really have reading difficulties. A study, like the one made by Invernizzi et al. (1997), where 25 % of the population is included, represents a generous sample, which may even include pupils that do not really have any major reading problems. The reading ability of some of these pupils might improve regardless of the methods applied. If, on the other hand, the sample only comprises the 10 % weakest readers (as in Wise et al., 1999), there is a greater chance that those participating in the study really belong to the group with substantial reading difficulties. A sampling criterion that has been applied in several studies, including the second study of this thesis, is to allow the staff to select the pupils who should participate. This involves some uncertainty whether the right pupils are actually chosen. A study by Snowling (2011) shows, however, that the standard of teacher assessment of pupils' reading ability is high and that there is no great risk involved in making the sampling on the basis of these.

The next aspect concerns the reliability of the study and the possible appearance of a Hawthorne effect, in other words, whether the intervention results may be due to the extra attention paid to the pupils who participated in the study (see Adair, 1984). There are several studies which have tried actively to consider and try to control for the possibility of a Hawthorne effect (Gustafson et al., 2007; Hatcher et al., 1994; Wise et al., 1999). To control for such an effect, these studies have contained an arithmetic test at the beginning and end of the intervention. If the pupils in the experiment group had done better on the arithmetic test than those in the control group, a Hawthorne effect might be suspected. The same methodological approach with an arithmetic test included has been used in the second study of this thesis.

4.2 Response to intervention (RTI)

In recent years, especially in the USA, Response to intervention (RTI) has been much debated, which has led to new ways of organizing the teaching both of reading and of special needs in the comprehensive school (Berkeley, Bender, Peaster, & Saunders, 2009, Fletcher & Vaughn, 2009, Fuchs & Fuchs, 2006; Reynolds & Shaywitz, 2009; Rose, 2009). The studies included in this thesis are partly inspired by this view, for example by allowing some flexibility within each intervention and by comparing the effects of several different interventions, instead of assuming that a specific type of intervention should suit all pupils. We also used evidence-based methods, which are claimed to form a central element in RTI.

The basic ideas behind RTI involve trying to find the best teaching method taking into consideration how the individual pupil responds to the specially adapted pedagogical efforts made (Grigorenko, 2009). RTI is characterized by the following: general screening of all pupils to identify children at risk and using evidence-based interventions that are individually adapted, continuously followed up and adapted further for pupils who require extra support (Barth et al., 2008; Berkeley et al., 2009; Bradley, Danielsson & Doolittle, 2005; Fuchs, Mock, Morgan, & Young, 2003; Vaughn & Fuchs, 2003). In an RTI model, teaching is structured on different levels or in tiers (Berkeley et al., 2009; Vaughn & Fuchs, 2003). Most RTI models consist of three different levels, the idea behind being that they represent successively increasing intensive, specific and individualized efforts (Berkeley et al., 2009; Fuchs et al., 2003). Level 1 (Tier 1) entails teaching for all pupils by the class teacher in the classroom. Pupils who do not reach the "acceptable level" on this level will take part in Level 2 (Tier 2), where reading instruction takes place in smaller groups parallel with classroom work. Evaluations and result follow-ups are important aspects of this level. Individual assessments are made continuously, perhaps every second week and, if a pupil does not respond to the efforts made, the work may be intensified or changed (Mellard, McKnight, & Woods, 2009). The interventions are dynamic and the pedagogical work can be described as a step-by-step process. Since this work makes demands on pedagogical competence, special needs pedagogues and sometimes school psychologists, too, are involved at Level 2 to function as supervisors and/or to be directly involved in teaching the pupils (Berkeley et al., 2009; Gresham, 2004). Those pupils who still have reading difficulties and have not yet passed Level 2 are now referred to Level 3, which means even more intensive teaching in small groups or individually, with longer sessions and together with specially trained teachers (Denton et al., 2011). One advantage is, supposedly, that the use of a categorical dyslexia diagnosis is avoided and that the focus is rather on developing reading abilities (Fuchs & Fuchs, 2006). A pupil's reading difficulties is then defined on the basis of how he or she

responds to the teaching or to the interventions provided. The studies presented in this thesis are inspired by responses to interventions. In Chapter 7 a model is described which is partly inspired by response to intervention.

5. THE EMPIRICAL STUDIES OF THE THESIS – METHODOLOGICAL ASPECTS

The chapter begins with a brief introduction of methodological aspects of intervention studies and then goes more specifically into the studies that are made within the framework of the thesis. The chapter concludes with a short summary of each article, which is included in its entirety in Appendices 1-4.

5.1 Intervention studies

An intervention study in its purest form may be compared to an experiment where the outcome of one variable is controlled by actively manipulating another while all other variables are kept constant. This approach is neither implementable nor imaginable in the school world. What is, however, both implementable and desirable is research that enables an immediate systematic study of different pedagogical interventions and their effects. There are also scientific methods at hand for dealing with research of the type conducted in school environments rather than in laboratories. The use of different statistical analyses enables us to estimate the likelihood of whether a difference depends on a real, generalizable effect or whether it is random. The more individuals included in the population studied, the greater the reliability of measurements, and if the individuals are to be divided into different groups, this should be randomized. Even in retrospect there are statistical methods available to correct for effects of different confounding variables. Taking into consideration the methodological difficulties connected with intervention studies in this field, one should interpret the conclusions of a single intervention study with caution. There are also pedagogical models which may be regarded as possible bridges between quantitative intervention studies and reading pedagogy the way it is materialized in the classroom. One such model

is Response to intervention (RTI). A further description of RTI is presented in Section 4.3.

5.2 Studies and articles included in the thesis

The four articles included in the thesis build on material from two different studies. Study 1 should be regarded as a preliminary study, whose empirical material forms the basis of the first article in the thesis. The second, third and fourth articles are based on empirical material from Study 2. In the discussion I refer to Study 1 concerning results published in the first article (Fälth et al., 2011), and to Study 2 concerning results published in the other three articles (Gustafson, Fälth, Svensson, Tjus, & Heimann, 2011; Fälth, Gustafson, Tjus, Heimann, & Svensson, 2013; Fälth, submitted 2013). See Table 1 for a schematic picture of the studies and articles forming part of the thesis.

Table 1. Schematic picture of the studies and articles in the thesis

Studie	**1**	**2**		
Number of participants	14	130		
Number of test occasions	4	5		
Article	1	2	3	4
Type of data	Reading tests	Reading tests	Reading tests	Interviews conducted six weeks after completed intervention
Test occasions	1-4	1-3	1-5	
Period of time covered by the data	14 weeks	17 weeks	One year after completed intervention	

What is common to both studies is that they contain interventions conducted to promote the reading development of struggling readers in the early grades of the comprehensive school. Another common feature is that computer-based programs in training reading were used in the studies. One of the training programs, Omega-IS, was used in both studies.

5.2.1 Sample, participants and procedure

In Study 1 a total of 14 pupils participated, 11 boys and 3 girls from grades 1-4. The sample was based on two tests, Fonolek ('Phonogame', Olofsson & Hemmingsson, 1993) and Vad sa du fröken? ('What did you say, Miss?', Alstam-Malcus & Fritzell, 2006), which were conducted in pre-school with children aged 6. Pupils who did not reach the accepted level on these two tests and who were assessed by their class teachers as requiring special needs tutoring in Swedish were requested to take part in the study. After matching the pupils by sex and age they were divided into two groups. Group 1 was randomly assigned to using the computer-based Omega-IS program for reading training (see 5.2.2) during the intervention and Group 2 was assigned to Reading Recovery (se 5.2.2). The pupils were tested individually by different reading tests on 4 occasions (see Figure 1).

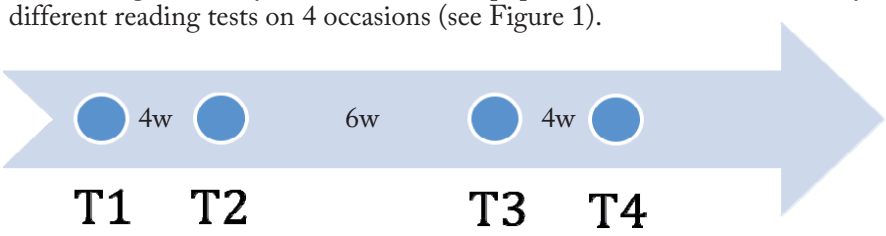

Figure 1. Test occasions in Study 1

Four weeks passed between test occasion 1 (T1) and test occasion 2 (T2).The intervention took place between T2 and test occasion 3 (T3) and lasted for 6 weeks. Another 4 weeks passed between T3 and test occasion 4 (T4).

During the intervention period all pupils received one-to-one tutoring by their ordinary special needs teacher on a total of 20 occasions. For the group training with Omega-IS the sessions lasted from 15 minutes at the beginning to 40 minutes at the end of intervention. No other special tutoring during the intervention was provided, and the children had no reading homework. In the Reading Recovery group the sessions were 30 - 40 minutes each. This group also had homework linked to the method on 20 different occasions. The homework lasted for 10 - 20 minutes, always with a parent present.

In Study 2 participated a total of 130 pupils and 42 teachers from 41 different Swedish schools, including both city and countryside schools. All the pupils had spent a little more than half the autumn term in grade 2 when the study began (test occasion 1). The average age of the pupils on the first test occasion was 8 years and 5 months. Out of the totally 130 participants 100 had been selected during the second half of the spring term of grade 1 by their own class teachers and/or special needs teachers as being pupils supposed to require extra support in Swedish during the following term (the autumn term of grade 2). The remaining 30 pupils, who were defined by the class teachers as "typical readers", constituted a control group. This group was selected by drawing lots in five of the participating schools, with 5 pupils per school. The sex distribution in the control group mirrored that of the study group with a percentage distribution between boys and girls of 70/30. In the control group the percentage distribution between boys and girls was 63/37. The 100 pupils selected for the experiment were matched by sex and word decoding ability and randomly assigned to four different groups. Group 1, consisting of 18 boys and 7 girls, was assigned to using the computer-based Omega-IS reading training program during the intervention. Group 2, comprising 17 boys and 8 girls, was assigned by lot to using Comphot (Phonological training), the other computer-based reading training program), while Group 3, including 17 boys and 8 girls, alternated every second time between the two programs (Combined training). Group 4, finally, which contained 18 boys and 7 girls, was assigned by lot to receive regular special needs tutoring.

During the intervention period all pupils received one-to-one tutoring by their regular special needs teacher on 25 occasions in all. Every lesson lasted between 15 and 25 minutes. Groups 1-3 always worked with their training programs. In the fourth group the special needs teacher in question tailored the tutoring to suit the pupils' needs in Swedish. The pupils were tested individually by different reading tests on 5 occasions (see Figure 2).

Article 2 deals with test data from the start as far as and including the third test occasion, a period which lasted about 4 months, while Article 3 has a more long-term perspective, containing all test data from five different measuring points, spread roughly over a year. See Figure 2 for a survey of the test occasions in Study 2.

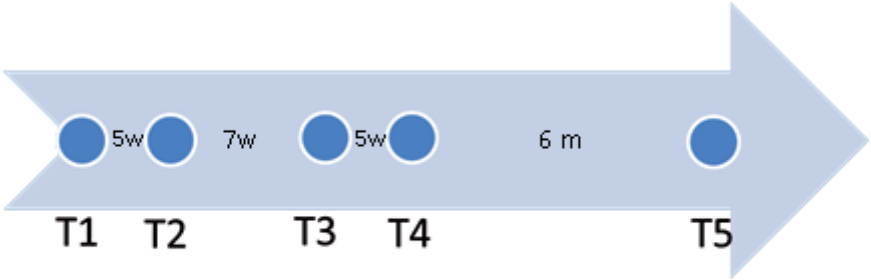

Figure 2. Test occasions in Study 2

Between the first (T1) and the second test occasion (T2) 5 weeks passed. The intervention took place between T2 and the third test occasion (T3) and lasted 5-9 weeks. Between T3 and the fourth occasion (T4) there was an interval of 5 weeks and between T4 and the fifth (T5) 6 months. In the presentation of the results in Articles 2 and 3 the values of each test and group are weighed together at T1 and T2 to form a 'baseline' in order to achieve a starting value with maximum stability.

The fourth article is based on interview material with participating pupils and teachers from Study 2. Altogether, 25 pupils and 18 teachers were interviewed. All the interviews were conducted individually. The questions concerned their perceptions and experiences of their participation in the intervention study (see also Section 5.8). This article includes an account of how these experiences may help interpreting the quantitative results, which are described in the second and third articles of the thesis.

The empirical material of Study 1, which constitutes the first article, has been gathered by me. I have tested the pupils on 4 occasions and conducted the interventions together with them. I am the principal author of the first article. The empirical basis of the second and third articles belongs to Study 2, where I functioned as one of the test leaders for the pupils. Twenty-five out of a total of 130 pupils were tested by me on five different occasions. I am co-author of the second article and principal author of the third. The data containing all the interviews, transcriptions and interpretations for the fourth article has been collected by me. I am the single author of this article.

Every article is summarized in Section 5.5 – 5.8 under the headings: aim, participants, procedure, materials, results and discussion. The articles are presented in their entirety in Appendices 1 - 4.

5.3 Training programs used in the studies

5.3.1 Reading Recovery

In Study 1 in this thesis Reading Recovery is one of the method used, and in order to facilitate the understanding of this article (Fälth et al., 2011), the concept is introduced here.

Reading Recovery is an early intervention program for children who were slow at learning to read and are therefore liable to literacy difficulties. The program was first developed in New Zealand in the 1970s by Marie Clay, and was in use there for over 30 years. It comprises 12–20 weeks of intensive, one-to-one tuition taking place every day targeted in particular at the lowest 20% of children with regard to literacy attainment, and was taught by specially trained teachers (Clay, 1993). According to Clay, reading is a psycholinguistic process where the teacher creates meaning out of a text. Clay argues that reading is about communication between reader and author and that the requirement for becoming a good reader is to read coherently and to choose a text that is meaningful for the individual, which is in line with the reasoning in Section 2.5.

Both reading and writing are included in Reading Recovery. Each session lasts for 30 minutes, with the specially trained teacher involving the pupil in various activities concerning texts appropriate to the reading level of the child. They include re-reading texts previously encountered, identifying letters and words, writing and reassembling a story, and reading another text. When children have reached the point that they can write and read texts which the average child in their class can, they are 'successfully discontinued' from the program (Clay, 1993). Children who do not achieve this target are usually referred to special education. One of the purposes of the program is to provide the pupils with strategies, e.g. for self-monitoring and how to make use of contextual clues when correcting their reading (Clay, 1993), which is in line with the discussion in Chapter 2 and 4 about pupils' metacognitive ability.

Reading Recovery has been criticized for being an expensive and not particularly effective program for reading training (Center et al., 1995). Iversen and Tunmer (1993) examined whether the program could be made more effective by introducing more systematic training in word reading. Thirty-two pupils in the first grade who were running the risk of developing reading and writing disabilities were divided into three groups. The first group used Reading Recovery, while the second group worked with Reading Recovery with phonological training elements added, by which the pupils learnt to discover that a number of words have the same letter sequence. With the help of magnetic letters words were built that existed in the texts the

children read. The teacher might, for example, choose the word *and*, lay it out and read it, mix the letters and then ask the pupil to lay the word again. When the pupil managed both to read and lay the word, the teacher added a new letter before it to form another word *(land, sand, band, hand)*. The third group participating in the study was a control group. The result of the intervention showed significant differences in reading development post intervention for the two Reading Recovery groups in comparison with the control group. Significant differences were also found between the two Reading Recovery groups, which illustrated the clear advantages of the group that received extra elements of phonological training. The conclusion drawn from the study was that the children at risk of developing reading difficulties learnt to read faster when a more systematic training in word decoding was added. This working method was preferable to the activities in the control group, whose pupils did not receive this explicit training in word decoding (Iversen & Tunmer, 1993).

In the first study of the thesis a modified variant of Reading Recovery was employed, similar to the one used by Iversen and Tunmer (1993). The contents described above were included, as well as elements of phonological training like getting the children to listen for the first or last sound of a word. These elements of adding phonologically oriented training are in line with the discussion in Section 2.2.

5.3.2 Omega-IS

The computer-based reading comprehension training program, named Omega-IS (Omega-Interactive Sentences) (Heimann, Lundälv, Tjus, & Nelson (2004), was used in both of the studies included in the thesis. The program applied a top-down strategy including both word and sentence level processing of written language. By clicking on text buttons with words or phrases, the child "wrote a sentence" like "The dog chases the dinosaur", and then the child heard the pre-recorded spoken sentence, followed by an animated illustration of its meaning. Thus the program offered a close to one-to-one correspondence between text, speech and animations for semantic comprehension and the training of text material. The lessons included in the program went from two-word (noun + verb) and three-word sentences (noun + verb + noun) to stories inside which the children could construct their own stories choosing different actors and scenarios in order to increase their motivation to explore literacy. In total, it was possible to construct more than 1900 different sentences and receive feedback in the form of speech and animations, as described above.

Positive results on reading ability when using Omega-IS have previously been reported, among others, for children with autism and children with cerebral palsy (Tjus, 1998; Tjus, Heimann, & Nelson, 2004) and pre-school children at

risk of developmental dyslexia (Helland, Tjus, Hovden, Ofte, & Heimann, 2011). Increased motivation for reading (Tjus, Heimann, & Nelson, 2001) and positive effects on processing speed (Tjus, 1998) have also been observed.

5.3.3 Comphot

The computerized phonological training program COMPHOT (Ferreira, Gustafson, & Rönnberg, 2003) was used in Study 2. The program contained four sections: Rhyme (4 exercises), Position (8 exercises), Addition (5 exercises) and Segmentation (3 exercises). Exercises were mainly phonological and sound-based. Pictures were included in the exercises, and when participants clicked on them the corresponding words were sounded out by a natural, recorded voice. The task for the child was, for instance, to decide which pictures depicted words that rhymed or had the same initial phoneme. In other exercises the task was to combine or remove phonemes or segments of words. There were also some links to written letters and words. The units of language that were focused on in COMPHOT were phonemes, word segments and whole words. No sentences or passages were presented to participants. In order to make the exercises entertaining and motivating, game-like elements were included. The program supplied direct feedback to the participant. After correct choices the computer responded with a “happy” sound, and when the child made a mistake the computer produced a “sad” sound. There were also personal high score lists where children could check their performances on the different exercises.

Comphot was used in a previous study (Gustafson et al., 2007). The results from that study indicated that phonological training with Comphot was effective in promoting reading skills for children with reading disabilities in grades 2 and 3, especially for those with pronounced phonological problems.

5.4 Ethical review

The empirical studies which form the basis of the four articles in the thesis have been vetted and granted an ethical permission by the Regional Ethical Review Board in Linköping (reference number 131-08). The ethical issues especially considered in the application concerned sampling, information on consent and ethical considerations in connection with the test occasions. As the participants were children aged eight, consent was required from the children themselves as well as from their parents. We used separate letters of consent, one to the parents and one to those children who were potential project participants. At the testing and also during the intervention, test leaders and teachers were instructed to look out for signs of unease among the pupils.

This was especially important as children are in a position of dependence and may feel forced to participate.

5.5 Summary of Article 1

The effects of two training programs regarding reading development among children with reading disabilities.

Aim

The aim of this study was to examine the effects of two different training programs on the reading skills of children with reading disabilities. In addition to group comparisons, individual differences of the effects of the interventions were reported.

Participants

Fourteen pupils from grades 1-4 participated in the study. All participants possessed reading difficulties. The pupils were divided into two groups, matched by sex and age. The intervention type for each group was randomly assigned.

Procedure

The participants' reading ability was tested on altogether four occasions: twice before the intervention, with an interval of 4 weeks, and twice after the intervention, this time, too, with a four-week interval. The intervention took place between the second and third test occasions and consisted of 20 lessons of one-to-one tutoring. The study contained two different interventions: the first group was assigned by lot to use a Reading Recovery-inspired intervention (for details see Section 5.3.1) while the other group used Omega-IS, a computer-based program for training reading (for details see Section 5.3.2).

Material

Three tests were used for measuring the participants' reading skills with regard to word decoding. *Word recognition* was assessed by the Wordchains test. *Sight word reading* was assessed by an individual reading pace test. In the *Non-word reading test* the pupil was asked to read from a list as many non-words as possible in one minute. Even though these are not real words, they can be pronounced.

Results

The most striking finding from this study was the size of the gains in reading achievement made by this sample of disabled readers. As a result of the intervention, both groups improved significantly in all tests assessing word and non-word decoding. No statistically significant differences were yielded between the intervention programs

Discussion

The conclusion was that one-to-one tutoring has a positive impact regardless the method used. A discussion about home assignments was also included. Judging by the result of the Omega-IS group, it might also be possible to reduce the homework for children with reading disabilities if their reading is well tutored in school.

5.6 Summary of Article 2

Effects of three interventions on the reading skills of children with reading disabilities in grade 2

Aim

The aim of this study was to measure the effects of three intervention programs with the purpose of improving reading ability among children with reading disabilities in grade 2.

Participants

Altogether 130 pupils participated in the studies. Of these, 100 were selected by their class or special needs teacher as pupils needing special support in Swedish. These pupils also performed at least .75 standard deviations below the mean of the typical readers on a sight word reading at the first test session. The remaining 30 pupils were so-called typical readers.

Procedure

The participants (100 pupils in the experiment group) were matched by age, sex and word decoding ability and divided into four different groups. The remaining 30 typical readers formed a control group. Next, the groups were randomly assigned to using different computer-based reading training programs, either Omega-IS or Comphot, or a combination of the two. The fourth group was assigned to ordinary special instruction. Detailed information about each program is provided in Section 5.3.2 and 5.3.3. The fourth group was not allotted any specific training program, but it was up to the special needs teacher to tailor the tutoring of the pupil in question. All teaching in these four groups was done on a one-to-one basis. Every participant was tested on 5 test occasions by a battery of reading tests (see Material). The results from the first three measurements were presented in this article.

Material

The test battery included measures of reading comprehension, passage comprehension, word decoding, pseudo-word reading, segment subtraction, RAN, verbal fluency, spelling, working memory and arithmetic.

Results

The results demonstrated that the effects of the interventions can be regarded as satisfactory for all the three interventions that included computer-based training. The most positive effects were obtained for the group that received combined training. When a composite change score representing general reading improvement was calculated, the results showed that the progress in reading made by children who received combined training was significant higher than that of ordinary special instruction.

Discussion

The positive results of combined training were discussed and are in line with previous studies. The positive effect might also be due to the participants being a heterogeneous group where both decoding and reading comprehension difficulties are represented. The discussion includes the argument that the group receiving the ordinary special instruction had an advantage compared to the three interventions, because the special needs teachers were free to choose the reading instruction they thought would best meet the specific requirements of the individuals.

5.7 Summary of Article 3

Computer-based interventions targeting reading skills of children with reading disabilities – A longitudinal study

Aim

The aim of this longitudinal study was to examine the effects of three computer-based interventions for children with reading disabilities: phonological training, comprehension training and a combination of both. We also examined how the results persist over time at two different follow-up sessions that extended over a year.

Participants

Altogether 130 pupils participated in the studies. Out of these, 100 were selected by their class or special needs teacher for needing special support in Swedish. These pupils also performed at least .75 standard deviations below the mean of the typical readers on a sight word reading at the first test session. The other 30 are so-called typical readers.

Procedure

The participants (100 pupils in the experiment group) were matched by age, sex and word decoding ability and were then divided into four different groups, with the remaining 30 typical readers as a control group. The groups were subsequently assigned by lot to using different computer-based reading training programs, either Omega-IS or Comphot, or a combination of the two. The fourth group was assigned to ordinary special instruction. Detailed information on each program can be found in Section 5.3.2 and 5.3.3. The fourth group did not make use of any specific training program, but there it was up to the special needs teachers to tailor the tutoring for each pupil. All teaching in these four groups was done on a one-to-one basis. All participants were tested on five occasions with a battery of reading tests (see Material below). The results of all five measurements were introduced in this article.

Material

The test battery included measures of: reading comprehension, passage comprehension, word decoding, pseudo-word reading, segment subtraction, RAN, verbal fluency, spelling, working memory and arithmetic.

Result

The results demonstrated that gains in decoding, reading comprehension, and non-word reading can be achieved by intensive phonological training in combination with reading comprehension training and that these gains persist over a 1-year follow-up period. The results of development over time with regard to sight word reading, reading comprehension and non-word reading were presented in development curves illustrating that the gap between typical readers and the combined group in particular decreased from the baseline to the second follow-up. These results were strengthened by the declining number of pupils in the combined group who were in need of special education after a period of 1 year.

Discussion

Our results suggest that combined training was the most effective method in this study even though the total amount of training was equivalent between the intervention groups. Our participants had decoding or reading comprehension problems, or both, and an intervention covering both components might therefore provide suitable contents for most of the children in this group. A factor contributing to why the combined training was the most effective intervention could be the variation it offered when using two programs different approaches. This may have resulted in maintaining motivation to a greater extent among the pupils who were part of the group receiving combined training.

5.8 Summary of Article 4

The need of variation – pupils' and teachers' experiences of participating in a reading intervention study

Aim

The aim of the study was to describe and analyze pupils' and teachers' experiences in participating in an intervention study in order to elucidate the quantitative results previously reported from that study.

Participants

The participants of the study were 25 pupils and 18 teachers. The reason for the number discrepancy was that some of the participating teachers had two pupils taking part in the study. The pupils and their teachers were part of an intervention study comprising a total of 130 participants. The aim of that study was to promote reading development among the pupils.

Procedure

All the interviews were conducted individually. Each teacher interview took on average 45 minutes, and each pupil interview 20 minutes. The questions to both teachers and pupils concerned the contents and form of the interventions. The interviews were processed on the basis of inductive thematic analysis which involved searching through data to identify recurrent patterns and keywords. Finally, the material was summarized and quotes from the interviewees were used to illustrate and clarify the text.

Results

The results of this study highlight the quantitative results we found in Articles 2 and 3 above (Gustafson et al., 2011; Fälth et al., 2013), where a method for reading training entailing a combination of phonological and orthographic comprehension training turned out to be the most effective in promoting students' reading development both in the short and the long run. The principal results accounted for in this article were as follows: A) the framework of an intervention study is important, but flexibility within the framework is even more so, B) variation within a strict framework maintains the motivation of both pupils and teachers, and C) the system of computer-based training creates confidence in the pupil.

Discussion

The importance of flexibility within an intervention is a distinct result of this study. In this context this means both variation and level adaptation, but also flexibility in the sense of being able to individually adapt the contents to the needs of the pupil during the class session in question. Variation here means that the contents are sufficiently variable for maintaining pupil motivation. Although there are several studies enhancing the importance of motivation in pupils, this study has also made the motivation of the teacher visible.

6. GENERAL DISCUSSION

This chapter contains a discussion of the results to which the empirical studies of the thesis have contributed, linked to research in the field. The focus of the discussion is pedagogical and the intent is to use the intervention studies of this thesis as a basis for discussing how reading ability can develop in pupils with reading difficulties. Starting from the empirical results, the chapter is introduced by a discussion of combined reading instruction and various possible interpretations of its positive effects, focusing on the concepts of motivation, structure and computer-based training. The durability of the results is focused under the heading "Long-term effects", which is followed by considerations regarding intervention as a method for teaching reading. The discussion creates a platform for the next chapter which deals with pedagogical implications leading to presenting a model of how to organize the teaching of reading based on an intervention plan for pupils with reading difficulties.

6.1 Positive effects of combined training

One important result from the thesis is that combined training turned out to be efficient both in the short (Article 2) and the long run (Article 3). The results of Study 2 showed that intervention combining phonological training and reading comprehension training was significantly more effective than regular special needs teaching. The observed improvements for the combined training were also higher than for each training program separately. This is in line with results shown in several studies (e.g. Hatcher et al., 1994; Hatcher et al., 2006; Iverson & Tunmer, 1993 and Lovett et al., 2000) that interventions combining phonological training with some other type of reading or comprehension training have positive effects on pupils' reading ability.

To what extent any reading difficulties will affect an individual depends largely on the educational preparedness of the school (Fouganthine, 2012).

Some questions are raised: What does effective educational preparedness look like? How should teaching be conducted to prevent any pupil from lagging behind in reading? On the basis of the results of this thesis and in line with previous studies (e.g. Hatcher et al., 2006; Saine et al., 2011; Snowling, 2011 and Torgesen, 2005) educational awareness should include resources for organizing teaching in small groups or on a one-to-one basis for a limited period for pupils who already have problems with their reading or are running the risk of facing such. A possible interpretation of the long-term results is presented further on in the discussion.

The results of Study 2 where a composite score of reading was used (see Article 2: Gustafson, et al., 2011 for further information) illustrate that the progress in reading of pupils who received combined training was statistically significantly higher than that of those in the group receiving regular special education. Even when comparing the combined training group with pupils from the control group (so-called typical readers) the combined group represents a steeper development curve (see Article 3). The combined group never catches up with the control group, but the gap between the groups diminishes between the first test occasion and the last. These results agree with those of Lovett et al. (2000) in demonstrating that a combination of phonological training and the teaching of reading strategies and reading comprehension was more effective than training with each program separately. Compared to Lovett's study, our study contains, in addition to the control group consisting of so-called typical readers, yet another comparison group. The latter consists of pupils with reading difficulties who received regular special needs teaching instead of participating in one of the groups training with the specific programs. A study conducted by Frost et al. (2005) may also underline the results from the second and third articles in the thesis by showing that a combination of phonological and semantic skills is important for early reading development.

The positive results from the group receiving the combined training in Study 2 is reinforced by the stronger reduction of the number of pupils who still require special needs teaching in Swedish in comparison with the other groups. Only seven out of a total of 25 in the group receiving combined training still received special needs teaching after finishing the combined intervention. The other three groups included between 20 and 22 of a total of 25 pupils who still required special needs training support after the intervention. This difference was statistically significant (see Article 4).

What is it that makes the combined training effective? One possible explanation, supported to some extent by Iverson and Tunmer (1993), is the likelihood that training with a broad approach is better suited for including more pupils like those participating in the study with their great variety in

types of difficulties. The results from Study 2 also show that combined training seems to be most effective for pupils with initially high values on tests that measure working memory and logical thinking (Articles 2 and 3). This might indicate that such training requires that the pupils possess some cognitive flexibility to be able to draw the most benefit from it.

The design of Study 2 allows us some control of the teacher effect but also of school effects, which would not be the case if we had, for example, made half the schools use one program and the other half the other program. All participating teachers had, as far as possible, at least 2 pupils each participating in the study and belonging to different intervention groups. If we had allowed the participating teachers to use the same program for both their pupils, the risk of teacher effects had been greater.

Another aspect of the reliability of the results is whether there might exist a Hawthorne effect, i.e. whether the result of the intervention may depend on the extra attention devoted to the pupils. Methodologically, we have tried to control for a Hawthorne effect by including 'something new' into all three experiment groups. In their reading training they were all allowed to use computer-based programs that were entirely new to them. All groups received the same number of one-to-one-tutoring training occasions. In addition, there were two control groups, one of which consisted of pupils with the same kind of reading difficulties as in the experiment groups. A further measure taken to obviate any Hawthorne effect involved the use of a test not related to reading or reading-related skills. This was an arithmetic test whose purpose was to see whether the pupils increased as much on that test, which measured skills which they had not trained during the intervention. The results showed no increase in their results of the arithmetic test other than what could be expected as a natural consequence of having grown one year older and passing one more year at school.

6.2 The motivation aspect

One possible explanation, emanating from the result of Study 2, that could supplement the above discussion is the perception of the combined training as a motivating factor for both pupils and teachers and thus contributing to the positive effects of the training (Article 4). Naturally, the motivation factor is important when learning to read (Taube, 2007a). Indeed, research suggests that interventions focusing on improving both reading skill and reading motivation produce greater improvements in children's reading attainment (Guthrie, Mckae, & Klauda, 2007). However, in order to make the most of the reading motivation, it is important to understand the factors that may influence

it. While the relationship between children's motivation for and their skill at reading has been established (e.g., Baker & Wigfield, 1999; Wang & Guthrie, 2004), it is possible that other factors, such as personality characteristics (Medford & McGeown, 2012) as well as the structure of the intervention, influence children's motivation to read. The results described in the fourth article of the thesis make it clear that it is the variation offered by the combined training by its use of two different training programs with a different focus that is motivating. The pupils in the combined group were more able to mobilize attention and maintain concentration during the intervention period than the pupils in the other three groups (Article 4). This argument could also be expanded to illustrate the importance of motivation as contributory to why the combined training has the greatest positive effect on pupils' reading ability.

Taube (2007b) and Medford and McGeown (2012) elucidate the importance of the motivation factor linked to reading from the pupils' perspective, in addition to which the results of the second study of this thesis also highlight the importance of motivating teachers for interventions to succeed. Those participating in Study 2 stated that the combined training was motivating not only for the pupils but also for them in their capacity of teachers. In Study 2, a group of pupils took part who received regular special needs teaching to which was added the study's demands concerning intensity and one-to-one tutoring. How to plan the teaching after the individual pupil's requirements was up to every individual special needs teacher. Judging by the results of the reading tests of various kinds presented in the second and third articles of the thesis, the combined training did significantly better than the regular special needs teaching, as already mentioned. In addition to the quantitative results of these tests (see Articles 2 and 3) the interviews with the teachers confirmed that being involved in the combined group had been perceived as motivating. The discussion illustrates that a successful intervention is characterized both by being matched against the pupil's need of knowledge (cf also Tunmer & Greaney, 2010) and by being motivating both for pupils and teachers. This is in line with the argumentation in Section 2.5, where Jenner's (2004) factors characterizing the motivation process are described. The first factor emphasizes that the goal must not be too distant, and that it is important for the pupil to feel that this can be managed. This is turn is related to Jenner's third factor concerning the likelihood of failing, and the way pupils view their chances of succeeding. If the contents of an invention are matched to the pupil's cognitive level, there is great likelihood that the outcome will be success and not failure. If, in addition, the matching succeeds in pinpointing the pupil's need of knowledge, it also touches Jenner's second factor, which deals with the value of attainment, in other words, what the pupils themselves perceive as valuable and worth attaining. This reasoning agrees with what emerged from the interviews with the pupils (Article 4) when they expressed

the advantage of knowing beforehand what was expected of them during the intervention period. It was a matter of both knowing how long each work session would last, how many sessions in all they were to work, but also what were the contents and structure of each lesson.

There is a significant emphasis within education on improving children's reading and motivation to read. However, knowledge of the factors underpinning reading motivation is necessary in order to succeed. A study by Medford and McGeown (2012) suggests that children's reading motivation is not only predicted by their reading experiences, but also by personality characteristics. By improving their knowledge of the predictive factors, educators will be in a better position to identify ways of raising the levels of motivation within the classroom. In addition, differences in personality characteristics suggest that it is important to consider the individual when implementing educational and motivational strategies and interventions (Medford & McGeown, 2012). This is underlined by the results of Study 2, with different pupils perceiving different aspects of the interventions as motivating. Several of them mention the contents of the intervention and even give examples of some exercises, while others emphasize the importance of the form or structure for the motivation they felt.

6.3 The importance of structure coupled with flexibility

Even from a teacher perspective, the structure of the intervention was perceived to be motivating. We already know that actions have to be systematic (Kjeldsen et al., 2003) to be effective for pupil´s reading development. The perception of systematics as also motivating for teachers was made clear in the fourth article. Several of them state in the interviews that they will reorganize their special needs teaching after participating in this intervention study. Their intention is to plan a more intensive and structured teaching which goes on for a limited period and then to evaluate the activities. The conclusion drawn from the interviews that both pupils and teachers perceive the systematics of the activities as important agrees with Kjeldsen et al. (2003). According to several teachers, the importance of a structured special needs teaching was made visible during the time of the intervention study, whose structure with its pre-determined number of lessons contributed, in their view, to giving the participating pupils the needed 'more time on task'. The participating teachers agree with previous research (e.g. Fast, 2007; Johansson, 1992; Olson & Wise, 1992; Riis, 1991 and Roth & Beck, 1987) that this contributes to the positive development of the reading ability in all groups. In the light of the much needed amount of training, both studies

clearly illustrate that breaks from this intensive special needs teaching are necessary. The necessity of building breaks into such teaching to avoid it from being constantly pursued with the same intensity and structure for a whole term or school year is something that has dawned upon several teachers, as they say, and made them motivated for it. The pupils, too, describe the break from the intensive reading training that occurred after completing the intervention as something positive.

Another aspect regarding the structure of interventions became visible in Study 2, whose results demonstrate that some flexibility within the rigid framework is beneficial. It appeared in interviews with the teachers that they were positive about not feeling locked by a structure that was too rigid. All teachers appreciated being able to influence the intervention, as the lesson contents were not entirely predetermined. For each intervention group there were given frames for the teachers to keep within with regard to the number of lessons and the minimal requirements for the length of each lesson. The flexibility meant that they could adapt the level of difficulty by choosing exercises and the time to devote to each lesson. Even the length of the entire work session could be individually adapted and altered from time to time. There is of course a risk in research contexts that a structure like this could lead to lower internal validity, since the work sessions during the intervention do not look exactly the same for all participants. Caffrey, Fuchs and Fuchs (2008) comment on this in terms of studies that are 'research based' or 'clinically based' with the goal of the latter being to maximize the pupil's learning rather than conducting generalizable research studies. There are greater chances of individualizing if one need not overly consider reliability and generalizability when the primary goal is to maximize the learning of an individual (Navarro & Mora, 2011). To assume that there is an intervention or structure that suits all pupils is not reasonable, as pupils differ and develop differently over time (Aaron, 1997; Gustafson et al., 2000; Navarro & Mora, 2011).

In addition to arguing that interventions should be well structured, as described above, previous research demonstrates that they also have to be intensive (Denton, et al., 2006; Wolff, 2011). As for intensity, the results of the studies conducted within the framework of this thesis show that both pupils and teachers perceived the intensive structure as positive. Calculated on the basis of all 100 completed interventions in Study 2, the average was 3.9 classes per week. Besides the number and length of classes per week, the intensity level involves how long the intervention is supposed to proceed. Among the questions to consider are: How many classes in all should there be during the intervention period? Alternatively, for how many weeks should the intervention proceed? The result of the second and third articles of the thesis illustrates both short- and long-term positive effects of concentrating the

teaching during a limited time period. This is in line with results from studies by Bus and van IJzendoorn (1999) and Underwood (2000), which show positive effects of periodically intensifying the special needs teaching.

It emerges from the interviews with the pupils that they felt positive about knowing beforehand how many work sessions were to be conducted during the intervention. Some pupils had work schedules where they ticked off every class and had "a countdown, just as before Christmas", as one girl expressed it (Article 4). According to the National Reading Panel (2000), an intervention for pupils with reading and writing difficulties should last about 20 hours, which also sounds reasonable when taking the results of our studies into account. Several of the teachers claimed that in order to maintain both their own and the pupils' motivation, it was necessary with a break following after completing the intervention.

6.4 Interventions with computer-based training

As both the training programs used in Study 2 (Omega-IS and Comphot) are computer-based, one explanation for the positive reading results in the experimental groups may be the motivating power of computers, as shown in previous studies (e.g., Fawcett & Lynch, 2000, Folkesson & Swalander, 2007; Hall, Hughes, & Filbert, 2000 and Riis, 1991).

Omega-IS was first used in Study 1 after only having appeared in reading teaching contexts for pupils received into special school for pupils with learning disability, for whom it had proved to be very beneficial (see e.g. Tjus, 1998). The positive results for Study 1 refer to using Omega-IS in the comprehensive school, which led to the decision to transfer the program to Study 2. Training with Comphot also gave positive effects in earlier studies for pupils with reading and writing difficulties (see e.g. Gustafson et al., 2007). Study 1 applies another non-computerized reading training program (Reading Recovery; see Section 5.3.1 for more information). The results show positive effects of both programs with some advantage for the computer-based one. As the pupils included in the group that trained with the computer-based program had no home assignments linked to the intervention, in contrast to the Reading Recovery group, the outcome suggests an advantage for the computer-based program. It should however be pointed out that the Reading Recovery concept without home assignments included has not been tested in this context.

Both Omega-IS and Comphot contain a function giving immediate feedback on the tasks. This was positively regarded by the pupils, judging by the

interviews. Having their efforts confirmed in the form of feedback from the computer was commented on by several pupils. They liked it when "the computer was happy", as one pupil expressed it. Even when the task was not correctly performed they got feedback, as this pupil comments: "When I've made a mistake in a task I've often thought inside my head that this is probably wrong, and then it's a good thing that the computer tells me so, but here I don't have to explain how I thought but instead I get a new chance as if nothing had happened" (Quoted by a pupil participating in Study 2). This is an experience worth pondering about as a teacher. Are teachers sometimes too anxious to try to understand how pupils think when they do a task wrongly? Sometimes it may be enough to agree with the pupil that things did not turn out quite right and hand out a new similar task. Built into both programs is also a pause, where the teacher is exhorted to reflect on and make the pupil aware of the purpose of the task just performed. This somehow illustrates a metacognitive approach (Andreassen & Bråten, 2011; Myrberg, 2003), like the one advocated by Palinscar and Ransom (1988), the purpose of which is that the pupil learns what thinking strategies are successful in this context.

Torgesen et al. (2010) problematize the teacher's role in computer-based training: Is the training more efficient if the teacher devotes more time to preparing the pupils for the exercises to be done, or if the teacher is present during the work sessions? Torgesen et al. (2010) argues that if the effect of the added teacher time is small, it may be meaningful either to prolong the computer work sessions for the individual pupil or reduce the participation of the teacher and utilize the educational resources in other ways. In both studies in this thesis the teacher plays an active role in the computer-based training, and the results of the teacher interviews demonstrate that they perceived their participation as an important element in the training. Similar results concerning the importance of a participating teacher for a successful intervention are presented in a study by Bowyer-Crane et al. (2008). Like the structure of that study, our studies, too, offered opportunities to clarify and explain the tasks to the pupils, which was considered valuable by all participating teachers. Some of them expressed that talks with the pupil in connection with the exercises made them aware that even though the text on the screen was correctly decoded the pupil did not wholly understand the meaning of it. This offered the teacher a chance to explain the contents to the pupil, which is in line with the argumentation of Keene and Zimmermann (2003) about the importance of making pupils aware of what they have read. A majority of the teachers in Study 2 mentioned, however, that the teacher support could be reduced the further the pupil had become acquainted with the program. This is visualized from the perspective of the pupils in the interviews presented in Article 4. According to them, the systematics of the computer programs made them feel at home with the way the classes were structured, which was of course a positive experience. The description above supports

Torgesen et al. (2010) as well as the participant teachers' notion that computer training releases time for the teachers. If it should be possible to reduce the teacher support without jeopardizing the outcome (effectiveness) of the interventions the resources for computer-based interventions would not have to be as extensive (Torgesen et al., 2010).

6.5 Long-term effects

The results of Study 2 demonstrate that the positive intervention effects on the pupils' reading ability in the short run (Article 2: Gustafson, et al., 2011) remain even at the last measurement, which was performed half a year after the intervention was completed. Theses long-term effects are in line with the results of a study by Vellutino, Scanlon and Sipay (1997), one year after the intervention those children who were classed as 'treatment responders', and who made marked gains during the intervention, were found to have maintained these gains. In our study this is illustrated by the development curves in Article 3 (Fälth et al., 2013), which show a positive development of various reading-related abilities at the group level even afterwards. These development curves visualize how the gap between so-called typical readers and the group receiving combined training diminishes over time. There may be different explanations for this. It may be a matter of delayed effects due to an increased ability to focus on and sustain attention, a possible interpretation of results that is also made in the study by Torgesen et al. (2001). Alternatively, this development might derive from efficient teaching in reading and writing after the intervention. That the results remain and the pupils continue to develop their reading abilities could also be because of changes in their reading habits and because they actually read more after participating in the intervention. Furthermore, since the summer holidays fell between the last two measurements of the development curves, it might argue for the latter explanation about a positive change of reading habits. The most probable explanation is, after all, a combination of the above. It is important to point out that reading difficulties can be counteracted by preemptive activities in preschool (Lundberg et al., 1988; Lyytinen et al., 2004) as well as by continued training during school years (Catts & Kamhi, 2005; Gustafson et al., 2011; Wolff, 2011).

6.6 Essential prerequisites for implementing a good intervention

In Study 2 we drew on teachers' knowledge about their pupils to determine which pupils were in line for participating in the intervention study. The

teachers were asked to state which of the pupils in the first year of school would in their view require extra support in reading when starting on their second year. As this way of sampling involved both advantages and disadvantages, it may of course be questioned (Snowling, 2011). One advantage for the research team was that we saved both time and resources on not conducting large-scale screening, which would have been an alternative to the teacher estimates. Other studies (e.g. Juel, 1996 and Snowling, 2011) indicate that teachers on the whole possess a good knowledge of their pupils and that the risk that some pupil should be left undiscovered is less than the other way around. What we could confirm, after carrying out the first test, is that these selected pupils' reading ability lay below the level expected at their age. The results on the reading and writing tests of all the one hundred pupils who had been chosen by their class and/or special needs teachers proved the need to instigate efforts to promote a good reading development.

A further aspect of teacher knowledge about pupils is that adaptations to the individual level become possible. The teacher must possess a good insight into where in the reading development the pupil currently stands (Ehri & McCormick, 1998; Frith, 1985; Høien & Lundberg, 2000) to be able to adapt the tasks to each individual pupil. In the follow-up interview with the pupils in Study 2, the latter mentioned the positive reaction when they found that the exercises had not been too hard to manage. Since the contents of an intervention can preferably be adapted to different levels, the teachers' knowledge of their pupils is a key factor. Taube (2007b) stresses how important it is that the teacher is familiar with the reading process and is able to plan the teaching so that the pupil does not face all difficulties simultaneously. Medford and McGeown (2012) also point to the necessity of adapting the interventions to the personalities of individual pupils to make them as motivated as possible. Against this background and with a good insight into the level of each pupil's knowledge or proficiency, the teacher has ample opportunities to adapt the contents of an intervention to constitute the right challenge. It is necessary for the pupil to feel that the exercises are tangible and manageable. Being faced with too high demands at school and always feeling that one cannot live up to these can be disastrous for the motivation for studying (Taube, 2007b). Nor must the exercises, as pointed out by some of the interviewed teachers, be too simple. The demands must not be so low that they do not constitute any challenge for the pupil. A good pedagogical competence in the field is required as well as a good knowledge of the individual pupil in order to plan and implement teaching that does not constitute too much, nor too little, of a challenge; cf. Vygotsky's zone of proximal development (Vygotsky 1934/1962).

One aspect of the contents of interventions that has been highlighted within the framework of the thesis is whether the intervention should be combined

with home assignments or not (Article 1). In connection with the use of the Reading Recovery method in Study 1, a task was included in the intervention that should be carried out after school hours, a home assignment in other words. To carry out this task the pupil needed support from an adult. After encountering several parents' and pupils' negative experiences of homework, it is worth reflecting in retrospect on its specific value before entering upon an intervention with such work. For some pupils and their families homework that requires parents' commitment functions excellently, but this is not the case for everybody. One parent of a pupil participating in Study 1 in the group without any homework disclosed that the intervention period was the first time since the school start that they had experienced "a normal family life without the quarrelling and frustration that doing homework entailed". For some reasons it may do more harm than good with home assignments for some pupils in a specific situation. The results of Study 1 include several examples where a pupil has felt relief to be included in a group free from homework during the intervention period. Homework may fulfil different functions, and teachers should be aware of the reasons for choosing an intervention with or without it. The role of parents in reading training may be important but there is a danger that the outcome is, as described in the overview of current knowledge made by the Swedish National Agency for Education (2007) that the reading training of the children is largely done together with the parents and that the school delegates the responsibility for those children who need support in their reading to these children's parents. It is the school pedagogues that are responsible for the reading development of pupils and, when feasible, some reading training should be done outside school hours. With a good knowledge of pupils the pedagogue can determine whether home assignments linked to interventions can be expected to function as intended.

The results of the studies included in the thesis indicate that computer-based efforts are one way of providing effective supplementary reading tutoring for pupils in grade 2. The meaning of supplementary is that one cannot ascribe pupils' successes to the particular intervention alone. Parallel with the intervention, but also before and after, regular teaching in Swedish was going on at school. The result of an intervention is also affected by what knowledge and skills the pupils bring along from the start (Snowling, Stothard, & Bishop 2000; Torgesen et al., 1994). Another meaning of supplementary in this context is that not all teaching of reading should take the form of an intervention, but that what is done within the framework of the intervention should supplement regular teaching. There is always a risk to make definite statements of what has given rise to a specific effect, especially in school contexts. Therefore all results must be interpreted with caution (Hatcher et al., 1994).

7. PEDAGOGICAL IMPLICATIONS AND FURTHER RESEARCH

The quality audit conducted by the Swedish Schools Inspectorate (2011) concerning the situation of pupils with reading and writing difficulties in the comprehensive school clearly demonstrates the necessity of developing and adapting teaching to the needs of the individual pupil. The report shows that the chances of pupils with such problems of developing their ability to read and write are limited, as there is a lack of appropriate pedagogical measures in most schools. Investigating and diagnosing reading and writing difficulties is one thing, but all investigations have to be followed by forward-looking measures for the individual pupil. The results of the studies included in this thesis point to the possibilities of shaping efforts to promote a good reading development by intervention-based actions in accordance with the following guidelines:

- Well-structured interventions with relevant contents may be effective for pupils with reading difficulties.
- The motivation of both pupils and teachers is important to consider in planning and implementing interventions.
- Some flexibility enabling both individual and level adaptation within the intervention is desirable.
- A broad reading intervention comprising both phonological and comprehension training may be a suitable measure as a first stage.
- In addition to intensity, having a break after a number of training occasions is also important.
- To consider whether the intervention should be combined with homework or not is important.

By working with interventions the special education activities are concentrated in chunks of time rather than being smeared out in much smaller doses over long periods of time. Such a way of organizing special needs education has proved beneficial in several studies, for example by Bus and van IJzendoorn (1999), Ehri et al. (2001) and Underwood (2000). In the next paragraph a model is presented of how pedagogical work with pupils in need of extra reading support can be organized. According to the model below it is important to point out that the studies conducted within the framework of this thesis have only comprised the first step in the model, up to the first “B”. The remaining part of the model illustrates one way of continuing to organize the special needs teaching of reading on the basis of an RTI-influenced structure.

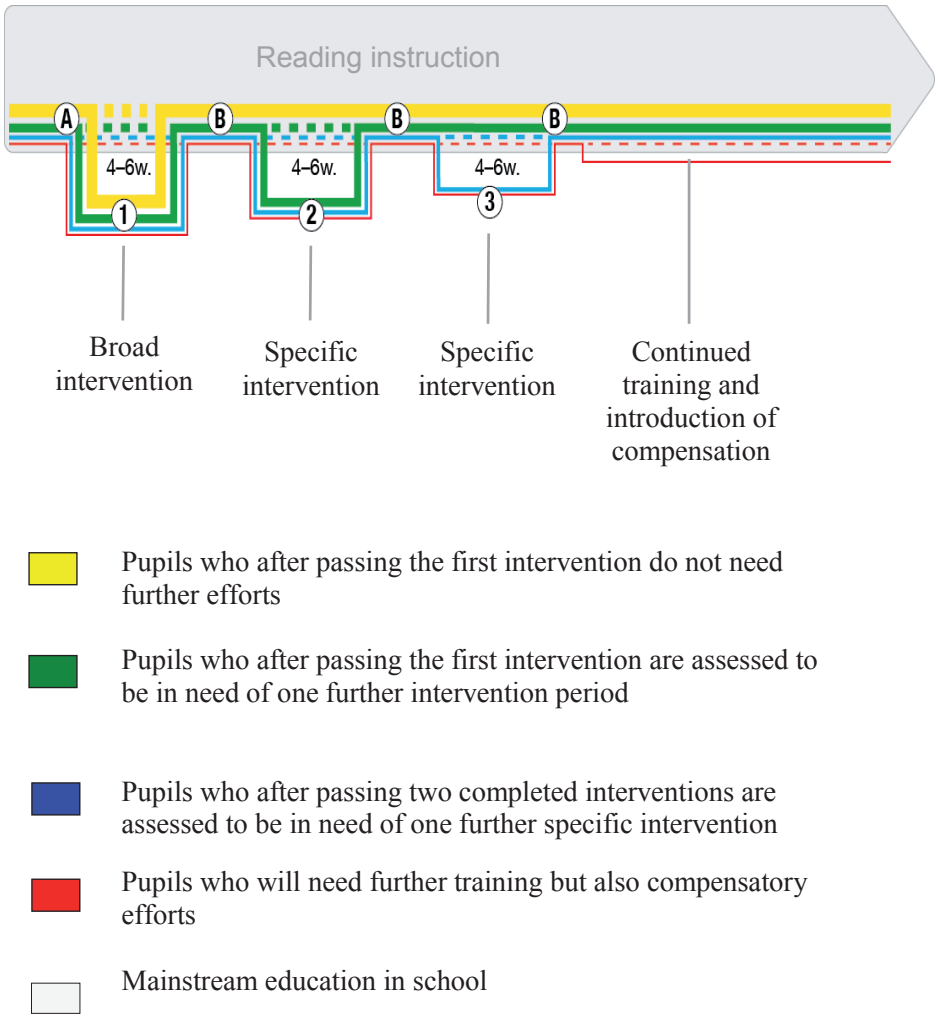

Figure 3. Model of how special needs teaching can be organized for pupils needing extra reading assistance

A. Identification – what is the current level of knowledge of the pupil's reading? Strengths and weaknesses are pinpointed. If the pupil is in need of extra reading support, this is symbolized by the coloured lines starting at the farthest left in the model. Before any effort has been implemented and evaluated we do not know which group (colour) the pupil belongs to. After analyzing the pupil's strengths and weaknesses the intervention will be planned. One issue concerns level adaptation – at which level can the training begin? Another issue regards individual adaptation – which structure suits the pupil (short or long work sessions, do mornings function better or are afternoons preferable, small group or one-to-one tutoring)? Planning the intervention also involves determining for how long it should continue and on which days. If the intervention should be combined with homework is also an issue to take into consideration.

The number 1 in the model above corresponds to the first intervention when the pupil works intensively for 4-6 weeks.

B. Assessment – a new analysis of the pupil's relevant abilities after completing the intervention. The result of the intervention is an important part of the assessment, where the teacher not only considers the actual reading ability level but also the improvement that has supposedly taken place during the intervention. This assessment forms the basis of how the teacher decides about the continuation. Has the intervention had such a positive effect on the pupil's reading ability that no further extra efforts are required? If the answer is yes and the pupil is now estimated to be able to read without any extra pedagogical efforts, the pupil will henceforward take part in regular teaching only. In the above model this pupil is symbolized by the yellow line. If the answer is no, meaning that the intervention has not had a sufficiently positive effect on the pupil's reading ability, the pupil will need continued support and more extra activities. This group of pupils is symbolized by the green line in the model above. After a break from the special needs teaching in reading the next intervention starts (the number 2 in Fig. 3). Even if the pupil is assessed to belong to the yellow group, he or she will be monitored carefully during the further reading development.

If the pupil is considered to be in need of further efforts (the blue line in the model), these will follow the same pattern: assessment (B) followed by a break from the special education activities in reading instruction and after that, if necessary, a new intervention (3) begin.

The red line symbolizes that there may be more pupils whose training is still not sufficient and who should also receive compensating activities by using assistive technology from an early stage. Several international studies (e.g. Berkeley, 2011; Edyburn, 2007; Gregg, 2012 and McKenna & Walpole, 2007) highlight the advantages of using assistive technology. The authors also argue for the risk of training on an ability for too long which the pupil has failed to achieve in spite of the training. One advantage of using assistive technology at an early stage may be that the risk of developing a weak school self-image diminishes (McNulty, 2003). The pupil can keep up with schoolwork via alternative tools despite problems with the written language.

The above is an attempt to illustrate how special education activities for the early reading development of pupils can be organized on the basis of interventions. Furthermore, the interventions must be filled with contents that are appropriate for the individual pupil. According to the results from Study 2 in this thesis, the first intervention (number 1 in Fig. 3) should be broad and include training in both phonology and reading comprehension.

However the major part of the time in school devoted to learning is not spent by pupils working with different interventions together with special education teachers, but in the ordinary classroom. For this reason interventions should be viewed as a supplement to regular teaching and not as the school hour when all the reading instruction of these pupils is supposed to be done. This is symbolized by the coloured lines in the figure being dotted, i.e. the pupils are of course also included in main stream education. Ideally all teachers must possess knowledge and understanding of how to best face and work with pupils who have reading difficulties (Marchand-Martella, et al., 2007).

In a further study we plan to modify the intervention structure from study 2 in this thesis, using as a starting point the results found in Study 2 (Fälth et al., 2013; Gustafson et al., 2011), with the group receiving combined training showing the best results in, for example, word decoding development and reading comprehension. All pupils in the new study will start with an intervention period consisting of a combination of phonological and reading comprehension training. After 4-5 weeks the effort is evaluated and, depending on its success and on the strengths and difficulties of the pupil, the contents of the intervention will be changed. Pupils who require further

training will now receive a new intervention including either combined training or one which focuses on training phonology or reading comprehension. The structure of this study is partly illustrated in the above model (Fig. 3) of the first two steps (A + Intervention 1 + B, where the intervention is evaluated and the teacher assesses which intervention to refer the pupil to in step 2, followed by a further assessment).

To get an intervention-based pedagogical method to function, it is necessary to gain more knowledge about what interventions are effective for different pupils and to study the effects of both the form and the contents of pedagogical interventions concerning reading. Consequently, my thesis might be a contribution that could be used in future projects involving stepwise and level-adapted interventions. The focus of intervention research often lies on trying to find the optimal method. In this thesis I have tried to go one step further and the propositions below may be essential theoretical contributions to intervention research. Combined training in reading suits a great many pupils, but in further pedagogical measures it is also important to take individual differences into consideration when structuring interventions. The motivation is another aspect to consider in intervention studies; motivation can have positive effects for both teachers and pupils provided the training is well structured and combined with activities that train both decoding and reading comprehension. The model in Figure 3 can be an example of how to organize the special educational efforts in reading instruction. However, further research is needed and it is an educational challenge to learn more about how to adapt individualized interventions targeting the needs of children who struggle with learning to read. A question that should be highlighted in collaboration between researchers and teachers can be formulated: What efforts suit what pupils under what conditions?

SAMMANFATTNING

Inledning

Dagens samhälle ställer stora krav på läs- och skrivfärdigheter och ”god läsfärdighet tycks vara en nyckel till framgång i ett arbetsliv som kräver ständig nyinlärning, omställningar och anpassningar till ny teknik och ny organisation” (Lundberg 2010, s 131). Det är en pedagogisk utmaning för skolans lärare att ge alla elever de redskap som krävs för att exempelvis kunna läsa nya främmande ord och så småningom kunna läsa och förstå faktatexter, vilket kräver såväl god avkodningsförmåga som god läsförståelse. Utmaningen för läraren består i att kunna identifiera på vilken nivå den enskilda eleven befinner sig i sin läsutveckling och bemöta eleven precis där, med siktet inställt på att eleven skall nå ett effektivt utvecklat läsande där han eller hon använder sin läsning självmant för att ta reda på saker eller för att få en upplevelse.

Det finns idag kunskap och stöd inom forskningen angående lämpliga insatser för att främja läsutvecklingen men det behövs mer kunskap om vilka insatser och interventioner som är effektiva för olika elever. I denna avhandling ingår två interventionsstudier som båda handlar om att finna lämpliga åtgärder för elever som har det svårt med sin läsning. I studierna ingår datorbaserade träningsprogram och komponenter som enligt tidigare forskning visat sig vara viktiga vid läsning.

Avhandlingen är en sammanläggningsavhandling som förutom kappan består av 4 separata artiklar.

Syfte och frågeställningar

Förutsättningarna för läsning är att kunna avkoda skriven text och att kunna förstå innebörden av den. För elever som har svårigheter med sin läsning har tidigare studier visar på vikten av tidiga, intensiva och systematiska insatser. Mot bakgrund av detta, är det övergripande syftet med denna avhandling att analysera effekter av interventioner uttryckt i såväl kvantitativa resultat på elevernas läsförmågor som kvalitativa tolkningsaspekter av interventioner som metod för att främja läsutvecklingen. Följande forskningsfrågor ställs:

- Vilka effekter har interventionerna på elevernas läsförmågor?
- Hur upplever elever och lärare sitt deltagande i interventionerna? Vilka erfarenheter gjordes och hur kan dessa erfarenheter belysa de kvantitativa resultaten från interventionerna?

Teoretiska utgångspunkter

Läsning kan definieras som förmågan att omkoda text till något som läsaren redan behärskar och som han eller hon på ett meningsfullt sätt kan ta till sig – nämligen individens talade språk (Tunmer & Greaney, 2010). Dessa grundläggande idéer är representerade i en modell av vad läsning är vilken utvecklats av Gough och Tunmer (1986) och som kallas 'the Simple View of Reading'. I modellen *L (Läsning) = A (Avkodning) × F (Förståelse)* görs två påståenden: läsning kan brytas ned i två komponenter, ordavkodning och språkförståelse. Båda komponenterna behövs för framgång i läsningen, var för sig är de är inte tillräckliga. Ett mål för läsningen är att ordavkodningen ska bli automatiserad, så att fokus kan läggas på att förstå innehållet i det lästa. En god avkodningsförmåga betonas i den tidiga läsutvecklingen. Om eleven inte kan läsa de enskilda orden i texten snabbt och effektivt, kan en stor del av de kognitiva resurserna bli bundna i avkodningsprocessen, vilket försämrar förståelsen av texten och därmed också lärandet.

Läsning är en komplex förmåga som vi behärskar olika väl, och gränsen för när något kallas för svårighet blir ibland godtycklig och dras på olika sätt i olika sammanhang. Läs- och skrivsvårigheter är en övergripande term som innefattar alla svårigheter med att läsa och/eller skriva, oavsett vad som är orsaken. Avhandlingens empiriska studier fokuserar lässvårigheter. Gemensamt för eleverna i avhandlingens båda studier är att de på något sätt har svårigheter med sin läsning. Svårigheterna kan finnas på olika nivåer och vissa av eleverna som är med i studierna kan antas ha dyslexi även om vi inte

har tagit del av eventuella diagnoser. Vi har istället valt den mer övergripande termen lässvårigheter då deltagarna beskrivs.

Det finns flera studier som visar att läsförmågan hos elever med lässvårigheter kan förbättras genom intensiv och individualiserad undervisning vilken fokuserar på såväl fonologiska färdigheter som precision vid läsning av text (Lundberg, 1984; Torgesen et al., 2001; Torgesen, 2005; Wolff, 2011).

Metod

Avhandlingens fyra artiklar bygger på material från två olika studier. Studie 1 ska betraktas som en förstudie, och det empiriska materialet därifrån ligger till grund för avhandlingens första artikel. Avhandlingens andra, tredje och fjärde artikel bygger på empiriskt material från studie 2.

I studie 1 deltog totalt 14 elever, 11 pojkar och tre flickor från årkurs 1-4. Eleverna matchades utifrån kön och ålder och delades in i två grupper. Grupp 1 lottades till att använda det datorbaserade lästräningsprogrammet Omega-IS under interventionen och grupp 2 lottades till använda Reading Recovery. Eleverna testades individuellt med olika lästester vid fyra tillfällen. Under interventionsperioden fick alla elever en-till-en-undervisning av sin ordinarie speciallärare vid totalt 20 tillfällen. För gruppen som tränade med Omega-IS varade lektionerna mellan 15 och 40 minuter. Eleverna i denna grupp fick ingen ytterligare specialundervisning under interventionsperioden och de hade inga läxor som var kopplade till interventionen. I Reading Recovery-gruppen varade varje lektion mellan 30 och 40 minuter. Denna grupp hade även läxor vid 20 tillfällen som var kopplade till interventionen. Läxläsningen genomfördes tillsammans med en förälder och pågick 10 till 20 minuter.

I studie 2 deltog totalt 130 elever och 42 lärare från 41 skolor i fyra kommuner. Av totalt 130 elever bedömdes 100 under senare delen av vårterminen i årskurs 1, av sina respektive lärare vara i behov av extra stöd i svenska under nästkommande termin (höstterminen i årskurs 2). De resterande 30 eleverna bedömdes av lärarna vara så kallade ’typiska läsare’ och de utgjorde en kontrollgrupp. De 100 försökseleverna delades utifrån kön och ordavkodningsförmåga in i fyra olika grupper: Grupp 1, lottades att använda det datorbaserade lästräningsprogrammet Omega-IS (läsförståelseträning) under interventionen. Grupp 2 lottades att använda det datorbaserade lästräningsprogrammet Comphot (fonologisk träning) medan grupp 3 lottades att använda båda programmen varannan gång (kombinerad träning). Grupp 4 lottades att få ordinarie specialundervisning.

Under interventionsperioden fick alla elever en-till-en-undervisning av sin ordinarie speciallärare vid totalt 25 tillfällen. Varje lektion pågick 15 till 25 minuter. Grupperna 1, 2 och 3 arbetade alltid enligt respektive interventionsupplägg. I grupp 4 utformade respektive speciallärare undervisningen utifrån elevens behov i svenska. Eleverna testades individuellt med olika lästester vid fem tillfällen.

Resultat och diskussion

I studie 1 visade resultaten att båda grupperna, Reading Recovery-gruppen och gruppen som tränade med Omega-IS, förbättrades signifikant på tester som mäter ordavkodning efter genomgången intervention. Däremot fanns ingen signifikant skillnad mellan de båda grupperna med avseende på hur mycket de förbättrats.

I studie 2 visade resultaten att den kombinerade träningen var signifikant mer effektiv vad gäller ordavkodning och läsförståelse än ordinarie specialundervisning både på kort sikt, direkt efter avslutad intervention, och på lång sikt, ett halvår senare. Resultaten visade också att gapet mellan kontrollgruppen av typiska läsare och gruppen som fick kombinerad träning hade minskat från första till sista testtillfället. De positiva resultaten i studie 2 avseende gruppen som erhöll den kombinerade träningen förstärks av att det i den gruppen inte återfanns lika många elever som efter avslutad intervention fortfarande var i behov av specialundervisning i svenska. Endast sju elever av totalt 25 i gruppen som fick kombinationsträning bedömdes av speciallärare vara i behov av specialpedagogiskt stöd i svenska efter avslutad intervention. För de övriga tre grupperna om vardera 25 elever var bedömningen att 20, 21 och 22 elever fortfarande var i behov av specialpedagogiskt stöd i svenska efter interventionen.

Den pedagogiska beredskap en skola besitter kommer att påverka hur en elevs läsutveckling framskrider. Utifrån resultaten i denna avhandling och i linje med tidigare studier (t.ex. Hatcher et al., 2006; Saine et al., 2011; Snowling, 2011 och Torgesen, 2005) bör en pedagogisk beredskap omfatta resurser för att under vissa begränsade tidsperioder kunna bedriva undervisning i mindre grupper eller en-till-en, för elever som har eller riskerar att få svårigheter med läsningen.

Resultaten från studierna i denna avhandling visar på möjligheterna att utforma insatser för att främja en god läsutveckling genom att arbeta interventionsbaserat. Övergripande visar resultaten att välstrukturerade interventioner med relevant innehåll kan vara effektiva för elever som har

svårigheter med läsningen. Resultaten visar också att det är viktigt att beakta både elevens och lärarens motivation i samband med planering och genomförande av interventionerna. Vad gäller innehållet i interventionerna visar resultaten att en bred intervention som rymmer både fonologisk träning och förståelseträning kan vara en lämplig insats för elever med lässvårigheter i årskurs 2. Intensiteten på interventionen är betydelsefull, men det är även viktigt att göra ett uppehåll efter ett visst antal träningstillfällen. Resultaten från en av studierna visade att eleverna kan förbättra sin läsförmåga utan att undervisningen är kopplad till hemuppgifter.

För att ett interventionsbaserat arbetssätt ska kunna fungera är det nödvändigt att undersöka effekter av både form och innehåll i läspedagogiska interventioner. Avhandlingen ger här ett bidrag som skulle användas i framtida projekt där stegvisa och nivåanpassade interventioner genomförs. Viktiga frågor i den fortsatta forskningen som kan belysas i samverkan mellan forskare och praktiker är vilka insatser som passar för vilka elever under vilka förhållanden.

REFERENCES

Aaron, P. G. (1997). A component-based approach to the diagnosis and treatment of reading disabilities. In B. Ericson & J. Rönnberg (Eds.), *Reading disability and its treatment* (pp. 37-66). EMIR, Report No. 2, Norrköping: Eve Malmquist Institute for Reading, Linköping University.

Aaron, P.G., Joshi, M., & Williams, K.A. *(*1999). Not all reading disabilities are alike. *Journal of Learning Disabilities, 32*, 120–137.

Adair, J. G. (1984). The Hawthorne Effect: A reconsideration of the Methodological Artifact. *Journal Of Applied Psychology, 69*(2), 334-345.

Adams, M. J. (1990). *Beginning to read: Thinking and learning about print*. Cambridge, MA: The MIT Press.

Alexandersson, M., Linderoth, J., & Lindö, R. (2000). *"Dra den dit å lägg den där!". En studie om barns möten med datorn i skolan* Göteborg: Göteborg University, Department of Education and Didactics.

Alstam-Malcus, A., & Fritzell, M. (1994). Vad sa' du fröken?: bedömning av tal och språk hos nybörjare. Göteborg: SIH läromedel.

Andreassen, R., & Bråten, I. (2011). Implementation and effects of explicit reading comprehension instruction in fifth-grade classrooms. *Learning and Instruction, 21*, 520-537.

Anmarkrud, Ø., & Bråten, I. (2010). Motivation for reading comprehension. *Learning and Individual Differences*, *19*, 252-256.

Arnbak E, (2010). *Läsning av faktatexter. Från läsprocess till lärprocess.* Stockholm: Natur och Kultur.

Askew, B. J., Kaye, E., Frasier, D. E., Mobasher, M., Anderson, N., & Rodríguez, Y. G. (2002). Making a case for prevention in education. *Literacy Teaching and Learning: An International Journal of Early Reading and Writing, 6*(2), 43-73.

Baker, L., & Wigfield, A. (1999). Dimensions of children's motivation for reading and their relations to reading activity and reading achievement. *Reading Research Quarterly*, *34*, 452-477.

Ball, E., & Blachman, B. (1991). Does phoneme awareness training in kindergarten make a difference in early word recognition and developmental spelling? *Reading Research Quarterly, 26*, 49-66.

Barth, A. E., Stuebing, K. K., Anthony, J. L., Denton, C. A., Mathes, P. G., Fletcher, J. M., & Francis, D. J. (2008). *Learning and Individual Differences, 18*, 296-307.

Berkeley, S., Bender, W. N., Peaster, L. G., & Saunders, L. (2009). Implementation of response to intervention: A snapshot of progress. *Journal of Learning Disabilities, 42*, 85-95.

Bowey, J. A. (2005). Predicting individual differences in learning to read. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 155-172).

Bowyer-Crane, C., Snowling, M. J., Duff, F. J., Fieldsend, E., Carroll, J. M., Miles, J., Götz, K., & Hulme, C. (2008), Improving early language and literacy skills: Differential effects of an oral language versus a phonology with reading intervention. *Journal of Child Psychology and Psychiatry, 49*(4), 422-432.

Bradley, R., Danielsson, L., & Doolittle, J. (2005). Response to intervention: 1997. *Journal of Learning Disabilities, 38*(6), 8-13.

Bramlett, R. K., Murphy, J. J., Johnson, J., Wallingsford, L., & Hall, J. D. (2002). Contemporary practices in school psychology: A national survey of roles and referral problems. *Psychology in the Schools, 39*(3), 327-335.

Bus, A. G., & van IJzendoorn, M. H. (1999). Phonological awareness and early reading: A meta-analysis of experimental training studies. *Journal of Educational Psychology, 91*(3), 403- 414.

Caffrey, E., Fuchs, D., & Fuchs L. S. (2008). The predictive validity of dynamic assessment: A review. *The Journal of Special Education, 41*(4), 254-270.

Cain, K. (2010). *Reading development and difficulties*. Oxford: Wiley-Blackwell.

Castles, A., & Coltheart, M. (2004). Is there a causal link from phonological awareness to success in learning to read? *Cognition, 91*(1), 77-111.

Catts, H., & Kamhi, A. (2005). *Language and reading disabilities. 2. ed*. Boston, Mass. Pearson Education Inc.

Catts, H., Adlof, S. M., & Weismer, S. E. (2006). Language deficits in poor comprehenders: a case for the simple view of reading. *Journal of Speech, Language and Hearing Research, 49*(2), 278-293.

Center, Y., Wheldall, K., Freeman, L., Outhred, L., & McNaught, M. (1995). An evaluation of Reading Recovery. *Reading Research Quarterly, 30*, 240-263.

Chall, J. S. (1983). *Stages of reading development*. New York. McGraw-Hill.

Chen, R., & Vellutino, F. R. (1997). Prediction of reading ability: A cross-validation study of the Simple View of Reading. *Journal of Literacy Research, 29*(1), 1–24.

Clay, M. (1993). *Reading recovery: A guidebook for teachers in training.* Auckland: Heinemann Education.

Critchley, M. (1973). Some problems of the ex-dyslexic. *Bulletin of the Orton Society, 23*, 7-14.

van Daal, V., & Reitsma, P. (2000). Computer-assisted learning to read and spell: result from two pilot studies. *Journal of Research in Reading, 23*, 181-193.

Damsby, G. (2007). *Kompensatoriska datorprogram - en dyslektikers möjlighet?: en studie i samverkan med specialpedagoger och elever med dyslexi*. Lund: FoU-enheten, Habilitering & Hjälpmedel, Region Skåne.

Danielsson, K. (2003). *Beginners read aloud. High versus low linguistic levels in Swedish beginners' oral reading*. (Doctoral thesis). Acta Universitatis Stockholmiensis. Stockholm studies in Scandinavian philology, 28. Stockholm: Almqvist & Wiksell International.

Denton, C. A., Fletcher, J. M., Anthony, J. L., & Francis, D. J. (2006). An evaluation of intensive intervention for students with persistent reading difficulties. *Journal of Learning Disabilities, 39*(5), 447-466.

Denton, C. A., Cirino, P. T., Barth, A. E., Romain, M., Vaughn, S., Wexler, J., & Fletcher, J. M. (2011). An experimental study of scheduling and duration of "Tier 2" first-grade reading intervention. *Journal Of Research On Educational Effectiveness, 4*(3), 208-230.

Doehring, D. G. (1976). Acquisition of rapid reading responses. *Monographs of the Society for research in Child Development, 41*, 1-54.

Ehri, L.C. (1999). Phases of development in learning to read words. In J. Oakhill & R. Beard (Eds.), *Reading development and the teaching of reading: A psychological perspective*. (pp. 79-108). Oxford: Blackwell Science.

Ehri, L. C., & McCormick, S. (1998). Phases of learning. Implications for instruction with delayed and disabled readers. *Reading & Writing Quarterly, 14*.

Ehri, L. C., Nunes, S. R., Willows, D. M., Valeska Schuster, B., Yaghoub-Zadeh, Z., & Shanahan, T. (2001). Phonemic awareness instruction helps children learn to read: Evidence from the National Reading Panel's meta-analysis. *Reading Research Quarterly, 36*, 250–287.

Elbro, C. (2004). *Läsning och läsundervisning.* Stockholm: Liber.

Elbro, C., & Petersen, D. K. (2004). Long term effects of phoneme awareness and letter sound training: An intervention study with children at risk for dyslexia. *Journal of Educational Psychology, 96*(4), 660-670.

Enochsson, A.-B. (2004). Internet seeking and motivation for learning to read. *Learning for Innovation in Technology Education,1,* 178-188.

Edyburn, D. L. (2011). Some of the best: Advances in special education technology research. *Closing the Gap, 29*(6), 30-33.

Fast, C. (2007). *Sju barn lär sig läsa och skriva. Familjeliv och populärkultur i möte med förskola och skola.* (Uppsala Studies in Education nr 115). Uppsala: Acta Universitatis Upsaliensis.

Fawcett, A.J., & Lynch, L. (2000). Systematic identification and intervention for reading difficulties: case studies of children with EAL. *Dyslexia*, 6, 57-71.

Ferreira, J., Gustafson, S., & Rönnberg, J. (2003*). COMPHOT: Computerized phonological training*. Linköping, Sweden: Department of Behavioral Sciences and Learning/Swedish Institute for Disability Research, Linköping University, Sweden.

Fletcher, J. M., Denton, C., & Francis, D. (2005). Validity of alternative approaches for the identification of learning disabilities: Operationalizing unexpected underachievement. *Journal of Learning Disabilities, 38*(6), 545-552.

Fletcher, J. M., Shaywitz, S. E., Shankweiler, D., Katz, L., Liberman, I. Stuebing, K., Francis, D. J., Fowler, A., & Shaywitz, B. A. (1994). Cognitive profiles of reading disability: Comparisons of discrepancy and low achievement definitions. *Journal of Educational Psychology, 86*(1), 6-23.

Fletcher, J. M., & Vaughn, S. (2009). Response to intervention: Preventing and remediating academic difficulties. *Child Development Perspectives, 3*(1), 30-37.

Folkesson, A.-M., & Swalander, L. (2007). Self-regulated learning through writing on computers: Consequences for reading comprehension. *Computers in Human Behavior, 23*, 2488-2508.

Foorman, B. R., Francis, D. J., Fletcher, J. M., Schatschneider, C., & Mehta, P. (1998). The role of instruction in learning to read: Preventing reading disabilities in at-risk children. *Journal of Educational Psychology*, *90*(1), 37–55.

Fouganthine, A. (2012). *Dyslexi genom livet. Ett utvecklingsperspektiv på läs- och skrivsvårigheter*. (Doctoral thesis). Stockholms Universitet.

Francis, D. J., Fletcher, J. M. Stuebing, K. K., Lyon, G. R., Shaywitz, B. A., & Shaywitz, S. E. (2005). Psychometric approaches to the identification of LD, IQ and achievement scores are not sufficient. *Journal of Learning Disabilities*, *38*(2), 98-108.

Francis, D. J., Shaywitz, S. E., Stuebing, K. K., Shaywitz, B. A., & Fletcher, J. M. (1996). Developmental lag versus deficit models of reading disability: A longitudinal, individual growth curves analysis. *Journal of Educational Psychology*, *88*(1), 3-17.

Frith, U. (1985). Beneath the surface of developmental dyslexia. In K. Patterson, J. Marshall, & M. Coltheart (Eds.), *Surface dyslexia, neuropsychological and cognitive studies of phonological reading*. (pp. 301-330). London: Erlbaum.

Frith, U. (1997). Brain, mind and behavior in dyslexia. In C. Hulme and M. Snowling (Eds.), *Dyslexia, Biology, Cognition and Intervention.* London: Whurr.

Frost, J., Madsbjerg, S., Niedersøe, J., Olofsson, Å., & Sørensen, P. M. (2005). Semantic and phonological skills in predicting reading development: From 3-16 years of age. *Dyslexia, 11*, 79-92.

Fuchs, D., & Fuchs, L. S. (2006). Introduction to response to intervention: What, why, and how valid is it? *Reading Research Quarterly, 41*, 93-99.

Fuchs, D., Mock, D., Morgan, P. L., & Young, C. L. (2003). Responsiveness to intervention: Definition, evidence, and implications for the learning disabilities construct. *Learning Disabilities: Research & Practice, 18*(3), 157-171.

Fälth, L., Gustafson, S., Tjus, T., Heimann, M., & Svensson, I. (2013). Computer-assisted interventions targeting reading skills of children with reading disabilities – A longitudinal study. *Dyslexia, 19*, 37-53.

Fälth, L., Svensson, I., & Tjus, T. (2011). The effects of two training programs regarding reading development among children with reading disabilities. *Psychology, 2*(3), 173-180.

Gail, T. (2004*). Phonological awareness. From research to practice.* New York: The Guilford Press.

Goswami, U. (1986). Children's use of analogy in learning to read: A developmental study. *Journal Of Experimental Child Psychology, 42*(1), 73-83.

Gough, P., & Tunmer, W. (1986). Decoding, reading, and reading disability. *Remedial and Special Education*, *7*(1), 6-10.

Gregg, N. (2012). Increasing access to learning for the adult basic education learner with learning disabilities: Evidence-based accommodation research. *Journal Of Learning Disabilities*, *45*(1), 47-63.

Gresham, F. M. (2004). Current status and future directions of school-based behavioral interventions. *School Psychology Review,* 33, 326-343.

Grigorenko, E. L. (2009). Dynamic assessment and response to intervention: Two sides of one coin. *Journal of Learning Disabilities, 42*, 111–132.

Gustafson, S., Ferreira, J., & Rönnberg, J. (2007). Phonological or orthographic training for children with phonological or orthographic decoding deficits. *Dyslexia, 13*, 211-229.

Gustafson, S., Fälth, L., Svensson, I., Tjus, T., & Heimann, M. (2011). Effects of Three Interventions on the reading skills of children with reading disabilities in grade 2 *Journal of Learning Disabilities, 44*, 123-135.

Gustafson, S., & Samuelsson, S. (1999). Intelligence and dyslexia: Implications for interventions. *Scandinavian Journal of Psychology, 40*(2), 127-134.

Gustafson, S., Samuelsson, S., & Rönnberg, J. (2000). Why do some resist phonological intervention? A Swedish longitudinal study of poor readers in grade 4. *Scandinavian Journal of Educational Research, 44*, 145-162.

Guthrie, J, T., & Knowles, K. (2001). Promoting reading motivation. In Verhoeven, Ludo & Snow, Catherine E. (Eds.). *Literacy and motivation. Reading engagement in individuals and groups*. London: Lawrence Erlbaum Associates.

Guthrie, J. T., McRae, A., & Klauda, S. L. (2007). Contributions of Concept-Oriented Reading Instruction to knowledge about interventions for motivations in reading. *Educational Psychologist, 42*, 237-250.

Guthrie, J. T., Wigfield, A., & Perencevich, K. C. (2004). Motivating reading comprehension: Concept-oriented reading instruction. *Lawrence Erlbaum Associates*.

Hall, T. E., Hughes, C. A., & Filbert. M. (2000). Computer assisted instruction in reading for students with learning disabilities: A research synthesis. *Education & Treatment of Children, 23*(2), 173.194.

Hatcher, P. J., & Hulme, C. (1999). Phonemes, rhymes, and intelligence as predictors of children's responsiveness to remedial reading instruction: Evidence from a longitudinal intervention study. *Journal of Experimental Child Psychology*, *72*(2), 130-153.

Hatcher, P., Hulme, C., & Ellis, A. W. (1994). Ameliorating reading failure by integrating the teaching of reading and phonological skills: The phonological linkage hypothesis. *Child Development, 65*(1), 41-57.

Hatcher, P. J., Hulme, C., Miles, J. V., Carroll, J. M., Hatcher, J., Gibbs, S., & ... Snowling, M. J. (2006). Efficacy of small group reading intervention for beginning readers with reading-delay: A randomised controlled trial. *Journal of Child Psychology and Psychiatry, 47*(8), 820-827.

Hatcher, P. J., Hulme, C., & Snowling, M. J. (2004). Explicit phoneme training combined with phonic reading instruction helps young children at risk of reading failure. *Journal of Child Psychology and Psychiatry, 45*, 338-358.

Heimann, M., & Gustafson, S. (2009). Lärande, läsning, och multimodalitet. In L. Bjaar & A. Frylmark (red.). *Barn läser och skriver – specialpedagogiska perspektiv* (s. 93-208). Lund: Studentlitteratur.

Heimann, M., Lundälv, M., Tjus, T., & Nelson, K. E. (2004). Omega-IS, multimedia software for enhancing language and communication development in children with disabilities.

Helland, T., Tjus, T., Hovden, M., Ofte, S., & Heimann, M. (2011). Effects of a Bottom-up and a Top-down Intervention Principle in Emergent Literacy in Children at Risk of Developmental Dyslexia. A Longitudinal Study. *Journal of Learning Disabilities, 44 (2),* 105-122.

Hoover, W., & Gough, P. (1990). The simple view of reading. *Reading and Writing: An Interdisciplinary Journal, 2*, 127-160.

Høien, T., Lundberg, I., Stanovich, K., & Bjaalid, I. (1995). Components of phonological awareness. *Reading and Writing. 7*(2), s. 171-188.

Høien, T., & Lundberg, I. (1999). *Dyslexi. Från teori till praktik*. Stockholm: Natur och Kultur.

Høien, T., & Lundberg, I. (2000). Dyslexia: From theory to intervention. *Neuropsychology and Cognition*, *18*ALL.

Invernizzi, M., Rosemary, C., Juel, C., & Richards, H. C. (1997). At-risk readers and community volunteers: A 3-year perspective. *Scientific Studies of Reading*, 1, 277-300.

Iverson, S., & Tunmer, W. (1993). Phonological processing skills and the reading recovery programme. *Journal of Educational Psychology*, *85*, 112–126.

Jacobson, C., & Lundberg, I. (1995). *Läsutveckling och dyslexi. Frågor, erfarenheter och resultat.* Stockholm: Liber Utbildning.

Jenner, H. (2004). *Motivation och motivationsarbete i skola och behandling.* Stockholm: Myndigheten för skolutveckling.

Jiménez, J.E., Hernández-Valle, I., Ramírez, G., Ortiz, M. R., Rodrigo, M., Tabraue, M., Estévez, A., O'Shanahan, I. (2007). Computer speech-based remediation for reading disabilities: The size of spelling-to-sound unit in a transparent orthography. *The Spanish Journal of Psychology, 10*, 52-67.

Joshi, R.M., & Aaron, P.G. (2000). The component model of reading: Simple view of reading made a little more complex. *Reading Psychology, 21*, 85–97.

Johansson, M.-G. (1992). Synpunkter och erfarenheter av datorstöd i läs och skriv. *Nordisk tidsskrift for spesialpedagogikk, 2*, 108-113.

Johansson, M.-G. (2010), *Datorträning i läsflyt och stavning. Analys och utvärdering av fixerad och resultatstyrd flash-cardexponering*. (Doctoral thesis). Umeå Universitet.

Juel, C. (1996). What makes literacy tutoring effective? *Reading Research Quarterly, 31*, 268-289.

Keene, E., Zimmermann, S., Jakobsson, U., & Fihn, C. (2003). *Tankens mosaik: om mötet mellan text och läsare*. Göteborg: Daidalos.

Kendeou, P., Savage, R., & van den Broek, P. (2009). Revisiting the Simple View of Reading. *British Journal of Educational Psychology, 79*, 353-370.

Kirby, J., & Savage, S. (2008). Can the simple view deal with the complexities of reading? *Literacy, 42*(2), 75-82.

Kjeldsen, A.-C., Niemi, P., & Olofsson, Å. (2003). *Training Phonological Awareness in Kindergarten Level Children: Consistency is More Important than Quantity*. Åbo: Department of Special Education.

Kullberg, B. (1991). *Learning to learn to read*. (Doctoral thesis). Göteborg: Acta Universitatis Gothoburgenis. Gothenburg studies in educational sciences, 81.

Liberg, C. (2006). *Hur barn lär sig läsa och skriva*. 2 uppl. Lund: Studentlitteratur.

Logan, S., Medford, E., & Hughes, N. (2011). The importance of intrinsic motivation for high and low ability readers' reading comprehension. *Learning and Individual Differences, 21*, 124-128.

Lovett, M., Barron, R., & Benson, N. (2003). Effective remediation of word identification and decoding difficulties in school-age children with reading disabilities. In H. L. Swanson, K. R. Harris, & S. Graham (Eds.), *Handbook of learning disabilities*, 273-293. New York: Guilford Press.

Lovett, M. W., Borden, S. L., DeLuca, T., Lacrerenza, L., Benson, N. J., & Brackstone, D. (1994). Treating the core deficits of development dyslexia: Evidence of transfer of learning after phonologically and strategy based reading training programs. *Developmental Psychology, 30*, 805-822.

Lovett, M. W., Steinbach, K. A., & Frijters, J. C. (2000). Remediating the core deficits of developmental reading disability: A double-deficit perspective. *Journal of Learning Disabilities, 33(4)*, 334-358.

Lundberg, I. (1984). *Språk och läsning*. Stockholm: Liber.

Lundberg, I. (2006). Early language development as related to the acquisition of reading. *European Review, 14*(1), 65-79.

Lundberg, I. (2010). *Läsningens psykologi och pedagogik.* Stockholm: Natur & Kultur.

Lundberg, I., Frost, J., & Petersen, O. (1988). Effects of an extensive program for stimulating phonological awareness in preschool children. *Reading Research Quarterly 23*(3), 263-83.

Lyon, G. R., Shaywitz, S. E., & Shaywitz, B. A. (2003). A definition of dyslexia. *Annals of Dyslexia, 53*, 1-14.

Lyytinen, H., Aro, M., Eklund, K., Erskine, J., Guttorm, T. K., Laakso, M.-L., et al. (2004). The development of children at familial risk for dyslexia: Birth to early school age. *Annals of Dyslexia*, *54*, 184-220.

Magnan, A., & Ecalle, J. (2006). Audio–visual training in children with reading disabilities. *Computers & Education, 46*, 407-425.

Marchand-Martella, N., Ruby, S., & Martella, R. (2007). Intensifying reading instruction for students within a three-tier model: Standard-protocol and problem solving approaches within a Response-to-Intervention (RTI) system, *TEACHING Exceptional Children Plus*: Vol. 3.

McKenna, M. C., & Walpole, S. (2007). Assistive technology in the reading clinic: Its emerging potential. *Reading Research Quarterly, 1*, 140-145.

McNulty, M. A. (2003). Dyslexia and the life course. *Journal of Learning Disabilities, 3*6, 363-381.

Medford, E., & McGeown, S. P. (2012). The influence of personality characteristics on children's reading motivation. *Learning and Individual Differences, 22*(6), 786-791.

Mellard, D. F., McKnight, M., & Woods, K. (2009). Response to intervention screening and progress-monitoring practices in 41 local schools. *Learning Disabilities Research & Practice, 24*, 186-195.

Moody, S. W., Vaughn, S., Hughes, M. T., & Fischer, M. (1998). Broken promises: Reading instruction in resource rooms. *Learning Disability Quarterly, 64*, 211-215.

Moreno, R. (2006). Learning in high-tech and multimedia environments. *Current Directions in Psychological Science, 15*, 63-67.

Morgan, P. L., & Fuchs, D. (2007). Is there a bidirectional relationship between children's reading skills and reading motivation?. *Exceptional Children, 73*(2), 165-183.

Morrone A., & Schutz P. (2000). Promoting achievement motivation. In: Minke, K. M., Bear, G. C., & National Association of School Psychologists, B. D. (2000). *Preventing School Problems--Promoting School Success: Strategies and Programs that Work.* Bethesda, MD: National Association of School Psychologists; 2000. pp. 143-170.

Mullis, I. V. S., Martin, M. O., Kennedy, A. M., & Foy, P. (2007). *PIRLS 2006 International Report. IEA's Progress in International Reading Literacy Achievement in Primary School in 40 Countries.* Chestnut Hill: TIMMS & PIRLS International Study Centre.

Muter, V., Hulme, C., Snowling, M. J., & Stevenson, J. (2004). Phonemes, rimes, vocabulary, and grammatical skills as foundations of early reading development: Evidence from a longitudinal study. *Developmental Psychology, 40*, 663-681.

Myrberg, M. (red.), (2003). Att skapa konsensus om skolans insatser för att motverka läs- och skrivsvårigheter [Elektronisk resurs]: rapport från "Konsensus-projektet" 5 september 2003. Stockholm: Lärarhögskolan, Institutionen för individ, omvärld och lärande.

Myrberg, M. (2007). *Dyslexi: en kunskapsöversikt.* Stockholm: Vetenskapsrådet.

Nation, A. (2005). Children's reading comprehension difficulties. In M. J. Snowling & C. Hulme (Eds.), *The Science of Reading*. Blackwell Publishing Ltd.

Nation, K., Cooksey, J., Taylor, J., & Bishop, D. (2010). A longitudinal investigation of the early language and reading skills in children with reading comprehension impairment. *Journal of Child Psychology & Psychiatry, 51*, 1031-1039.

National Reading Panel. (2000). *Report of the National Reading Panel: Reports of the subgroups.* Washington, DC: National Institute of Child Health and Human Development Clearing House.

Navarro, J., & Mora, J. (2011). Analysis of the implementation of a dynamic assessment device of processes involved in reading with learning-disabled children. *Learning and Individual Differences, 21*, 168-175.

Nicolson, R., Fawcett, A., & Nicolson, M. (2000). Evaluation of a computer-based reading intervention in infant and junior schools. *Journal of Research in Reading, 23*(2), 194.

Olofsson, Å., & Hemmingsson, I. (1993). Fonolek. LPC, Östersunds kommun.

Olson, R. K., & Wise, B. W. (1992). Reading on the computer with orthographic and speech feedback. *Reading and Writing, 4*(2), 107–144.

Palincsar, A., & Ransom, K. (1988). From the mystery spot to the thoughtful spot: The instruction of metacognitive strategies. *The Reading Teacher, 41*(8), 784-789.

Perfetti, C.A. (1992). The representation problem in reading acquisition. In P.B. Gough, L.C. Ehri, & R. Treiman (Eds.), *Reading acquisition* (pp. 145-174). Hillsdale, NJ: Erlbaum.

Perfetti, C. A., Landi, N., & Oakhill, J. (2005). The acquisition of reading comprehension skill. In M. J. Snowling & Hulme, C. (Eds.), *The Science of Reading*. Blackwell Publishing Ltd.

Poskiparta, E., Niemi, P., &Vauras, M. (1999).Who benefits from training in linguistic awareness in the first grade, and what components of it show training effects? *Journal of Learning Disabilities, 32,* 437–447.

Pressley M., & Ghatala, E.S. (1990). Self-regulated learning: Monitoring learning from text. *Educational Psychologist, 25*, 19-33.

Rack, J. P., Snowling, M. J., & Olson, R. K. (1992). The nonword reading deficit in developmental dyslexia. *Reading Research Quarterly, 27*, 29-53.

Ramus, F. (2001). Talk of two theories. *Nature, 412*, 393-395.

Regtvoort, A., & van der Leij, A. (2007). Early intervention with children of dyslexic parents: Effects of computer-based reading instruction at home on literacy acquisition. *Learning and Individual Differences 17*(1), 35–53.

Reichenberg, M. (2008). *Vägar till läsförståelse. Texten, läsaren och samtalet*. Stockholm: Natur & Kultur.

Reynolds, C. R., & Shaywitz, S. E. (2009). Response to intervention: Ready or not? Or from wait-to-fail to watch-them-fail. *School Psychology Quarterly, 24*, 130-145.

Riis, U. (1991). *Skolan och datorn.* Satsningen datorn som pedagogiskt hjälpmedel 1988-1991. Linköpings universitet, Tema Rapport 24.

Rose, J. (2009). *Identifying and teaching children and young people with dyslexia and literacy difficulties: an independent report*. Retrieved from: http://www.teachernet.gov.uk/wholeschool/sen/

Ross, S. G., & Begeny, J. C. (2011). Promoting fluency in English-language learners: Comparing the effects of a small-group and one-on-one reading intervention. *Psychology in the Schools, 48*, 604-618.

Roth, S.F., & Beck, I.L. (1987). Theoretical and instructional implications of the assessment of two microcomputer word recognition programs. *Reading Research, 12*, 197-218.

Saine, N., Lerkkanen, M.-K., Ahonen, T., Tolvanen, A., & Lyytinen, H. (2011). Computer-assisted remedial reading intervention for school beginners at risk for reading disability. *Child Development, 82*, 1013-1028.

Samuels S. J. (1994). Word recognition. In R. B. Ruddell, M. R. Ruddell & H. Singer (Eds.), *Theoretical models and processes of reading* (pp. 359-380). Newark, DE: International Reading Association.

Savage, R. (2001). The 'simple view' of reading: Some evidence and possible implications. *Educational Psychology in Practice, 17*(1), 17–33.

Scammaca, N., Vaughn, S., Roberts, G., Wanzek, J., & Torgesen, J. K. (2007). *Extensive reading interventions in grades k-3: From research to practice*. Portsmouth, NH: RMC Research Corporation, Center on Instruction.

Schrauben, J. E. (2010). Prosody's contribution to fluency: An examination of the theory of automatic information processing. *Reading Psychology*, *31*(1), 82-92.

Share, D. (1995). Phonological recording and self-teaching: Sine qua non of reading acquisition. *Cognition, 55,* 151-218.

Share, D. (1999). Phonological recording and orthographic learning: A direct test of the self-teaching hypothesis. *Journal of Experimental Child Psychology, 72*, 95-129.

Shaywitz, S. E. (2003). *Overcoming dyslexia*: a new and complete science-based program for reading problems at any level. New York: Vintage Books.

Shaywitz, S. E., & Shaywitz, B. A. (2005). Dyslexia (Specific reading disability). *Biological Psychiatry, 57*(11), 1301-1309.

Shaywitz, B., Shaywitz, S., Pugh, K., Mencl, W., Fulbright, R., Skudlarski, P., et al. (2002). Disruption of posterior brain systems for reading in children with developmental dyslexia. *Biological Psychiatry, 52*(2), 101-110.

Skolinspektionen (2011). *Läs- och skrivsvårigheter/dyslexi i grundskolan*. Stockholm: Skolinspektionen.

Skolverket (2007). *Vad händer med läsningen?: en kunskapsöversikt om läsundervisningen i Sverige 1995-2007.* Stockholm: Skolverket.

Snow, C., Burns, M.S., & Griffin, P. (Eds.), 1998, *Preventing Reading Difficulties in Young Children*, Committee on the Prevention of Reading Difficulties in Young Children., Snow, C.E., Burns, M.S., & Griffin, P. (1998). Preventing reading difficulties in young children [Elektronisk resurs]. Washington, DC: National Academy Press

Snowling, M. J. (1998). Connectionism and educational practice: A rejoinder. *Educational And Child Psychology, 15*(2), 66-68.

Snowling, M. J. (2000). *Dyslexia*. (2nd ed.) Oxford. Blackwell.

Snowling, M. J. (2011). Beyond phonological deficits: Sources of individual differences in reading disability. In S. A. Brady, D. Braze & C. A. Fowler (Eds.), *Explaining Individual Differences in Reading. Theory and Evidence*. New York. Psychology Press.

Snowling, M. J., & Hulme, C. (2011). Evidence-based interventions for reading and language difficulties: Creating a virtuous circle. *British Journal Of Educational Psychology*, *81*(1), 1-23.

Snowling, M. J., Stothard, S. E., & Bishop, D. V. M. (2000). Is pre-school language impairment a risk factor for dyslexia in adolescence? *Journal of Child Psychology & Psychiatry*, *41*, 587-600.

Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly, 21*, 360-407.

Stanovich, K. E. (1996). Toward a more inclusive definition of dyslexia. *Dyslexia, 2,* 154-166.

Stuart, M., Stainthorp, R., & Snowling, M. (2008). Literacy as a complex activity: Deconstructing the simple view of reading. *Literacy, 42*(2), 59-66.

Svensson, I. (2003). *Phonological dyslexia. Cognitive, behavioural and hereditary aspects*. (Doctoral thesis). Psykologiska Institutionen, Göteborgs Universitet.

Svensson, I. (2011). Reading and writing disabilities among inmates in correctional settings. A Swedish perspective. *Learning and Individual Differences. 21*, 19-29.

Swalander L, (2009). Självbild, motivation och dyslexi. In: Samuelsson et al. (2009). *Dyslexi och andra svårigheter med skriftspråket*. Stockholm: Natur och Kultur.

Taboada, A., Tonks, S. M., Wigfield, A., & Guthrie, J. T. (2009). Effects of motivational and cognitive variables on reading comprehension. *Reading and Writing, 22* (1), 85-106.

Taube K. (2007a). *Barns tidiga läsning*, Norstedts Akademiska Förlag.

Taube, K. (2007b*). Läsinlärning och självförtroende – psykologiska teorier, empiriska undersökningar och pedagogiska konsekvenser*. (4th rev. ed.). Stockholm: Norstedts Akademiska Förlag.

Tjus, T. (1998). *Language and literacy acquisition in children with developmental and learning disabilities.* Göteborgs Universitet.

Tjus, T., Heimann, M., & Nelson, K.E. (2001). Interaction patterns between children and their teachers when using a specific multimedia and communication strategy: Observations from children with autism and mixed handicaps. *Autism, 5,* 175-188.

Tjus, T., Heimann, M., & Nelson, K.E. (2004). Reading acquisition by implementing a multimedia intervention strategy for fifty children with autism or other learning and communication disabilities. *Journal of Cognitive and Behavioral Psychotherapies (2),* 203-221.

Torgesen, J. K. (2005). Recent discoveries on remedial interventions for children with dyslexia. In M. J.Snowling & C.Hulme (Eds.), *The science of reading: A handbook* (pp. 521–537). Oxford: Blackwell.

Torgesen, J. K., Alexander, A. W., Wagner R. K., Rashotte C. A., Voeller K. K. S., & Conway T. (2001). Intensive remedial instruction for children with severe reading disabilities: Immediate and long-term outcomes from two instructional approaches. *Journal of Learning Disabilities. 34*, 33-58.

Torgesen, J. K., & Hudson, R. (2006). Reading fluency: Critical issues for struggling readers. In S.J. Samuels and A. Farstrup (Eds.). *Reading fluency: The forgotten dimension of reading success.* Newark, DE: International Reading Association.

Torgesen, J.K., Wagner, R. K., & Rashotte, C. A. (1994). Longitudinal studies of phonological processing and reading. *Journal of Learning Disabilities, 27*, 276-286.

Torgesen, J. K., Wagner, R. K., Rashotte, C. A., Herron, J., & Lindamood, P. (2010). Computer-assisted instruction to prevent early reading difficulties in students at risk for dyslexia: Outcomes from two instructional approaches. *Annals of Dyslexia*, *60*(1), 40-56.

Troia, G. A. (1999). Phonological awareness intervention research: A critical review of the experimental methodology. *Reading Research* Quarterly, 34, 28-52.

Tunmer, W., & Greaney, K. (2008). Reading intervention research: An integrative framework. In G. Reid, A. Fawcett, F. Manis, & L. Siegel (Eds.), *The Sage handbook of dyslexia* (pp. 241-267). London: Sage.

Tunmer, W., & Greaney, K. (2010). Defining dyslexia. *Journal of Learning Disabilities, 43*, 229- 242.

Underwood, J.D.M. (2000). A comparison of two types of computer support for reading development. *Journal of Research in Reading, 23*, 136-148.

Utbildningsdepartementet (2011). *Läroplan för grundskolan, förskoleklassen och fritidshemmet 2011*. Stockholm: Utbildningsdepartementet.

Vandervelden, M. C., & Siegel, L. S. (1997). Teaching phonological processing skills in early literacy: A developmental approach. *Learning Disability Quarterly*, (2), 63.

Vaughn, S., & Fuchs, L. S. (2003). Redefining learning disabilities as inadequate response to instruction: The promise and potential problems. *Learning Disabilities Research & Practice (Blackwell Publishing Limited)*, *18*(3), 137-146.

Vellutino, F.R., Fletcher, J.M., Snowling, M.J., & Scanlon, D.M. (2004). Specific reading disability (dyslexia): What have we learned in the past four decades? *Journal of Child Psychology and Psychiatry, 45*(1) 2-40.

Vellutino, F.R., Scanlon, D.M., & Sipay, E. (1997). Toward distinguishing between cognitive and experiential deficits as primary sources of difficulty in learning to read: The importance of early intervention in diagnosing specific reading disability. In B. Blachman (Eds.), Foundations of reading acquisition and dyslexia: Implications for early intervention. Mahwah, NJ: *Lawrence Erlbaum Associations*, pp. 347-379.

Vellutino, F.R., Scanlon, D.M., & Spearing, D. (1995). Semantic and phonological coding in poor and normal readers. *Journal of Experimental Child Psychology, 59*, 76-123.

Vellutino, F., Scanlon, D., & Tanzman, M. (1998). The case for early intervention in diagnosing specific reading disability. *Journal of School Psychology*, *36,* 367-97.

Vellutino, F. R., Scanlon, D. M., Zhang, H., & Schatschneider, C. (2008). Using response to kindergarten and first grade intervention to identify children at-risk for long-term reading difficulties. *Reading and Writing, 21*, 437-480.

Vellutino, F. R., Tunmer, W. E., Jaccard, J. J., & Chen, R. (2007). Components of reading ability: multivariate evidence for a convergent skills model of reading development. *Scientific studies of reading*, *11*, 3-32.

Verhoeven, L., & Snow, C. (2001). Literacy and motivation: bridging cognitive and sociocultural viewpoints. In Verhoeven, L., & Snow, C. E. (Eds.), Literacy and motivation. Reading engagement in individuals and groups. London*: Lawrence Erlbaum Associates.* 1-19.

Verhoeven, L., van Leeuwe, J., & Vermeer, A. (2011). Vocabulary growth and reading development across the elementary school years. *Scientific Studies of Reading, 15*(1), 8 25.

Vygotsky, L. (1934/1962). *Thought and Language*, MIT, Cambridge, Massachusetts.

Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (1994). Development of reading-related phonological processing abilities: Evidence of bi-directional causality from a latent variable longitudinal study. *Developmental Psychology, 30*, 73-87.

Wang, J. H., & Guthrie, J. T. (2004). Modeling the effects of intrinsic motivation, extrinsic motivation, amount of reading, and past reading achievement on text comprehension between U.S. and Chinese students. *Reading Research Quarterly, 39*(2), 162-186.

Watts, M., & Lloyd, C. (2004). The uses of innovative ICT in the active pursuit of literacy. *Journal of Computer Assisted Learning, 20*, 50-58.

Wise, B. W., Ring, J., & Olson, R. K. (1999). Training phonological awareness with and without explicit attention to articulation. *Journal of Experimental Child Psychology, 72*, 271-304.

Wolf, M., & Katzir-Cohen, T. (2001). Reading fluency and its intervention. *Scientific Studies of Reading, 5*(3), 211-239.

Wolff, U. (2005). *Characteristics and varieties of poor readers*. (Doctoral thesis). Göteborgs universitet.

Wolff, U. (2011). Effects of a randomised reading intervention study: An application of structural equation modelling. *Dyslexia*, 17, 295-311.

Ziegler, J. C., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across language: A psycholinguistic grain size theory. *Psychological Bulletin*, *131*, 3-29.

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The Effects of Two Training Programs Regarding Reading Development among Children with Reading Disabilities

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Aim: The purpose of the study was to examine the effects of two different training programs regarding reading skills in 14 reading disabled Swedish children in grade two. Method: The children's results from two different decoding measures plus identification by teachers as having reading difficulties were used to select the participants. Seven of the children used Omega-IS, which entails computerized top-down, orthographic training and no additional homework, and seven children used non-computerized Reading Recovery inspired training with some components of phonological training included plus 20 homework occasions. For both programs the training sessions were conducted individually (one-to-one teaching) and lasted between 15 and 45 minutes. Results: Both groups improved significantly in all tests assessing word and non-word decoding as a result of the intervention. No significant differences were yielded between the intervention programs. Conclusion: The conclusion is that one-to-one teaching has a positive impact regardless whether a top-down or a reading instructional strategy with phonological components is implemented. Due to the result of the Omega-IS group it might also be possible to reduce homework for reading disabled children if reading is well tutored in school.

Keywords: Children, Intervention, Reading and Writing Disabilities

Introduction

Since there has been an increasing demand for literacy skills in modern society, a failure in this domain can seriously affect an individual's possibility to be an active citizen in democratic respects. Approximately 15 to 20 percent of school children in Sweden have some kind of reading and writing disabilities (Lundberg, 1985). Constant failure and the feeling of not being able to read are devastating for the self-esteem and may increase the risk of drop-outs in school, which in turn might enhance the risk of being marginalized in society (McNulty, 2003; Svensson, 2010). The negative effects of reading and writing disabilities and dyslexia involving low self-esteem seem to be most profound during the first 6 years of schooling (Stanovich, 1986). Findings also indicate that the early identification of literacy difficulties as well as the intervention process can even prevent reading disabled children from developing negative self-esteem (Humphrey, 2002; McNulty, 2003). It is therefore important to not only early identify, but also to remediate the children who are likely to encounter literacy difficulties in the future.

There is an abundance of research papers that have focused on reading and writing disabilities, but less than 1% of these studies have concerned intervening with dyslexia (Bakker, 2006). However, there are a number of studies attempting to examine individual differences in response to specific intervention, some of the methods used being computerized and some not. For example, an intervention study which did not use computerized programs was made by Torgesen et al. (2001) of 60 children between the ages of 8 and 10 with the focus on reading and writing. Half of the children were randomly assigned to a training program called ADD (Auditory Discrimination in Depth), which focuses on children's phonological skills through auditory and articulatory exercises. The other half used a program called EP (Embedded Phonic), which also focuses on children's phonological awareness, but through different types of texts, spelling exercises and strategies. All children received a total of 67.5 hours of one-to-one teaching, each divided into two 50-minute sessions per day for 8 weeks. Results showed that both groups made significant progress on tests that measure reading ability, and the results proved to be stable two years after the intervention. One year after the intervention ended it was reported that 40% of the participants were not in need of special education any longer. Another example is a computerized longitudinal intervention study of reading disabled children in grades 2-3, which showed that phonological and orthographic word decoding skills need to be taken into account when suggesting interventions (Gustafson, Ferreira & Rönnberg, 2007). This study also demonstrated that children with pronounced phonological word decoding problems showed more progress in reading after phonological than after orthographic training, while children with pronounced orthographic problems benefited more from orthographic than from phonological training.

Longitudinal intervention studies in different countries have demonstrated that phonological awareness training improves phonological and reading skills in novice readers, at-risk and reading disabled children (Alexander & Slinger-Constant, 2004; Ball & Blachman, 1988; Elbro & Petersen, 2004; Lundberg, Frost & Petersen, 1988; Poskiparta, Niemi & Vauras, 1999; Schneider, Kuspert, Roth, Vise & Marx, 1997; Torgesen, Morgan & Davis, 1992). The transfer effects from improved phonological skills to improved reading skills seem to be enhanced when the instruction provides explicit links between phonemes

and graphemes (Bradley & Bryant, 1983; Bus & van IJzendoorn, 1999; Ehri et al., 2001; Hatcher, Hulme & Ellis, 1994; Torgesen et al., 2001; Wise, Ring & Olson, 1999). The focus of the present study is on early intervention (grade 2) with different kinds of reading and writing difficulties. However, just one of the training programs in the study reported here explicitly contains phonological awareness training, being inspired by *Reading Recovery* (Clay, 1993) and not computerized. The other, computerized, method, *Omega-IS* (Omega-Interactive Sentences), is targeted at the word and sentence levels of written language, i.e., top-down processing (Heimann, Lundälv, Tjus & Nelson, 2004). The present study comparing a computerized method without any homework with a non-computerized method including homework where parents are requested to help the child has child has as far as we know very few reports before.

Aim

The aim of this study is to examine the effects of two different training programs on the reading skills of reading disabled children. In addition to group comparisons, individual differences of the effects of the interventions will be reported.

Hypothesis. Omega-IS had not been used previously in the clinical setting where the study was conducted, and on the basis of the first author's clinical experience of using Reading Recovery plus the additional homework training provided it was hypothesized that Reading Recovery would outperform the Omega-IS multimedia program in all three outcome measures.

Method

Participants

For participation in the study two inclusion criteria were used: (i) Results from two different measures, *Fonolek* [*Phonoplay*] and *Vad sa du fröken*? [*What did the teacher say*?], made in pre-school with children aged 6 were used in combination. *Fonolek* (Olofsson & Hemmingsson, 1993) is a phonological test, which includes sound synthesis, sound segmentation, and a section in which the child is to identify the initial sound, with 18 as the maximum score. A score under 12 is considered to be an indication of phonological problems. *Vad sa du fröken?* (Alstam-Malcus, & Fritzell, 2006) is a screening material for pre-school and first graders that map out the beginner's language and speech level. A speech pathologist ranks the speech development at five levels from A to E, with levels from A to C indicating speech problems. The children had to have both a score below 12 on *Fonolek* and to be ranked from level A, B or C on *Vad sa du fröken?* to fulfil the first criterion. Secondly, when the children were in grades 1-4 (in Sweden children usually begin grade 1 at the age of seven) they had to be identified by their teachers as having serious difficulty acquiring word-level reading skills. Out of 93 children, 20 (21.5%) fulfilled the inclusion criterion, and 14 children, all Swedish native speakers, gained the consent of their parents to participate in the study (see Table 1). All participants were assessed by Raven's Coloured Progressive Matrices (Raven, Court & Raven, 1984), and all scored above the 25th percentile, i.e. they were within the normal range. They were matched in age, non-verbal cognitive ability, measured by Raven's Coloured Progressive Matrices (Raven et al., 1984), and in decoding skills, assessed by the Wordchains test (Jacobson, 1993); see Measures for a description.

The experimental groups were randomly assigned to using either Omega-IS or Reading Recovery.

Procedure

The design of the intervention comprised Pre-, Start, Post 1 and Post 2 tests with four weeks between Pre- and Start Tests, six weeks between Start and Post 1 and four weeks between Post 1 and Post 2 tests, creating a baseline, an intervention and a follow-up period (Table 2). Two reading and one non-word reading tests were carried out for all children at Pre, Start, Post 1 and Post 2.

During the baseline period all participants received special tutoring twice a week in the Swedish language, with 3-4 participants in each group. They had no access to any other special tutoring during the time of the intervention study. The group of children who used the Omega-IS multimedia program completed 20 training sessions in total. The sessions lasted from 15 minutes at the beginning to 40 minutes at the end of intervention. No other special tutoring during the intervention was provided, and the children had no reading homework. In the Reading Recovery (RR) group the children received 20 training sessions of 30 - 40 minutes each. This group also had homework linked to the method on 20 different occasions. The homework lasted for 10 - 20 minutes, always with a parent present. All tutoring in the study, both with regard to Reading Recovery and Omega-IS, was made on a one-to-one basis, and the first author (L.F.) carried out all training sessions and assessment in both training programs.

Measures

Three tests were used in order to measure the participants' reading skills with regard to word decoding.

Word recognition. Word recognition was assessed by the Wordchains test (Jacobson, 1993). The participant is asked to silently read chains of words where the blank space between

Table 1.
Distribution of participants according to grade and gender.

Grade	Gender	
	Boys	Girls
First	4	-
Second	2	1
Third	2	1
Fourth	3	1

Table 2.
Design of the intervention showing test points and number of weeks for baseline, training and follow-up periods.

Pretest	Baseline 4 weeks	Start test	Intervention 6 weeks	Post test 1	Folow-up 4 weeks	Post test 2

words has been removed. Each chain consists of three semantically unrelated words, and the child is instructed to mark each word boundary with a pencil (Jacobson, 1993).

Sight word reading. This is an individual reading pace test called H4 (Franzén, 1999). In one minute the child should read as many words as possible from a list with commonly used words. The length of the words constantly increases.

Non-word reading. The child has to read from a list as many nonwords as possible in one minute. The words do not exist in reality, but they can be pronounced. Reading nonwords is thought to be done mainly via phonological processing. Since the words are nonwords it can be assumed that the child has never seen the words before; therefore, the orthographic direct way cannot be used (Jacobson, Svensson & af Trampe, unpublished data).

Training Programs

Omega-IS

Omega-IS is a multimedia program that uses a top-down strategy, i.e. by clicking on buttons with words or phrases sentences are constructed. Immediate feedback is obtained for both words and sentences in the form of speech and animations providing corresponding one-to-one semantic comprehension, thus inviting the child to explore written text. The lessons included in the program went from two-(noun + verb) and three-word sentences (noun + verb + noun) up to stories within which the child could construct their own stories and choose different actors and scenarios. This was done in order to increase the children's motivation to explore literacy. Positive results on reading have been reported, for instance for children with autism, cerebral palsy or developmental dyslexia (Tjus, 1998). The language material of the program is meant to be explored by the learner with help from and in interaction with a teacher or parent. This and the appended animations not only offer motivational literacy training but also give occasion for conversations where the learner can express his or her imagination and thoughts. The goal is to achieve an errorless co-con- struction of meaning from text through multimedia and suppor- tive interaction.

Reading Recovery

An intervention inspired by *Reading Recovery (RR)* (Clay, 1993) was used in the study. RR was used in a research and development study at Auckland University in the late 1970s and the early 1980s. RR is an educational program that offers early, intensive and individual reading education for children that are slow reading starters. The purpose of the program is, according to Clay (1993), to prevent early reading disabilities from becoming permanent.

The individual educational program cons ists of the following steps:

- Reading two or more well-known, easily read booklets or books
- Reading the booklet or book from the previous day
- Working with words and loose letters
- Writing one or two sentences
- Dissembling the sentences, which includes working with phonemes and word segments
- Reassembling the sentences to their original stage
- Introducing a new booklet or book

All the steps should be dealt with for about 30 - 40 minutes, which makes the tempo pretty high. The teacher takes minutes, a so-called "Running Record" when the child reads the book from the previous day. Reading that book has been the homework together with reassembling the original sentences and reading them out correctly to a parent. The homework takes about 10 - 20 minutes a day. This method offers practice on word and sentence levels but also focuses on phonological awareness (Clay, 1993; Frost, 2002; Jörgensen, 2001).

Statistical Analysis

The analysis focuses on changes over time in observed means between baseline, intervention and follow-up. The means for each period are calculated as change scores (mean at the end of a period minus mean at the start of the period). Both group comparisons (unpaired t-tests) and within-group comparisons (paired t-tests) are conducted. Even if a hypothesis was stated, a two-tailed significant level (alpha 0.5) was used for conservative reasons, due to the small sample observed. Since non-parametric and parametric methods yielded the same results, only parametric methods are reported.

Result

The descriptive results are shown both in tables (baseline, intervention, and follow-up periods) and as graphs at Pre-test, Start test, Post 1 and Post 2 tests.

Between-group comparison.

When comparing the Omega-IS group and the RR group for baseline, intervention and follow-up periods on change scores no significant difference was observed for any of the outcome measures (Tables 3 and 4).

Table 3.
Means and standard deviation of raw scores at observation points and change scores during baseline (BL), training (TR) and follow-up (FU) periods for the Omega-IS group.

	Pre test Raw score	Start test Raw score	Post test 1 Raw score	Post test 2 Raw score	*BL Change score*	*TR Change score*	*FU Change score*
Word recognition	15.0 (8.8)	15.1 (8.7)	21.1 (9.2)	21.0 (8.9)	0.1 (1.1)	6.0 (3.8)	−0.1 (0.7)
Sight word reading	45.3 (30.8)	45.0 (30.7)	54.3 (31.2)	53.6 (30.2)	−0.3 (0.9)	9.3 (4.8)	6.9 (4.8)
Non-word decoding	18.1 (9.4)	17.1 (8.1)	21.6 (9.7)	20.4 (8.6)	−1.0 (1.9)	4.4 (2.1)	−1.1 (1.3)

Table 4.
Means and standard deviation of raw scores at observation points and change scores during baseline (BL), training (TR) and follow-up (FU) periods for the Reading Recovery group.

	Pre test Raw score	Start test Raw score	Post test 1 Raw score	Post test 2 Raw score	*BL Change score*	*TR Change score*	*FU Change score*
Word recognition	14.1 (11.0)	14.1 (10.3)	19.7 (11.8)	19.0 (11.3)	−0.6 (1.6)	5.6 (4.5)	−0.7 (1.6)
Sight word reading	37.9 (23.7)	36.9 (21.4)	43.7 (23.1)	43.4 (22.6)	−1.0 (3.0)	6.9 (4.8)	−0.3 (0.9)
Non-word decoding	12.1 (5.0)	11.9 (4.6)	16.0 (5.1)	15.4 (5.4)	−0.3 (0.9)	4.1 (2.9)	−0.6 (0.8)

The groups were matched on the word recognition test and the mean for the groups on the Pre 1 test was identical (M = 14.71 Wordchains) (see Figure 1). During the intervention (from Start to Post 1) the results on word recognition increased for the Omega-IS group, M = 6.0, SD = 11.8 and on average 5.6 wordchains, SD = 9.2 for the RR group. The test at Post 2 showed that both groups almost maintained their results, i.e. that the Omega-IS group and the RR group decreased on average by 0.7 (SD = 11.3) and 0.14 (SD = 8.9), respectively.

The results for sight word reading show that the Omega-IS group had a better starting point, which means that the children in this group read on average almost 8 more words/minute in comparison with the RR-group when taking the Start test. At Post 1 the Omega-IS group had on average increased by 9.0 words/minute (SD = 31.2) and the increase for the RR-group was 6.3 words/minute (SD = 23.1).

The development curves for nonword decoding showed that the Omega-IS group had on average 5.28 more correctly read nonwords at Start compared to the RR-group (Figure 2). The intervention showed almost the same development in both groups. The Omega-IS group showed an increase by 3.9 nonwords/minute and the RR-group by 4.0 nonwords/minute. At Post 2 the results showed a decrease for the Omega-IS group by 1.1 nonwords, and a decrease for the RR-group by 0.6 nonwords.

Within-Group Comparison

Omega-IS

In the comparison of the different periods, a significant increase appeared when comparing change scores on baseline with training for all outcome measures (Table 3): Word recognition, $t(6) = -3.5$, $p = 0.013$; Sight word reading, $t(6) = -5.3$, $p = 0.002$; Non-word decoding, $t(6) = -4.2$, $p = 0.006$. A significant decrease on all measures was yielded when comparing training with follow-up period: Word recognition, $t(6) = 3.9$, $p = 0.008$; Sight word reading, $t(6) = 5.1$, $p = 0.002$; Non-word decoding, $t(6) = 4.7$, $p = 0.003$. No significant differences on any of the measures came out when comparing baseline and follow-up periods.

Reading Recovery

A significant increase was observed when comparing change scores on baseline with training for all outcome measures (Table 4): Word recognition, $t(6) = -2.9$, $p = 0.028$; Sight word reading, $t(6) = -3.9$, $p = 0.008$; Non-word decoding, $t(6) = -3.7$,

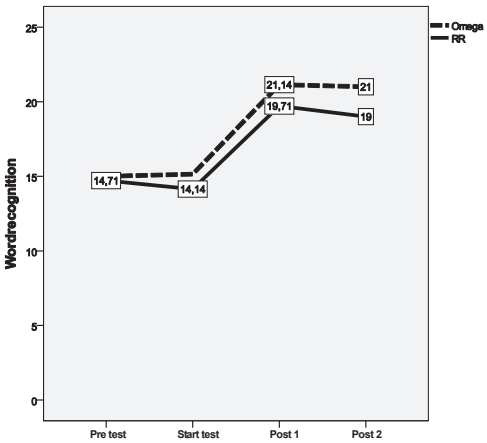

Figure 1.
Development curves for word recognition.

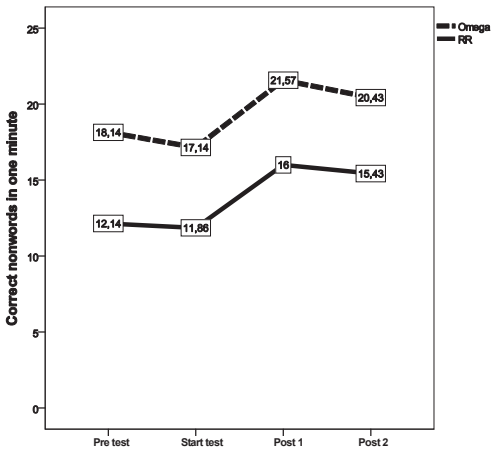

Figure 2.
Development curves for Phonological decoding test.

p = 0.010. A significant decrease was yielded on all measures when comparing training with follow-up periods: Word recognition, t(6) = 3.2, p = 0.019; Sight word reading, t(6) = 3.9, p = 0.008; Non-word decoding, t(6) = 5.1, p = 0.002. When comparing baseline and follow-up periods no significant differences were noted on any of the measures.

Individual Results

Figures 3 and 4 show individual curves for the word recognition test wordchains and the test that measures phonological decoding, i.e. nonword decoding.

The individual curves follow almost the same pattern regardless of the starting level at which the child started, i.e. there is an obvious increase between Start test and Post test 1, except for a couple of children where there is almost no development at all.

The individual curves follow almost the same pattern for the phonological decoding test as for the word recognition test. Regardless of the level at which the child started, there is an obvious increase between Post 1 and Post 2, except for a couple of children where there is hardly any development at all.

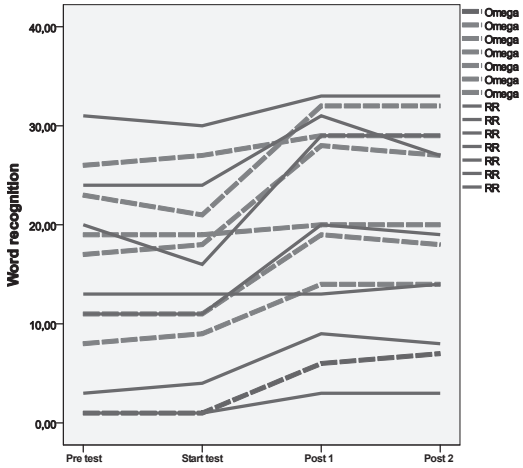

Figure 3.
Individual curves for word recognition test.

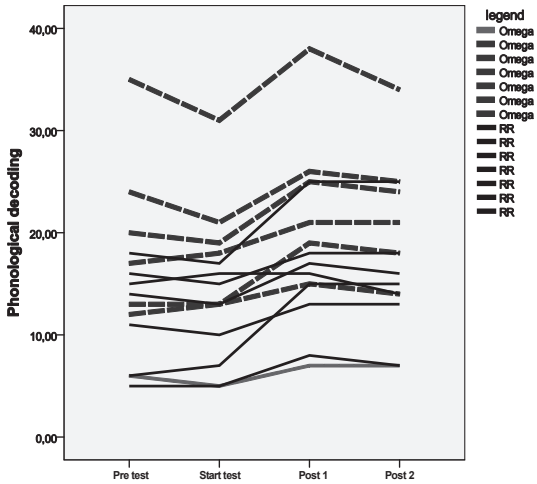

Figure 4.
Individual curves for Phonological decoding.

Discussion

The aim of the present study was to measure the effects of two intervention programs with the purpose of improving reading ability. The most striking finding from this study was the size of the gains in reading achievement made by this sample of disabled readers. At the group level both groups increase significantly between the Start and Post 1 tests and then the result curve flattens out between Post 1 and Post 2. As we expected, when the intervention is completed, there is no development on the varied skills tested, but the results remain even at the Post 2 test.

There are several different instructional methods when it comes to learning and improving reading ability, two of which are used in this study. The results showed that both groups, regardless of the method used, improved during the intervention in all of the tests measuring word recognition and phonological ability compared to baseline. However, there was no significant difference between the groups, even though the children in the Reading Recovery group had additional homework. It was hypothesized that Reading Recovery would outperform the Omega-IS multimedia program in all three outcome measures. This was not evidenced; instead the results indicate that a computer-based training program may be as effective as a non-computerized program for practising reading.

Looking at the results at the individual level, we see that some children have benefited greatly from the intervention, while others have hardly made any progress in, for example, their word decoding skills. One interpretation might be that some children respond positively to the type of intervention they received and that it was the right training for these particular individuals. Other children who did not respond positively to the intervention might have gained more if they had been exposed to the other intervention program or to some other type of intervention.

Even if this was not examined it can be speculated that those children who showed progress also increased their motivation for reading and enjoyed their training method. We have showed (Tjus, Heimann & Nelson, 2001) that enjoyment increases in children with learning disabilities as an effect of reading intervention and an important domain of children's self-concept is reading and writing skills having an impact on their self-perceived competence (Harter, 2006). Mc Nulty (2003) has shown that early remediation is important for the academic self esteem. However, the children showing no increase in reading gain may in contrast become frustrated and tired of the training they received. With the design used it was not possible to change training method. The ideal would have been to use a cross-over design letting the children use both methods but this was not possible due to human resources.

The study shows that intense one-to-one teaching, regardless of the method used, may increase children's reading ability. This could indicate that it is the teacher that matters providing pedagogical and emotional support, that it is indeed the effect of the teacher which makes a difference. However, in this study the same teacher who worked with the children in the ordinary special education taking place before the interventions also performed all interventions with all children. Test results show that there is no development between the Pre-test and the Start test, and the fact that the intervention does have an effect seems to indicate that it is the interventions that are crucial for the results of the Post 2 tests. During the interventions only one-to-one teaching was used, which was not the case during the regular special education taking place before the interventions. Children with this type of difficulty seem to take advantage of one-to-one teaching and it might be that the interaction between child and teacher increases exposure also to spoken language, which is crucial for long-term language development (Hart & Riesly, 1995).

Although the groups were initially matched on word recognition, they differ in particular at baseline in the test that measures non-word decoding, despite the fact that the two groups increase equally on this test. The children in the Omega-IS group generally reached the same results, even though they did not have homework. This is an interesting result since homework is looked upon as tiring by both children and parents. Many of the participants in this study say that they often feel that their homework takes too much time and effort. The results of this study actually show that with the right kind of training it might be able to achieve the same results on reading skills without a great deal of homework. A limitation of this study is the small number of participants and that the children are attending different grades. This makes it difficult to interpret the results according to a specific age.

The experience of children working with the multi-media program in this study is that both the technologies in themselves and the fact that the computer program gives continuous feedback on children's reading make a good incentive. A multi-media program that is stimulating for the children can give the same increase of reading ability and be a compliment to the original reading education, as has been shown in previous studies (Tjus 1998; Tjus, Heimann & Nelson, 2004).

The reading process is a very complex cognitive activity involving many sub-processes and systems. It is therefore not surprising that a group of reading disabled children tend to be quite heterogeneous, exhibiting different types of reading problems and also different challenges for remediation. Therefore, it is important that teachers have access to several different approaches and methods when remediating children with reading and writing disabilities. The result from the current study indicates that both of the intervention programs showed promising results. However, the results should be interpreted with caution, due to the small number of participants, and also taking into consideration that there was no control group in this study. It is hard to speculate about what the results would have been if these children had been part of the regular teaching and not been included in this study, which gives emphasis to the importance of having a control group to compare the results with. However, the design with a baseline the four-week gap in between the Pre-test and the Start test ensures the starting position, and the fact that virtually no development takes place in these weeks suggests that the effect was due to the intervene- tion. The Post 2 test after 4 weeks also contributes to making the results of the measurements intestable values. Furthermore, average improvements in reading skill might hide substantial individual differences in the effects of the intervention (Gustafson, Samuelsson, & Rönnberg, 2000; Torgesen & Davis, 1996). Considering the few intervention studies related to reading instruction, we think that educational interventions should be regarded from a dynamic rather than a static perspective. Recent studies in the fields of dynamic testing and assessment and response to intervention demonstrate the need to think of

educational interventions as ongoing processes where assessment can assist intervention and vice versa (see Grigorenko, 2009).

There is now strong evidence that the main manifestation of developmental dyslexia is word decoding deficits and that these shortcomings mainly stem from underlying phonological deficits (Bruck, 1992; Lundberg, Olofsson & Wall, 1980; Rack, Snowling & Olson, 1992; Stanovich & Siegel, 1994; Svensson & Jacobson, 2006). There is also strong evidence of biological (Galaburda et al., 1985; Morgan & Hynd, 1998) and genetic (Galaburda et al., 2006; Grigorenko, Ngorosho, Jukes & Bundy, 2006) influences that contribute to phonological deficits and poor word-decoding skills. The results of this study point to the importance of individualizing both testing and intervention, and the need for more systematic and scientific research on how to best adapt interventions to the specific needs of individual children. In a forthcoming investigation, with a sufficient number of participants, we are going to make deeper analyses regarding both orthographic and phonological aspects of different interventions and subgroups of reading disabilities.

References

Alexander, A. W., & Slinger-Constant, A.-M. (2004). Current status of treatments for dyslexia: Critical review. *Journal of Child Neurology*, *19*, 744-758.

Alstam-Malcus, A., & Fritzell, M. (2006). Vad sa du fröken? Umeå: Specialpedagogiska institutet.

Bakker, D. J. (2006). Treatment of development dyslexia: A review. *Paediatric Rehabilitation*, *9*, 3-13.

Ball, E. W., & Blachman, B. A. (1988). Phoneme segmentation training: Effect on reading readiness. *Annals of Dyslexia*, *38*, 208-225. doi:10.1007/BF02648257

Bradley, L., & Bryant, P. E. (1983). Categorising sounds and learning to read: A causal connection. *Nature, 301*, 419-421. doi:10.1038/301419a0

Bruck, M. (1992). Persistence of dyslexics' phonological awareness deficits. *Developmental Psychology*, *28*, 874-886. doi:10.1037/0012-1649.28.5.874

Clay, M. (1993). Reading recovery: A guidebook for teachers in training. Auckland: Heinemann Education.

Ehri, L. C., Nunes, S. R., Willows, D. M., Valeska Schuster, B., Yaghoub-Zadeh, Z., & Shanahan, T. (2001). Phonemic awareness instruction helps children learn to read: Evidence from the National Reading Panel's meta-analysis. *Reading Research Quarterly*, *36*, 250-287. doi:10.1598/RRQ.36.3.2

Elbro, C., & Petersen, D. K. (2004). Long term effects of phoneme awareness and letter sound training: An intervention study with children at risk for dyslexia. *Journal of Educational Psychology*, *96*, 660-670. doi:10.1037/0022-0663.96.4.660

Frost, J. (2002). Läsundervisning — Praktik och teorier. Stockholm: Natur och Kultur.

Galaburda, A. M., Sherman, G. F., Rosen, G. D., Aboitiz, F., & Geschwind, N. (1985). Developmental dyslexia: Four consecutive cases with cortical anomalies. *Annals of Neurology*, *18*, 222-233. doi:10.1002/ana.410180210

Grigorenko, E. L. (2009). Dynamic assessment and response to intervention: Two sides of one coin. *Journal of Learning Disabilities, 42*, 111-132. doi:10.1177/0022219408326207

Grigorenko, E., Ngorosho, D., Jukes, M., & Bundy, D. (2006). Reading in able and disabled readers from around the world: Same or different? An illustration from a study of reading-related processes in a Swahili sample of siblings. *Journal of Research in Reading*, *29*, 104-123. doi:10.1111/j.1467-9817.2006.00295.x

Gustafson, S., Samuelsson, S., & Rönnberg, J. (2000). Why do some resist phonological intervention? A Swedish longitudinal study of poor readers in grade 4. *Scandinavian Journal of Educational Research*, *44*, 145-162. doi:10.1080/713696666

Gustafson, S., Ferreira, J., & Rönnberg, J. (2007). DOT: Datorbaserad ortografisk träning. linköping: Institutionen för beteendevetenskap/ Institutet för handikappvetenskap, Linköpings universitet.

Hart, B. & Riesly, T. R. (1995). Meaningful differences in the everyday experience of young American Children. Baltimore, MD: Brookes.

Harter, S. (2006). The self. In: N. Eisenberg, W. Damon & R. M. Lerner, Eds., *Handbook of Child Psychology*, *Social*, *emotional*, *and personality development*, 6th Edition, John Wiley & Sons Inc, Hoboken, *3*, 505-570.

Heimann, M., Lundälv, M., Tjus, T., & Nelson, K. E. (2004). Omega-IS, a multimedia software for enhancing language and communication development in children with disabilities.

Humphrey, N. (2002). Teacher and pupil ratings of self-esteem in developmental dyslexia. *British Journal of Special Education*, *29*, 29-36. doi:10.1111/1467-8527.00234

Jacobson, C. (1993). Manual till ordkedjetestet. *The Word chains test*; *Manual*. Psykologiförlaget, Stockholm.

Jörgensen, K. (2001). Lyckas med läsning, läs- och skrivinlärning i Nya Zeeland. Stockholm: Bonnier Utbildning AB.

Lundberg, I. (1985). Språk och läsning. Stockholm: Liber.

Lundberg, I., Olofsson, Å., & Wall, S. (1980). Reading and spelling skills in the first school years predicted from phonemic awareness skills in kindergarten. *Scandinavian Journal of Psychology*, *21*, 159-173. doi:10.1111/j.1467-9450.1980.tb00356.x

McNulty, M. A. (2003). Dyslexia and the life course. *Journal of Learning Disabilities*, *36*, 363-381. doi:10.1177/00222194030360040701

Morgan, A. E., & Hynd, G. W. (1998). Dyslexia, neurolinguistic ability, and anatomical variation of the plenum temporal. *Neuropsychological Review*, *8*, 79-93. doi:10.1023/A:1025609216841

Olofsson, Å., & Hemmingsson, I. (1993). Fonolek. LPC Östersunds kommun.

Poskiparta, E., Niemi, P., & Vauras, M. (1999). Who benefits from training in linguistic awareness in the first grade, and what components show training effects? *Journal of Learning Disabilities*, *32*, 437-446, 456.

Psykologiförlaget, A. B. (1995). Raven's Matrices — Coloured. Stockholm: Psykologiförlaget.

Rack, J. P., Snowling, M. J., & Olson, R. K. (1992). The nonword reading deficit in developmental dyslexia. *Reading Research Quarterly*, *27*, 29-53. doi:10.2307/747832

Raven, C., & Raven. (1994). Raven's coloured progressive matrices. Psykologiförlaget.

Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly*, *21*, 360-407. doi:10.1598/RRQ.21.4.1

Svensson, I., & Jacobson, C. (2006). How persistent are phonological difficulties? A longitudinal study of reading retarded children. *Dyslexia*, *12*, 3-20. doi:10.1002/dys.296

Taube, K., Tornéus, M., & Lundberg, I. (1984). UMESOL. Stockholm: Psykologiförlaget.

Tjus, T. (1998). Language and literacy acquisition in children with developmental and learning disabilities. Göteborgs Universitet, Psykologiska institutionen.

Tjus, T., Heimann, M., & Nelson, K. E. (2004). Interaction patterns between children and their teachers when using a specific multimedia and communication strategy: Observations from children with autism and mixed handicaps. *Autism*, *5*, 175-188.

Tjus, T., Heimann, M. & Nelson, K. E. (2004). Reading acquisition by implementing a multimedia intervention strategy for fifty children with autism or other learning and communication disabilities. *Journal of Cognitive and Behavioural Psychotherapies*, *2*, 203- 221.

Torgesen, J. K., Alexander, A. W., Wagner, R. K., Rashotte, C. A., Voeller, K. K. S., & Conway, T. (2001). Intensive remedial instruction for children with severe reading disabilities: Immediate and long-term outcomes from two instructional approaches. *Journal of*

Learning Disabilities, *34*.

Torgesen, J. K., Morgan, S., & Davis, C. (1992). Effects of two types of phonological awareness training on word learning in kindergarten children. *Journal of Educational Psychology*, *84*, 364-370. doi:10.1037/0022-0663.84.3.364

Wise, B. W., Ring, J., & Olson, R. K. (1999). Training phonological awareness with and without explicit attention to articulation. *Journal of Experimental Child Psychology*, *72*, 271-304. doi:10.1006/jecp.1999.2490

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Effects of Three Interventions on the Reading Skills of Children With Reading Disabilities in Grade 2

Stefan Gustafson[1], Linda Fälth[2], Idor Svensson[2], Tomas Tjus[3], and Mikael Heimann[4]

Abstract

In a longitudinal intervention study, the effects of three intervention strategies on the reading skills of children with reading disabilities in Grade 2 were analyzed. The interventions consisted of computerized training programs: One bottom-up intervention aimed at improving word decoding skills and phonological abilities, the second intervention focused on top-down processing on the word and sentence levels, and the third was a combination of these two training programs ($n = 25$ in each group). In addition, there were two comparison groups, 25 children with reading disabilities who received ordinary special instruction and 30 age-matched typical readers. All reading disabled participants completed 25 training sessions with special education teachers. All groups improved their reading skills. The group who received combined training showed higher improvements than the ordinary special instruction group and the typical readers. Different cognitive variables were related to treatment gains for different groups. Thus, a treatment combining bottom-up and top-down aspects of reading was the most effective in general, but individual differences among children need to be considered.

Keywords

intervention, reading disability, individual differences, response to intervention

The process of reading is a very complex cognitive activity involving many subprocesses and systems. It is therefore not surprising that a group of children with reading disabilities tends to be quite heterogeneous, exhibiting different types of reading problems and therefore also different challenges for remediation. According to "the simple view of reading" (Hoover & Gough, 1990), three basic groups of poor readers can be identified: those with decoding problems (cf. developmental dyslexia), those with language comprehension problems, and those with both decoding and comprehension problems. It should be noted that in special education settings, these three groups often tend to be mixed together and that all children who receive special education in reading do not have developmental dyslexia. Cognitive and neuropsychological assessment can be used here both for problem identification and to assist in the development of appropriate interventions (Hale, Kaufman, Naglieri, & Kavale, 2006).

There is firm evidence that educational interventions focusing on developing phonological skills and linking phonological units of language (phonemes, word segments, and words) to the corresponding written units can improve the word decoding and reading skills of children with reading disabilities (Ehri et al., 2001; Elbro & Petersen, 2004; Hatcher, Hulme, & Ellis, 1994; Tijms & Hoeks, 2005; Torgesen et al., 2001; Wise, Ring, & Olson, 1999). Of course, word decoding strategies and word decoding skills are only two examples of variables that might predict response to phonological training (see also Torgesen & Davis, 1996), and in the present study a wide range of cognitive variables was examined (see Method section).

Average improvements of groups in response to phonological training might hide substantial individual differences in improvements, and while some children are easily remediated, other children are difficult to remediate (Gustafson, Ferreira, & Rönnberg, 2007; Gustafson, Samuelsson, & Rönnberg, 2000; Poskiparta, Niemi, & Vauras, 1999; Torgesen & Davis, 1996; Vellutino et al., 1996). For example, in a previous study (Gustafson et al., 2000) some children did benefit from a phonological intervention while other children seemed resistant to the same intervention. Results indicated that to benefit from the phonological training, children

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had to use a phonological word decoding strategy at least to some extent. It should be noted that participants in this study were in Grade 4 and therefore had more firmly established word decoding strategies than children who just started learning to read. Another study demonstrated a double dissociation among children with reading disabilities in Grades 2 and 3: Children with pronounced phonological problems increased their reading skill more from phonological training than from orthographic training, while children with pronounced orthographic problems did benefit more from orthographic than from phonological training (Gustafson et al., 2007).

Most intervention studies have focused on phonological bottom-up training since problems with reading have long been known to be related to deficits in phonological awareness (Elbro, 1996). However, the observations that some children do not improve as expected from a strict bottom-up strategy have lent support for the use of alternative strategies for children who are behind in their reading development. Some recent early intervention studies implementing a top-down strategy have reported positive findings. One example is a study by Berends and Reitsma (2006) where the effects of orthographic and semantic training were compared in a group of reading impaired children in first and second grades. It was found that semantic training outperformed orthographic training with the largest effect in second grade. In two studies by Hatcher, Goetz, et al. (2006) and Hatcher, Hulme, et al. (2006) it was observed that children at risk of developing dyslexia made significant gains in reading and spelling after training semantics and grammar.

The comprehension training used in this study is based on the rare event transactional model (Nelson, Welsh, Camarata, Tjus, & Heimann, 2001), which states that several learning conditions must act in concert to maximize the scaffolding effect and thus increase the likelihood for learning to take place. These learning conditions are often difficult to bring together so that significant learning can take place, and according to the theory, it is rare for all relevant and enhancing factors to be present simultaneously in any specific teaching or learning situation. The instructional aim is to facilitate learning in an as optimal way as possible for each student. This is especially true when teaching children with learning problems who often display high individual variation of needs, capabilities, and motivation. By making use of multimedia material where text is illustrated by enjoying animations combined with verbal and emotional interaction with the teacher, this strategy has proven to be an effective additional route to reading skills in both typically developing preschool children and children with various communicative impairments (Basil & Reyes, 2003; Heimann, Nelson, Tjus, & Gillberg, 1995; Tjus, Heimann, & Nelson, 1998, 2004). Significant progress in letter knowledge and word and sentence reading but also in phonological awareness has been found even if the multimedia program focused on orthographic and semantic training. When comparing one group of children with reading problems using this multimedia-based rare event strategy and a group using a Reading Recovery–inspired strategy, both groups made progress but no between-group difference could be documented (Fälth, Svensson, & Tjus, 2009).

Strategy instruction, that is, to encourage critical thinking and consideration of alternatives when making decisions, seems to be a successful method to enhance reading comprehension (Fletcher, Lyon, Fuchs, & Barnes, 2007), and some strategy instruction was included in the comprehension training of the present study. By receiving immediate feedback from the computer and by their teachers' support and comments, the children had the opportunity to reflect upon their decisions.

In addition to obtaining reading improvement, it is important to promote the children's motivation to engage in literacy and language learning. This has also been evidenced since positive changes in motivation and communication expressed by an increase of enjoyment and speech production have been noted (Tjus et al., 2001). See also Mayer (2008) and Moreno (2006) for a more detailed discussion on how to use multimedia to promote learning.

In the present study, participants were selected to represent the whole population of children with reading disabilities (see Participants section). Given the heterogeneous sample, including children who had problems with either decoding or comprehension or both components, it was by no means evident that all would benefit from the same intervention. It is possible that the two aspects of reading have different cognitive origins that imply distinct forms of interventions to remediate these two types of reading difficulties (for an overview, see Fletcher et al., 2007). The present study compared three different interventions, one focused on bottom-up processing, that is, phonological abilities and word decoding skills, and another on top-down processing and comprehension. We also examined the effects of an intervention that combines phonological training and comprehension training. A study by Lovett et al. (2000) showed that a combination of phonological training and strategy-based instruction proved superior to either program alone for children with severe reading disability. It should also be noted that many previous phonological intervention studies have contained a mix of different activities related to phonological skills and reading skills rather than focusing on one particular skill (e.g., Torgesen et al., 2001). Furthermore, since our participants have decoding problems, comprehension problems, or both problems, an intervention covering both components might provide an appropriate content.

The present study attempted to answer the following research questions. What are the general effects of the three interventions, phonological training, comprehension training, and combined training (phonological and comprehension training), on the reading skills of children with reading

Table 1. Cognitive Abilities Preintervention for Each Group (*M*, *SD*; *N* = 130)

Cognitive Tests Preintervention	Phonological Training		Comprehension Training		Combined Training		Ordinary Special Instruction		Typical Readers	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Nonverbal intelligence	24.04	4.58	23.44	4.17	26.28	3.93	23.00	4.73	26.17	5.32
Short-term memory	5.60	1.35	5.48	1.33	5.83	1.66	5.76	1.62	7.47	2.54
Working memory	4.92	1.15	4.48	1.83	4.38	1.44	4.56	1.29	5.50	1.33
Phonological short-term memory	7.92	2.10	5.79	2.34	6.60	2.77	6.29	2.79	9.43	1.50
Segment subtraction	5.38	2.53	4.64	2.04	4.96	2.64	4.80	2.33	8.57	2.54
Rapid automatic naming	128.5	31.7	128.9	40.9	130.0	42.4	132.8	52.0	91.3	12.1
Processing speed	25.36	3.55	24.58	5.88	27.67	7.30	25.17	4.98	30.60	4.06
Verbal fluency	11.76	5.09	8.04	4.03	11.36	4.57	9.36	5.08	17.03	5.60
Spelling	8.30	3.50	6.25	2.00	6.74	3.65	7.43	4.26	14.93	6.33
Pseudoword spelling	6.14	2.71	5.20	2.84	4.23	2.81	6.04	3.17	9.63	2.43
Arithmetic	15.52	3.72	13.96	2.76	15.17	3.42	14.56	2.89	17.87	3.32

disabilities in Grade 2 compared to comparison groups? What cognitive variables are correlated with reading improvement for each intervention?

Method

Participants

A total of 130 participants in Grade 2 were included in the study. They had received regular reading instruction in school for almost 1.5 years before the first test session was conducted. This previous instruction focused on knowledge about the letters of the alphabet and their corresponding sounds as well as spelling and text reading. They were randomly assigned to five groups: phonological training (25 children), comprehension training (25 children), phonological/comprehension training (25 children), ordinary special instruction (25 children), and typical instruction (30 children). Children with reading disabilities in the first four groups were approximately matched on sex, initial cognitive abilities, and initial reading skills (see Tables 1 and 2). Matched groups were obtained by monitoring group differences resulting from the random assignments and successively limiting the number of groups a child could be randomly assigned to, given his or her results at the first test session.

There were two main criteria for inclusion as a child with reading disability: (a) The child had been assigned to receive special instruction in reading in Grade 2. Since the interventions took place in general educational settings, this was a necessary requirement for practical reasons. (b) In the present study the child had to perform at least .75 standard deviations below the mean of the typical readers on the reading test sight word reading (see Materials) at the first test session (T1). Children who were recent immigrants and therefore did not master Swedish and children who had gross neurological disturbances or sensory deficits were not included in the study. Attrition rate was low. One school representing five children dropped out of the study after the first test session but before children were assigned to groups, so the design was not affected.

The ordinary special instruction group was not a traditional control group since these children also received their regular special instruction in reading (i.e., treatment as usual). Ordinary special instruction consisted of a variety of activities related to reading and writing, such as reading aloud or silently, discussing stories, spelling instruction, phonological awareness training, and some memory training. Compared to the three interventions (see Training Programs), ordinary special instruction was more heterogeneous, less focused, and less systematic. A nontreatment control group consisting of children with reading disabilities was not possible for ethical reasons.

Test Procedure

One of the authors (Linda Fälth) and 13 trained psychology students administered all tests to all participants. The psychology students had received training in test administration during their regular university courses and participated in several workshops and training sessions designed specifically

Table 2. Results on the Reading Tests (*M*, *SD*) Preintervention ((T1 + T2)/2) and Postintervention (T3) and Effect Sizes (Cohen's *d*[a]) for All Five Groups of Participants (*N* = 129)

	Preintervention		Postintervention		
	M	*SD*	*M*	*SD*	Cohen's *d*
Reading comprehension					
Phonological training (*n* = 22)	6.75	4.82	12.23	7.24	0.89
Comprehension training (*n* = 19)	3.63	4.19	7.11	6.62	0.65
Combined training (*n* = 21)	6.69	5.24	12.19	6.82	0.91
Ordinary special instruction (*n* = 22)	5.89	3.96	8.64	5.09	0.59
Typical readers (*n* = 30)	22.15	8.87	25.93	7.20	0.51
Passage comprehension[b]					
Phonological training (*n* = 23)	11.00	5.88	15.48	6.57	0.72
Comprehension training (*n* = 25)	6.24	4.21	10.60	5.18	0.92
Combined training (*n* = 25)	7.76	5.40	12.92	6.38	0.87
Ordinary special instruction (*n* = 25)	8.04	5.92	11.68	6.93	0.56
Typical readers (*n* = 30)	20.03	6.74	22.33	4.91	0.39
Word decoding					
Phonological training (*n* = 24)	6.72	3.25	10.92	3.54	1.25
Comprehension training (*n* = 24)	6.12	2.81	8.33	3.56	0.69
Combined training (*n* = 24)	6.52	2.45	10.79	4.46	1.25
Ordinary special instruction (*n* = 23)	6.72	2.46	8.78	3.40	0.70
Typical readers (*n* = 30)	15.30	5.84	18.93	6.49	0.59
Sight word reading					
Phonological training (*n* = 24)	33.08	14.00	49.38	17.74	1.06
Comprehension training (*n* = 23)	29.85	15.72	47.43	18.01	1.06
Combined training (*n* = 25)	29.40	12.01	47.68	15.94	1.34
Ordinary special instruction (*n* = 24)	30.48	13.22	45.08	20.05	0.91
Typical readers (*n* = 30)	87.77	22.15	100.90	24.19	0.57
Pseudoword reading					
Phonological training (*n* = 23)	5.98	4.28	8.30	5.41	0.45
Comprehension training (*n* = 20)	4.62	4.02	8.10	5.96	0.70
Combined training (*n* = 21)	6.19	4.38	11.57	6.94	0.95
Ordinary special instruction (*n* = 22)	4.93	4.85	7.41	5.25	0.48
Typical readers (*n* = 30)	16.02	6.47	18.73	8.59	0.35

[a]Cohen's *d* = (*M* at T3 – (*M* at T1 + *M* at T2)/2)/pooled *SD* for T1, T2, and T3.
[b]Data only from T2. Cohen's *d* = (*M* at T3 – *M* at T2)/pooled *SD* for T2 and T3.

for the present study. The test leaders were carefully instructed to follow the same test procedure and had written instructions for each test. They were also continuously supervised by two members of the research team.

There were two test sessions preintervention, the first (T1) in November 2008 and the second (T2) 5 weeks later. Between those test sessions children were assigned to groups but the intervention did not start until T2 had been completed. Data from T1 were used to ensure that groups were approximately matched (see previous). The purpose of T1 and T2 was to provide a solid and reliable documentation of preintervention status, and in the main analysis of variance (ANOVA), they were merged into a single preintervention variable. The third test session (T3) took place directly after the intervention, as soon as 25 training sessions had been completed for each child with reading disabilities. The duration between T2 and T3 varied between 5 and 9 effective school weeks. Test administrators visited the schools in approximately the same order on each test session to keep the duration more constant. Most tests were individually administered to increase the reliability, but group testing was allowed for the *Wordchains* test and the tests measuring spelling and pseudoword spelling. Most tests were administered on several occasions, but the relatively long interval between test sessions and the inclusion of comparison groups greatly reduced the potential problem of test-retest training effects. A few children failed to complete one or two tests, explaining why the reported number of participants varied slightly.

The reading tests were administered at T1, T2, and T3 except for *Woodcock Passage Comprehension*, which was only administered at T2 and T3 (given time restraints at T1).

Design

The main design was a factorial 5 × 2 split-plot design with the independent variable group (phonological training, comprehension training, combined training, ordinary special instruction, and typical readers) as a between-subjects variable and test session (preintervention and postintervention) as a within-subjects variable. The most important dependent variables were five different measures of reading comprehension and word decoding skills, which were also used to form a composite score of reading skill. In addition, 11 different cognitive variables—nonverbal intelligence, short-term memory, working memory, phonological short-term memory, segment subtraction, rapid automatic naming (RAN), processing speed, verbal fluency, spelling, pseudoword spelling, and arithmetic—were included preintervention to be able to analyze correlations with reading improvement (change scores) for each group.

Materials

Five different measures of reading skills were administered: reading comprehension, passage comprehension, word decoding, sight word reading, and pseudoword reading.

Reading comprehension. A reading comprehension test, *Vilken bild är rätt?* (Which Picture Is the Correct One?), developed by Lundberg (2001), was used comprising national norms for Grades 2 and 3 and with a test–retest reliability of .88. The child's task was to read two or three sentences and then mark the correct picture out of four where only one picture exactly fit the meaning of the sentences. The score was the total number of correct pictures subtracted by errors within 10 minutes.

Passage comprehension. A Swedish translation of a subtest from *Woodcock Reading Mastery Test–Revised* (Woodcock, 1987) was used. Children read a short passage of text with a blank line. The first passages had a corresponding picture. Children were instructed to fill in the blank verbally with a word that fit the passage. The level of difficulty increased within the test and it was ended when the participant failed on six consecutive passages.

Word decoding. Word decoding was assessed by the *Wordchains* test (Jacobson, 1993; Miller Guron, 1999). The participant silently read chains of Swedish words where the blank space between words had been removed. Each chain consisted of three semantically unrelated words and the child was instructed to mark each word boundary with a pencil. The chains were constructed to have no ambiguities regarding boundary locations and had a large proportion of high frequency words. The number of correctly marked word chains in 2 minutes was used as a measure of general word decoding skill. It was impossible to complete all 80 word chains in 2 minutes. The *Wordchains* test had test–retest correlations with an interval of 12 months between measurements of $r = .80$ to .90 in different groups of children in Grades 1 through 6 (Jacobson, 1993). Test–retest correlations between T1 and T2 in the present study was $r = .88$.

Sight word reading. A Swedish translation of the word subtest from the *Test of Word Reading Efficiency* (TOWRE; Torgesen, Wagner, & Rashotte, 1999) was used. Participants were asked to read simple words out loud as quickly as possible. Children were allowed to read for 45 seconds on each of two test versions (A and B), and the results were summed to increase reliability (test–retest reliability for children aged 6–9 years was .97).

Pseudoword reading. A list of pseudowords was presented to the participants. The participants' task was to correctly read aloud as many pseudowords (80 items) as possible in 1 minute. The pseudowords presented consisted of one up to four syllables. Data for comparison were available from previous studies (Svensson, 2009; Svensson & Jacobson, 2006). Test–retest correlations between T1 and T2 in the present study was $r = .90$.

In addition, 11 other tests were used to examine cognitive variables that could potentially predict the responsiveness to training.

Nonverbal intelligence. To get a measure of nonverbal intelligence at T1, a Swedish edition of *Raven's Coloured Progressive Matrices* was administered (Psykologiförlaget AB, 1995). Maximum score was 36.

Short-term memory (STM). Short-term memory was assessed by *Digit Span*, a subtest from *Wechsler Intelligence Scale for Children–Fourth Edition* (WISC-IV; Wechsler, 2003). The task was to repeat digits (a span from two to nine) forward in correct order. Each correctly repeated digit span was scored.

Working memory. Working memory was also assessed by *Digit Span* from WISC-IV (Wechsler, 2003). The task was to repeat digits (a span from two to eight) backward in correct order. Each correctly repeated digit span was scored.

Phonological short-term memory. Phonological STM was assessed by a nonword repetition test (Gathercole, Tiffany, Briscoe, Thorn, & The ALSPAC Team, 2005; Radeborg, Barthelom, Sjöberg, & Sahlén, 2006). The task for the pupil was to repeat nonwords that the test leader had just pronounced as exactly as possible. The test included 12 nonwords, consisting of two up to four syllables. Each correctly pronounced nonword was scored. Comparison data from an earlier study were available (Svensson, 2009). Test–retest correlations between T1 and T2 in the present study was $r = .78$.

Segment subtraction. A subtest from a Swedish standard test of phonological awareness, *UMESOL: Segment Subtraction* (Taube, Tornéus, & Lundberg, 1984), was used. Participants should decide and verbally report which segment of a word had been removed from a Swedish word (i.e., "What has been removed from the word *krokodil* [*crocodile* in English] if only *kroko* remains?"). Maximum score

was 15. Test–retest correlations between T1 and T2 in the present study was $r = .83$.

RAN. Rapid automatized naming for letters and for numbers was assessed (see Wolf & Denckla, 2005). The total time in seconds for naming both numbers and letters was used as a measure of RAN. There were two lists of numbers, and correlation between them at T2 was $r = .90$. There were two lists of letters, and the correlation between them at T2 was $r = .87$.

Processing speed. In the *Letterchain* test the task was to mark a pencil line between the two adjacent letters that were the same. Two such pairs in each letter chain occurred, for example, LIOOPKTTUR, where the marks should be as follows: LIO/OPKT/TUR. The performance was expressed as the number of correctly marked chains within a period of 2 minutes (Jacobson, 2001). Test–retest correlations between T1 and T2 in the present study was $r = .78$.

Verbal fluency. The *Initial Letter Verbal Fluency Test* (FAS) was administered. It has been used as an assessment of executive function and semantic memory store (Parker & Crawfoord, 1992). It is a timed test where the participant is asked to generate words beginning with the letters F, A, and S, respectively. The total number of real Swedish words was used as a measure of verbal fluency.

Spelling. Participants were asked to spell 34 Swedish words, 2 to 11 letters long. The test leader first said the word, then a sentence containing the target word, and then the word was repeated and the child were instructed to write it and spell it correctly on a response sheet. There was a time limit of 15 seconds for each response and the test was terminated if the child made four consecutive errors.

Pseuoword spelling. In this test, 12 pictures of "monsters" were presented on a sheet of paper. Each monster had a Swedish pseudoword as their name (e.g., *Liplo*, *Gadrö*). The name was spoken out loud to the children and they were asked to write the monster's name next to its picture. Names were chosen so that one specific spelling should be most appropriate, but all phonetically correct Swedish spellings were regarded as correct answers.

Arithmetic. Participants received a mix of 60 simple addition and subtraction tasks (i.e., 5 + 1 = __ and 9 − 2 = __) on a sheet of paper and were asked to complete as many as possible in 1 minute. The large number of items made it impossible to complete them all in 1 minute. The number of correct answers was used as a measure of arithmetic skill.

Training Programs

The phonological training program, named COMPHOT (Ferreira, Gustafson, & Rönnberg, 2003), had four sections: *Rhyme* (four exercises), *Position* (eight exercises), *Addition* (five exercises), and *Segmentation* (three exercises). Exercises were mainly phonological and sound based. Pictures were included in the exercises and when participants clicked on them the corresponding words were sounded out by a natural, recorded voice. The task for the child was, for instance, to decide which pictures depicted words that rhymed or had the same initial phoneme. In other exercises the task was to combine or remove phonemes or segments of words. There were also some links to written letters and words. The units of language that were focused in COMPHOT were phonemes, word segments, and words. No sentences or passages were presented to participants. To make the exercises entertaining and motivating, game-like elements were included. The program supplied direct feedback to the participant. After correct choices the computer responded with a "happy" sound and when the child made a mistake the computer produced a "sad" sound. There were also personal high score lists where children could check their performances on the different exercises.

The comprehension training program, named Omega-IS (Omega-Interactive Sentences) (Heimann, Lundälv, Tjus, & Nelson, 2004), used a top-down strategy including both word- and sentence-level processing of written language. By clicking on text buttons with words or phrases, the child "wrote a sentence" such as "The lion chases the swan," then the child heard the sentence being read by prerecorded human speech, and then the meaning of sentence was illustrated by an animation. Thus, the program offered close to one-to-one correspondence between text, speech, and animations, providing semantic comprehension and training of text material. The lessons included in the program went from two- (noun + verb) and three-word sentences (noun + verb + noun) up to stories in which the child could construct stories and choose different actors and scenarios to increase the children's motivation to explore literacy. In total, more than 1,900 different sentences were possible to construct with feedback in speech and animations as described previously.

Both training programs were computerized and had been developed with the assistance of professional programmers.

A third intervention group, combined training, used both COMPHOT and Omega-IS. During the first 20 training sessions of combined training, COMPHOT and Omega-IS were used alternately, that is, each program was used every other session. During the last 5 training sessions the children were allowed to choose which program to use. Thus, 10 to 15 of the 25 sessions (40%–60%) were spent on each program.

Training Procedure and Training Times

A total of 52 special education teachers representing 41 Swedish schools participated in the interventions. To reduce potentially confounding teacher effects, children belonging to two of the four groups phonological training, comprehension training, combined training, or ordinary special instruction were assigned to each special education teacher.

These children received the intervention or ordinary special instruction as part of their scheduled special education sessions in their regular schools. Before the actual intervention started, special education teachers had been instructed

on how to use the training programs, and information and educational suggestions were also included in a written manual for each program. Special education teachers could adapt the intervention to the appropriate level of difficulty for individual children by selecting difficulty level for exercises and by focusing the training on particular exercises. However, they were instructed to include all types of exercises for each and every child at least once. Special education teachers were encouraged to have an active role in all three interventions. Authors monitored treatment integrity by personal meetings, e-mail correspondence, and phone calls.

Each reading disabled participant received a total of 25 training sessions. Special education teachers were instructed that the minimal time for a session was 10 minutes but that longer times were preferred, and most sessions lasted 15 to 25 minutes. Children who received phonological training had an average total training time of 422.2 minutes (SD = 102.9, n = 23), for the group comprehension training it was 443.5 minutes (SD = 111.7, n = 19), for combined training 480.9 minutes (SD = 117.7, n = 21), and for ordinary special instruction 502.7 minutes (SD = 117.1, n = 23). A one-way ANOVA showed that there was no significant main effect of group on training times. The observed differences would tend to favor the comparison condition ordinary special instruction rather than the intervention groups.

Results

Characteristics of Participants

In the group phonological training there were 17 boys and 8 girls, in the group comprehension training 18 boys and 7 girls, in the group combined training 17 boys and 8 girls, in ordinary special instruction 18 boys and 7 girls, and in the group typical readers 19 boys and 11 girls. A chi-square test showed that there were no significant differences between the proportions of boys/girls between the five groups, $\chi^2(4, 129) = .69$, $p > .05$.

The test battery included 11 cognitive test and the results for each group preintervention can be seen in Table 1.

The 11 one-way ANOVAs comparing the means of the five groups all revealed significant main effects of group (all ps < .05). Tukey's honestly significant difference (HSD) post hoc tests showed that on short-term memory, segment subtraction, RAN, verbal fluency, spelling, and pseudoword spelling typical readers outperformed all other groups (all ps < .05). On nonverbal intelligence, Tukey HSD revealed no significant differences. On working memory, typical readers performed significantly better than combined training (p < .05). On phonological STM, typical readers outperformed comprehension training, combined training, and ordinary special instruction, and phonological training outperformed comprehension training (all ps < .05). On processing speed, typical readers performed significantly better than phonological training, comprehension training, and ordinary special instruction (all ps < .05). On arithmetic, typical readers outperformed comprehension training, combined training, and ordinary special instruction (all ps < .05).

Thus, typical readers tended to outperform the other groups in many cognitive areas whereas only one significant difference was found between groups of children with reading disabilities.

The four groups of children with reading disabilities were also approximately matched on initial reading skills (see Table 2 and the following analyses).

General Effects of the Intervention

General effects of the intervention are presented in Table 2. There were two test sessions preintervention and one after the intervention. To firmly establish a baseline status, results from T1 and T2 were combined into a single preintervention variable. Only participants who completed all three test sessions were included in Table 2 and in the corresponding statistical analyses.

Five separate one-way ANOVAs on preintervention scores of reading skills (see Table 2) all revealed statistically significant main effects of group (all ps < .01). Tukey HSD post hoc tests revealed that typical readers performed significantly better than the other four groups in all five analyses (all ps < .01). No other differences between groups were statistically significant. Thus, the four groups of children with reading disabilities were approximately matched on the five measures of reading skills preintervention and performed significantly below typical readers.

General effects of the interventions were analyzed by five separate split-plot ANOVAs with group (five levels) as a between-subjects variable and test session (two levels) as a within-subjects variable (see Table 2). Results showed statistically significant main effects of test session (i.e., improvements) for all five measures of reading skills (all ps < .01).

There was a statistically significant interaction between group and test session for word decoding, $F(4, 120) = 2.71$, $p < .05$, $MSE = 5.00$. Combined training and phonological training showed larger improvements than the other groups (see Table 2). For reading comprehension, passage comprehension, sight word reading, and pseudoword reading, there were no significant interactions.

The design included two different comparison groups measured on several occasions, and one of these (typical readers) performed better than the other groups preintervention. Therefore, when calculating effect sizes (Cohen's d), posttest scores were compared with pretest scores within each group instead of comparisons between groups. Original standard deviations (instead of paired t test values) were used in the calculations in order not to overestimate effect sizes (see Dunlop, Cortina, Vaslow, & Burke, 1996). According to Cohen (1988), d = .20 can be considered a small effect, d = .50 a moderate effect, and d = .80 or above a large effect.

The phonological training group showed large effects on reading comprehension, word decoding, and sight word reading; a large to moderate effect on passage comprehension; and a moderate to small effect on pseudoword reading. Comprehension training resulted in large effects on passage comprehension and sight word reading, large to moderate effects on word decoding and pseudoword reading, and moderate to large effects on reading comprehension. Combined training resulted in large effects on all five measures. Ordinary special instruction obtained a large effect on sight word reading, a large to moderate effect on word decoding, moderate to large effects on reading comprehension and passage comprehension, and a moderate to small effect on pseudoword reading. Typical readers showed a moderate effect on reading comprehension, moderate to large effects on word decoding and sight word reading, and moderate to small effects on passage comprehension and pseudoword reading.

Analysis of General Effects Using a Composite Change Score

To obtain a more general and more reliable measure of improvements in reading skills, a composite score was calculated. First, change scores were calculated for the five reading tests shown in Table 2 by subtracting the scores at T2 from the scores at T3. Test session 1 was not included because data were missing for passage comprehension. Also, T2 could be regarded as the most crucial test session since it was completed closer to the intervention. Change scores were then transformed into standardized z values, and a mean z value was calculated representing a composite measure of improvement in reading skills between T2 and T3.

Mean standardized composite change scores were for phonological training .12 (SD = .59), comprehension training .02 (SD = .56), combined training .38 (SD = .68), ordinary special instruction –.09 (SD = .47), and typical readers –.17 (SD = .48). These scores represent general improvements in reading. Thus, the group combined training enhanced their reading skills the most between T2 and T3. A one-way ANOVA revealed a significant main effect of group, $F(4, 111) = 3.54$, $p < .01$. Tukey HSD post hoc test revealed two statistically significant differences: Combined training showed significantly higher improvements in reading skills than the two groups ordinary special instruction and typical readers (both ps < .05).

What Cognitive Variables Are Correlated With Reading Improvement for Each Intervention?

To examine individual differences in reading improvements, bivariate correlations were calculated between the composite change score of reading skills (see previous discussion) and the 11 cognitive variables measured preintervention (see Table 3).

Within the group phonological training, there were significant negative correlations between reading improvement and two of the cognitive variables: RAN and pseudoword spelling (both ps < .05). Note that a low score on RAN represents rapid naming measured in seconds, so a high gain from phonological training was associated with good initial performance on RAN and a poor performance on pseudoword spelling. The group comprehension training revealed no significant correlations. The group combined training showed a significant positive correlation between reading improvement and working memory ($p < .05$). Within the ordinary special instruction group there were significant negative correlations with short-term memory ($p < .05$) and phonological short-term memory ($p < .01$) and a significant positive correlation with spelling ($p < .05$). Typical readers only showed a significant positive correlation between reading improvement and verbal fluency ($p < .05$).

For some of the cognitive variables, phonological STM, segment subtraction, processing speed, spelling, and pseudoword spelling, data were available also postintervention at T3. Correlations between change scores for these variables (T3 scores minus T2 scores) and the composite change score of reading improvement were calculated for each group. For the group phonological training there was a significant correlation between improvement in pseudoword spelling and reading improvement ($r = .58$, $p < .01$). For combined training there was a significant correlation between improvement in segment subtraction and reading improvement ($r = .67$, $p < .01$). The other three groups revealed no significant correlations between improvements in cognitive abilities and reading improvement.

Discussion

General Effects of the Interventions

The first aim of this study was to measure the effects of three intervention programs with the purpose to improve reading ability. The general effects of the interventions can be regarded as satisfactory for all three interventions and the most positive effects were obtained for the group who received combined training (see the following). Results showed that the three intervention groups improved their reading skills at least as much as the comparison groups ordinary special instruction and typical readers (see Table 2). It can be argued that the group receiving the ordinary special instruction had an advantage compared to the three interventions in that special education teachers were free to choose the reading instruction they thought would best meet the particular needs of individual children and that they could choose from various existing exercises and training programs

Table 3. Correlations (Pearson's *r*) Between the Composite Score of Reading Improvement and Cognitive Abilities Preintervention

Cognitive Variables Preintervention	Phonological Training (n = 22)	Comprehension Training (n = 20)	Combined Training (n = 22)	Ordinary Special Instruction (n = 23)	Typical Readers (n = 29)
Nonverbal intelligence	.16	–.07	.33	.16	.06
Short-term memory	.00	.18	.16	–.43*	.04
Working memory	–.04	.06	.48*	.30	.16
Phonological short-term memory	.05	.11	.18	–.58**	.03
Segment subtraction	.00	.15	.13	–.32	.17
Rapid automatic naming	–.44*	–.08	–.32	.11	.09
Processing speed	.18	–.10	.34	.37	–.04
Verbal fluency	.39	–.09	.18	.24	.43*
Spelling	.08	–.15	.28	.46*	–.05
Pseudoword spelling	–.52*	.27	.39	.09	–.21
Arithmetic	.40	.14	.43	–.07	.14

Note. *$p < .05$, **$p < .01$.

they were already familiar with. Thus, the ordinary special instruction group represents a comparison group that is difficult to surpass (see Gustafson et al., 2000, 2007). Keeping this in mind, it is notable that a statistically significant interaction was found on word decoding where the intervention groups combined training and phonological training showed higher improvements than the ordinary special instruction group and the other groups (see Table 2).

One might have expected comparatively better effects for comprehension training on reading comprehension, but reading comprehension is a product of both decoding and comprehension and it seems that for children with reading disabilities in Grade 2 who were still in an early stage of reading development, basic phonological training was just as effective. On passage comprehension, however, comprehension training had the highest observed effects.

Surprisingly, phonological training only produced a moderate to small effect on pseudoword reading. One explanation is that the phonological training program COMPHOT contained basic phonological awareness training and was not directly targeted at phonological word decoding. Also, another phonological variable, pseudoword spelling, was important for reading improvement for this group (see Table 3 and the following discussion). Maybe pseudoword spelling was a more pure and sensitive phonological test than pseudoword reading because no letters or written words were presented to the child.

As stated earlier, the most positive effects on reading skills were obtained for the group who received combined training. When a composite change score representing general reading improvement was calculated, the results demonstrated that children who received combined training made statistically significantly more progress in reading than ordinary special instruction and typical readers. This is in line with the findings by Lovett et al. (2000), which demonstrated that a combination of phonological training and strategy-based instruction was more effective than either program alone. A study by Frost, Madsbjerg, Niedersøe, Olofsson, and Sørensen (2005) also demonstrated that both phonological skills and semantic skills are important in early reading development. Since reading involves both bottom-up processes and higher level semantic processes, it is not surprising that training containing both these components was effective.

The effectiveness of any intervention also depends on the characteristics of the participants. Some of the children with reading disabilities in the present study had comprehension difficulties, and they might benefit from reading instruction targeting those problems. Furthermore, targeting reading comprehension seems to benefit reading ability regardless of the source of difficulty, that is, positive effects are observed also for those children with reading disabilities with decoding problems (for an overview, see Fletcher et al., 2007).

The intensity of the three interventions was only moderate. It is quite possible that at least for the phonological training program more intense training would yield even better results (Lundberg, 2009; Torgesen et al., 2001). Motivational aspects then also need to be considered to ensure that training will not become repetitive, tiring, or boring for the participants.

What Cognitive Variables Are Correlated With Reading Improvement for Each Intervention?

Within the group phonological training, large reading improvement was correlated with poor performance on pseudoword spelling preintervention (see Table 3). Pseudoword

spelling can be regarded as a pure phonological test requiring distinct phonological representations. Thus, this finding is in line with previous findings that children with pronounced phonological problems benefit a lot from a phonological intervention (Gustafson et al., 2007). There are at least two possible explanations of this result. One possibility is that children with congenital phonological deficits (possibly developmental dyslexia) benefit from interventions targeted at their specific deficit. Another explanation is more developmental; for children to benefit from phonological training they should be in an early stage of their reading development and rely on phonological word decoding when reading at least to some extent (Ehri et al., 2001; Gustafson et al., 2000; see also Frost et al., 2005). Treatment gains in reading from phonological training were also significantly correlated with improvement in pseudoword spelling. This indicates that a specific effect of the phonological training (improvement in a phonological ability) was associated with general reading improvement.

For the group who received phonological training, large improvement in reading was also correlated with good initial performance on RAN. Maybe RAN was a complementary ability that enhanced the experience of the training program and the treatment gains on reading. Reading is a complex cognitive activity, and if the intervention is specific and focused on one aspect, then other cognitive abilities preintervention might help boost treatment gains.

For the group who received comprehension training, there were no significant correlations between reading improvement and initial cognitive abilities. Given that comprehension training revealed positive effects on reading and was rather focused in nature, we expected to find at least some significant results differentiating between responders and nonresponders. In the present study, only effects on reading were analyzed, and it is possible that comprehension training had differentiating effects on other abilities. This group also suffered from the lowest statistical power.

Combined training was effective in general, and for this group a positive correlation was found between reading improvement and initial working memory (see Table 3). Working memory is important for reading skills (Gathercole, Alloway, Willis, & Adams, 2006; Swanson & Jerman, 2007) but was not explicitly targeted in any of the interventions. A well-functioning working memory might have worked as a good complement to phonological training and comprehension training. Also, a good working memory might have led to more rewarding learning experiences when using some of the exercises in the training programs.

Also, note that even though only 1 of the 11 correlations between cognitive variables and reading improvement was statistically significant, all the other 10 correlations pointed in the same direction. The general pattern of results indicates that higher reading improvement might be associated with good initial cognitive abilities for this group (see Table 3). One explanation of this pattern of results would be that combined training put higher demands on cognitive abilities since children had to integrate knowledge from two different training programs. Phonological skills also seemed important for combined training since there was a significant correlation between improvement in segment subtraction and reading improvement.

The ordinary special instruction group revealed significant negative correlations between reading improvement and two measures of memory: short-term memory and phonological short-term memory. Reports from special education teachers reveal that some children in this group received memory training. Maybe some aspect of this training resulted in reading improvements for children with poor initial memory skills. For the ordinary special instruction group, there was also a significant correlation between reading improvement and initial spelling. Good initial spelling might have worked as an important complementary ability and/or a skill that was utilized during the reading instruction and enhanced the experience of ordinary special instruction.

Typical readers showed a significant positive correlation between reading improvement and verbal fluency. Verbal fluency includes a phonological component. Even if these children are typical readers, they are still in an early stage of their reading development when phonological abilities are important (Høien & Lundberg, 1988; Lundberg, 2009; Samuelsson, Gustafson, & Rönnberg, 1996).

Finally, we want to emphasize that educational interventions should be regarded from a dynamic rather than static perspective. Recent studies in the fields of dynamic testing and assessment and response to intervention demonstrate the need to think of educational interventions as ongoing processes where assessment can assist intervention and vice versa (see Grigorenko, 2009). In the present intervention study, we have identified cognitive variables that are associated with treatment gains in reading for different groups of children. This can be regarded as an assessment and might provide suggestions for future interventions for individual children at their respective schools. Intervention studies can contribute with general theoretical knowledge as well as have direct educational implications.

Limitations

Two of the interventions used in the present study were quite specific, but the combined training was broader and contained two very different components. In the present study it is not possible to assess how the two different components interacted and led to the positive effects obtained for the combined training program.

It should also be noted that some individual variation was allowed within each intervention. Teachers were asked to use all exercises at least once but were free to spend more time on certain exercises than others to facilitate children's

learning and keep them motivated. Thus, children belonging to the same group had somewhat different experiences during the intervention.

Teachers are important mediators of knowledge and skills and it is possible that some special education teachers approached the interventions more enthusiastically and had more positive effects on the children's learning than other teachers. We tried to control for this teacher effect by having each special education teacher meet children belonging to two different groups. Ideally each teacher should have met children belonging to all four groups of children with reading disabilities to further reduce teacher effects. However, this would have put too high demands on the special education teachers since they would have needed to master and administer three different interventions as well as ordinary special instruction.

Ideally, the number of participants should have been higher to increase statistical power, obtain more reliable results, and allow more sophisticated statistical methods to be used. Given the promising results of the interventions, especially for combined training, follow-up testing will take place during 2009.

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References

Basil, C., & Reyes, S. (2003). Acquisition of literacy skills by children with severe disability. *Child Language Teaching and Therapy*, *1*, 27–48.

Berends, I. E., & Reitsma, P. (2006). Addressing semantics promotes the development of reading fluency. *Applied Psycholinguistics*, *27*, 247–265.

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

Dunlop, W. P., Cortina, J. M., Vaslow, J. B., & Burke, M. J. (1996). Meta-analysis of experiments with matched groups or repeated measures designs. *Psychological Methods*, *1*, 170–177.

Ehri, L. C., Nunes, S. R., Willows, D. M., Valeska Schuster, B., Yaghoub-Zadeh, Z., & Shanahan, T. (2001). Phonemic awareness instruction helps children learn to read: Evidence from the National Reading Panel's meta-analysis. *Reading Research Quarterly*, *36*, 250–287.

Elbro, C. (1996). Early linguistic abilities and reading development: A review and a hypothesis about distinctness of phonological representations. *Reading and Writing: An Interdisciplinary Journal*, *16*, 453–485.

Elbro, C., & Petersen, D. K. (2004). Long term effects of phoneme awareness and letter sound training: An intervention study with children at risk for dyslexia. *Journal of Educational Psychology*, *96*, 660–670.

Fälth, L., Svensson, I., & Tjus, T. (2009). *Improvement in reading among children with reading disabilities: The effects of two training programs*. Unpublished manuscript.

Ferreira, J., Gustafson, S., & Rönnberg, J. (2003). *COMPHOT: Computerized phonological training*. Linköping, Sweden: Department of Behavioural Sciences and Learning/Swedish Institute for Disability Research, Linköping University, Sweden.

Fletcher, J. M., Lyon, G. R., Fuchs, L. S., & Barnes, M. A. (2007). *Learning disabilities: From identification to intervention*. New York, NY: Guilford.

Frost, J., Madsbjerg, S., Niedersøe, J., Olofsson, Å., & Sørensen, P. M. (2005). Semantic and phonological skills in predicting reading development: From 3-16 years of age. *Dyslexia*, *11*, 79–92.

Gathercole, S. E., Alloway, T. P., Willis, C., & Adams, A. (2006). Working memory in children with reading disabilities. *Journal of Experimental Child Psychology*, *93*, 265–281.

Gathercole, S. E., Tiffany, C., Briscoe, J., Thorn, A., & The ALSPAC Team. (2005). Developmental consequences of poor phonological short-term memory function in childhood: A longitudinal study. *Journal of Child Psychology and Psychiatry*, *46*, 598–611.

Grigorenko, E. L. (2009). Dynamic assessment and response to intervention: Two sides of one coin. *Journal of Learning Disabilities*, *42*, 111–132.

Gustafson, S., Ferreira, J., & Rönnberg, J. (2007). Phonological or orthographic training for children with phonological or orthographic decoding deficits. *Dyslexia*, *13*, 211–229.

Gustafson, S., Samuelsson, S., & Rönnberg, J. (2000). Why do some resist phonological intervention? A Swedish longitudinal study of poor readers in Grade 4. *Scandinavian Journal of Educational Research*, *44*, 145–162.

Hale, J. B., Kaufman, A., Naglieri, J. A., & Kavale, K. A. (2006). Implementation of IDEA: Integrating response to intervention and cognitive assessment methods. *Psychology in the Schools*, *43*, 753–770.

Hatcher, P. J., Goetz, K., Snowling, M. J., Hulme, C., Gibbs, S., & Smith, G. (2006). Evidence for the effectiveness of the Early Literacy Support programme. *British Journal of Educational Psychology*, *76*, 351–367.

Hatcher, P. J., Hulme, C., & Ellis, A. W. (1994). Ameliorating reading failure by integrating the teaching of reading and phonological skills: The phonological linkage hypothesis. *Child Development*, *65*, 41–57.

Hatcher, P. J., Hulme, C., Miles, J. N. V., Carroll, J. M., Hatcher, J., Gibbs, S., Smith, G., . . . Snowling, M. J. (2006). Efficacy of small group reading intervention for beginning readers with

reading-delay: A randomised controlled trial. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *47*, 820–827.

Heimann, M., Lundälv, M., Tjus, T., & Nelson, K. (2004). *Omega–Interactive sentences, a multimedia software for language exploration and play*. Göteborg, Sweden: Topic Data & Språkbehandling HB.

Heimann, M., Nelson, K. E., Tjus, T., & Gillberg, C. (1995). Increasing reading and communication skills in children with autism through an interactive multimedia computer program. *Journal of Autism and Developmental Disorders*, *25*, 459–480.

Høien, T., & Lundberg, I. (1988). Stages of word recognition in early reading development. *Scandinavian Journal of Educational Research*, *32*, 163–182.

Hoover, W., & Gough, P. (1990). The simple view of reading. *Reading and Writing: An Interdisciplinary Journal*, *2*, 127–160.

Jacobson, C. (1993). *Manual till Ordkedjetestet* [The Wordchains test; manual]. Stockholm, Sweden: Psykologiförlaget.

Jacobson, C. (2001). *Läskedjor* [Wordchains]. Stockholm, Sweden: Psykologiförlaget.

Lovett, M. W., Lacerenza, L., Borden, S. L., Frijters, J. C., Steinbach, K. A., & De Palma, M. (2000). Components of effective remediation for developmental reading disabilities: Combining phonological and strategy-based instruction to improve outcomes. *Journal of Educational Psychology*, *92*, 263–283.

Lundberg, I. (2001). *Vilken bild är rätt?* [Which picture is the correct one?]. Stockholm, Sweden: Natur och Kultur.

Lundberg, I. (2009). Early precursors and enabling skills of reading acquisition. *Scandinavian Journal of Psychology*, *50*, 611–616.

Mayer, R. E. (2008). Applying the science of learning: Evidence-based principles for the design of multimedia instruction. *American Psychologist*, *83*, 760–769.

Miller Guron, L. (1999). *Wordchains*. *A word reading test for all ages*. Windsor, UK: NFER-Nelson.

Moreno, R. (2006). Learning in high-tech and multimedia environments. *Current Directions in Psychological Science*, *15*, 63–67.

Nelson, K. E., Welsh, J. M., Camarata, S. M., Tjus, T., & Heimann, M. (2001). A rare event transactional model of tricky mix conditions contributing to language acquisition and varied communicative delays. In K. E. Nelson, A. Aksu-Koç, & C. E. Johnson (Eds.), *Children's language, Volume 11: Interactional contributions to language development* (pp. 165–195). Mahwah, NJ: Lawrence Erlbaum.

Parker, D. M., & Crawford, J. R. (1992). Assessment of frontal lobe dysfunction. In J. R. Crawford, W. McKinlay, & D. M. Parker (Eds.), *Handbook of neuropsychological assessment* (pp. 267–291). Hove, UK: Erlbaum and Associates.

Poskiparta, E., Niemi, P., & Vauras, M. (1999). Who benefits from training in linguistic awareness in the first grade, and what components show training effects? *Journal of Learning Disabilities*, *32*, 437–446, 456.

Psykologiförlaget AB. (1995). *Raven's Matriser–Coloured*. Stockholm, Sweden: Author.

Radeborg, K., Barthelom, E., Sjöberg, M., & Sahlén, B. (2006). A Swedish non-word test for preschool children. *Scandinavian Journal of Psychology*, *47*, 187–192.

Samuelsson, S., Gustafson, S., & Rönnberg, J. (1996). The development of word-decoding skills in young readers. *Scandinavian Journal of Educational Research*, *40*, 325–332.

Svensson, I. (2009). *Att utveckla läs- och skrivförmågan bland elever på särskilda ungdomshem. Ett försök med särskilda insatser* [Developing reading and writing skills among pupils in special juvenile institutions—A special effort attempt]. Stockholm, Sweden: The National Board of Institutional Care.

Svensson, I., & Jacobson, C. (2006). How persistent are phonological difficulties? A longitudinal study of reading retarded children. *Dyslexia*, *12*, 3–20.

Swanson, H. L., & Jerman, O. (2007). The influence of working memory on reading growth in subgroups of children with reading disabilities. *Journal of Experimental Child Psychology*, *96*, 249–283.

Taube, K., Tornéus, M., & Lundberg, I. (1984). *UMESOL: Fonologisk medvetenhet: Handläggning för kartläggning och utveckling*. Stockholm, Sweden: Psykologiförlaget AB.

Tijms, J., & Hoeks, J. (2005). A computerized treatment of dyslexia: Benefits from treating lexico-phonological processing problems. *Dyslexia*, *11*, 22–40.

Tjus, T., Heimann, M., & Nelson, K. E. (1998). Gains in literacy through the use of a specially developed multimedia computer strategy: Positive findings from thirteen children with autism. *Autism*, *2*, 139–156.

Tjus, T., Heimann, M., & Nelson, K. E. (2001). Interaction patterns between children and their teachers when using a specific multimedia and communication strategy: Observations from children with autism and mixed intellectual disabilities. *Autism*, *5*, 175–187.

Tjus, T., Heimann, M., & Nelson, K. E. (2004). Reading acquisition by implementing a multimedia intervention strategy for fifty children autism or other learning and communication disabilities. *Journal of Cognitive and Behavioral Psychotherapies*, *4*, 203–221.

Torgesen, J. K., Alexander, A. W., Wagner, R. K., Rashotte, C. A., Voeller, K. K. S., & Conway, T. (2001). Intensive remedial instruction for children with severe reading disabilities: Immediate and long-term outcomes from two instructional approaches. *Journal of Learning Disabilities*, *34*, 33–58.

Torgesen, J. K., & Davis, C. (1996). Individual difference variables that predict response to training in phonological awareness. *Journal of Experimental Child Psychology*, *63*, 1–21.

Torgesen, J., Wagner, R., & Rashotte, C. A. (1999). *A test of word reading efficiency (TOWRE)*. Austin, TX: PRO-ED.

Vellutino, F. R., Scanlon, D. M., Sipay, E. R., Small, S. G., Chen, R., Pratt, A., & Denckla, M. B. (1996). Cognitive profiles of difficult-to-remediate and readily remediated poor readers: Early intervention as a vehicle for distinguishing

between cognitive and experiential deficits as basic causes of specific reading disability. *Journal of Educational Psychology*, *88*, 601–638.

Wechsler, D. (2003). *Wechsler Intelligence Scale for Children–Fourth edition (WISC-IV)*. San Antonio, TX: Harcourt Assessment.

Wise, B. W., Ring, J., & Olson, R. K. (1999). Training phonological awareness with and without explicit attention to articulation. *Journal of Experimental Child Psychology*, *72*, 271–304.

Wolf, M., & Denckla, M. B. (2005). *Rapid Automatized Naming and Rapid Alternating Stimulus Tests (RAN/RAS)*. Austin, TX: PRO-ED.

Woodcock, R. (1987). *Woodcock Reading Mastery Tests–Revised*. Circle Pines, MN: American Guidance Service.

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III

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Computer-assisted Interventions Targeting Reading Skills of Children with Reading Disabilities – A Longitudinal Study

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The purpose of the present study was to examine the effects of three computerized interventions on the reading skills of children with reading disabilities in Grade 2. This longitudinal intervention study included five test sessions over 1 year. Two test points occur before the intervention, and three afterwards. The last follow-up was conducted 1 year after the first measurement. One hundred thirty children in Grade 2 participated in the study. Three groups of children with reading difficulties received computerized training programmes: one aimed at improving word decoding skills and phonological abilities, the second focused on word and sentence levels and the third was a combination of these two training programmes. A fourth group received ordinary special instruction. In addition, there was one comparison group with age-matched typical readers. All groups improved their reading skills. The group that received combined training showed greater improvement than the one with ordinary special instruction and the group of typical readers at two follow-ups. The longitudinal results indicate additional positive results for the group that received the combined training, the majority of students from that group being no longer judged to be needing special education 1 year after the intervention.

Keywords: children; computer-assisted intervention; longitudinal; reading disability

Research within educational psychology, in collaboration with other disciplines, has made great progress in understanding reading and writing difficulties (Catts & Kamhi, 2005) including their diagnosis and treatment (Cohen & Brady, 2011; Grigorenko, 2009; Hintikka, Landerl, Aro, & Lyytinen, 2008; Morris *et al*., 2012; Torgesen *et al*., 2001) and their prevention (Gillon, 2004; Høien & Lundberg, 2004; Kjeldsen, Niemi, & Olofsson, 2003; Shayne & Wagne, 2010). Students with reading difficulties are not a homogeneous group, and different types of disabilities may therefore require different types of interventions. The Simple View of Reading (Gough & Tunmer, 1986) highlights both decoding and comprehension as key aspects of literacy. Optimal reading instruction would therefore include training in both of these abilities (Tunmer & Greaney, 2010). Many studies have demonstrated that phonological (Ehri *et al*., 2001; Elbro & Petersen, 2004; Hatcher, Hulme, & Ellis,

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1994; Hulme, Snowling, Caravolas, & Carroll, 2005; Torgesen *et al.*, 2001) and comprehension training (Helland, Tjus, Hovden, Ofte, & Heimann, 2011; Nelson, Welsh, Camarata, Tjus, & Heimann, 2001) is effective and results in positive effects on reading ability. Although most intervention studies have focused on bottom–up training of phonological skills (targeting letters and sounds), a minority of studies have also successfully implemented more top–down strategies (e.g. with increased focus on sentences and on whole text). For example, Berends and Reitsma (2006) showed that semantic training outperformed orthographic training for a group of reading-impaired children in the first and second grades, with the largest effect in Grade 2. Both Hatcher, Goetz, *et al.* (2006) and Hatcher, Hulme, *et al.* (2006) also observed that children at risk of developing dyslexia made significant gains in reading and spelling after training in semantics (and grammar). Other researchers demonstrated the benefits of both top–down and bottom–up approaches to training. Snowling and Hulme (2011) demonstrated the effectiveness of a combined intervention, incorporating phonological training and training on oral language and vocabulary for children with reading problems. Morris *et al.* (2012) and Wolff (2011) also suggested the importance of multi-component intervention strategies.

In this study, we examined the effects of both single-component and multi-component interventions for students with reading difficulties. The interventions utilized two different types of computer-based training programmes for reading: one was phonologically oriented and the second focused on reading comprehension. Students completed interventions either with one of the programmes or with a combination of the two programmes. Previous results from this study over a shorter period have been reported in Gustafson, Fälth, Svensson, Tjus, and Heimann (2011). The present study contains two additional follow-ups that extend over the period of 1 year.

Advances in information and communication technology have introduced new possibilities for remediation of literacy difficulties. Compared with traditional textbooks, computers can provide text and training material in an attractive way, for example through animations and immediate feedback (Fast, 2007), which can scaffold and support memory and attention processes central to learning (Moreno, 2006). Furthermore, Fast (2007) emphasized the importance of the use of the prior computer-based knowledge in the process of acquiring literacy. Strategies focusing on word exploration in a playful way by combining motivating computer programmes with structured teacher–child interaction can not only promote reading and phonological development (Heimann, Nelson, Tjus, & Gillberg, 1995; Irasquin, Drent, & Verhoeven, 2005; Tjus, Heimann, & Nelson, 1998, 2004) but also motivation and communication (Tjus, Heimann, & Nelson, 2001). Computer-assisted reading instruction has been explored as an individual-oriented, intensive and useful method of training reading skills (e.g. Magnan & Ecalle, 2006; Nicolson, Regtvoort & van der Leij, 2007; Torgesen *et al.*, 2001). Similarly, computer-based training has been shown to be useful for students with reading difficulties (e.g. Elbro, 1996; Jiménez *et al.*, 2007; Saine, Lerkkanen, Ahonen, Tolvanen, & Lyytinen, 2011; van Daal & Reitsma, 2000; Wise, Ring, & Olson, 1999). However, the sample sizes in many of these projects have been relatively small, and most of the studies did not have an adequate control group. In the present longitudinal study, the progress of three remedial reading groups was contrasted not only with the progress of typical readers but also with a control group of children with reading difficulties comparable with the students in the

three other groups. Several assessment time points, along with three follow-ups, were included to assess changes in reading abilities. In addition, effect sizes were calculated to assess the effectiveness of the programmes for improving literacy outcomes.

A number of intervention studies (Cohen & Brady, 2011; Hintikka *et al*., 2008; Macaruso & Hook, 2006; Saine *et al*., 2011; Torgesen *et al*., 2001; van Daal & Reitsma, 2000; Wolff, 2011) have already attempted to examine the changes in response to specific interventions. Torgesen *et al*. (2001) compared two training programmes, one focusing on the promotion of children's phonological skills through auditory and articulatory exercises and the other focusing on phonological awareness acquired through engagement with different types of texts, spelling exercises and strategies. Results showed that both groups of children made significant progress on tests of reading ability, with improvements still evident 2 years following the intervention. Another example is a computerized longitudinal intervention study of reading-disabled children in Grades 2–3 made by Gustafson, Ferreira, and Rönnberg (2007). Children with pronounced phonological word decoding problems showed more progress in reading after phonological skills training than after orthographic training, whereas children with pronounced orthographic problems benefited more from orthographic than from phonological training (Gustafson *et al*., 2007). Although the results of that study showed that phonological and orthographic word decoding skills both need to be taken into account when suggesting interventions, it is clear that we still need to learn more about how to adapt educational interventions to different groups of reading-disabled children.

Many intervention studies compare one or two different types of interventions with one comparison group. In contrast, our study investigated the relative effectiveness of three different computer-based interventions within a comparison of two different groups, a group of mainstream readers and a group of students who have reading difficulties. The top–down method used in the present study to practise reading comprehension is the computerized programme Omega–Interactive Sentences (Omega-IS; Heimann, Lundälv, Tjus, & Nelson, 2004). Omega-IS is based on the Rare Event Transactional Model (Nelson *et al*., 2001), which states that several learning conditions must act in concert in order to maximize leverage and thereby increase the likelihood of learning taking place. Making use of multimedia material, where text is illustrated by animations and sound combined with verbal interaction with the teacher, has proved to be an effective strategy to practise reading (Basil & Reyes, 2003; Heimann *et al*., 1995; Tjus *et al*., 1998, 2004). Significant progress in letter knowledge, word and sentence reading as well as in phonological awareness has been found in studies based on this top–down strategy. Fälth, Svensson, and Tjus (2011) compared a group of children with reading problems using this multimedia strategy, Omega-IS, with a group using a strategy based on Reading Recovery (Clay, 1993). Despite no between-group differences in the effectiveness of the intervention, both groups made significant gains in reading skills.

In addition to comprehension, the Simple View of Reading also highlights the role of decoding in literacy skill development. Good decoding capability requires the acquisition of phonological skills to map graphemes to phonemes. In the current study, one of the computerized interventions focuses only on phonological training utilizing the COMputerized PHOnological Training (COMPHOT) programme (Ferreira, Gustafson, & Rönnberg, 2003). Exercises in this programme are sound based, with the focus on phoneme units, word segments and words.

COMPHOT has been used in a previous intervention study, with positive results on phonological awareness and reading skills for children with reading disabilities (Gustafson *et al*., 2007).

The results from the first three test sessions have been reported in Gustafson *et al*. (2011). The present study contains two additional test sessions: follow-up 1, 5 weeks after the intervention was completed, and follow-up 2, 6 months later. The aim of this longitudinal study was to examine the effects of three computerized interventions for children with reading disabilities: phonological training, comprehension training and a combination of both. We also examined how the results persist over time at five different follow-up sessions that extended over a year.

METHOD

Participants

One hundred thirty students in Grade 2 were selected from 41 Swedish schools participating in the study. All students had received regular school-based reading instruction for almost 1.5 years before the first test session was conducted. One hundred participants were selected by their teachers as children who would benefit from special instruction in reading and who had performed at least .75 standard deviations (*SD*) below the mean of the typically developing readers on the sight word reading test (see Materials) at the first test session (T1). Children with reading difficulties were randomly assigned to one of four groups: phonological training (17 boys and 8 girls), comprehension training (18 boys and 7 girls), combined training (17 boys and 8 girls), and ordinary special instruction (18 boys and 7 girls). The remaining 30 students, who performed reading scores in the normal range, comprised a comparison group of typical readers (19 boys and 11 girls). There were no significant differences between the proportions of boys/girls across the five training groups [$\chi^2(4, 129) = .69$, $p > .05$].

Test Procedure

All tests were administered by one of the authors (L. F.) and 13 Master-level psychology students. The students had received training in test administration during their regular university courses and had participated in several additional training sessions designed specifically for the present study. The test leaders were carefully instructed to follow the same test instructions and procedure for each test.

There were two pre-intervention tests, T1 and T2 (at 5-week intervals), the average of which provided a performance baseline for each child. The third test session (T3, referred to in the text and figures as a post-test) took place directly after the intervention. The duration between T2 and T3 varied between 5 and 8 weeks. The fourth test session (T4, follow-up 1) took place 5 weeks after the intervention, and the final test session (T5, follow-up 2) occurred 1 year after the first test session.

All tests were individually administered except for the Word recognition test. A few children failed to complete one or two of the tests, and therefore, the reported number of participants in each condition varies slightly. The reading tests were administered at T1, T2, T3, T4 and T5, except for the reading comprehension

test, which was only administered at T2, T3 and T5. The cognitive tests were administered at T1 and T5.

Materials

Sight word reading

A Swedish translation of the word subtest from the Test of Word Reading Efficiency (Torgesen, Wagner, & Rashotte, 1999) was used. Participants were asked to read aloud simple words as quickly as possible for 45 s. The test includes two test versions (A and B), the results of which were summed. Reported test–retest reliability for children aged 6–9 years at this test was .97. The total maximum score was 100.

Word recognition

Word recognition was assessed using the Wordchains test (Jacobson, 1993). The task for the children was to silently read chains of words, where the blank space between words had been removed, and then mark each word boundary with a pencil. Each chain consisted of three semantically unrelated words. Test–retest correlations for the Wordchains test at a 12-month interval range from $r = .80$–.90 in different groups of children in Grades 1–6 (Jacobson, 1993). Test–retest correlations between T1 and T2 in the present study was $r = .88$. The maximum score was 60.

Non-word reading

The task is to read in 1 min as many non-words as possible from a list. The test–retest correlation between T1 and T2 in the present study was $r = .90$. The maximum score was 84.

Segment subtraction

A subtest from a Swedish standard test of phonological awareness, UMESOL: Segment Subtraction (Taube, Tornéus, & Lundberg, 1984), was used. The participants were to decide and verbally report which segment of a word had been removed from a Swedish word (i.e. 'What has been removed from the word *krokodil* [*crocodile* in English] if only *kroko* remains?'). The maximum score was 15. The test–retest correlation between T1 and T2 in the present study was $r = .87$.

Reading comprehension

A Swedish translation of a subtest from Woodcock Reading Mastery Test – Revised (Woodcock, 1987) was used. The students read a text passage with a blank line and were instructed to fill in the blank verbally with a single word that fit the passage. The level of difficulty increased with the number of items, and the test ended when the participant failed on six consecutive passages. The maximum score was 68.

Rapid automatized naming

Rapid automatized naming (RAN) for letters and for numbers was assessed (see Wolf & Denckla, 2005). The total time in seconds for naming numbers and letters was used as a measure of RAN.

Processing speed

In the Letterchain test (Jacobson, 2001), the task was to identify in unpronounceable letter strings as many instances of two adjacent letters that were the same in 2 min. Two such pairs in each letter chain occurred, for example, RSFFBPOKKPT (where the marks should be PSF/FBPOK/KPT). A test–retest reliability of .78 was measured between T1 and T2 in this study. The maximum score was 60.

Verbal fluency

The Initial Letter Verbal Fluency Test (FAS) was administered. It has been used as an assessment of executive function and semantic memory store (Parker & Crawford, 1992). It is a timed test (60 s per letter) where the participant is asked to generate words beginning with one of the letters F, A and S. The test results were used as a measure of verbal fluency. The correlation between the results from F and A was .53, between A and S .69, and between F and S .63.

Short-term memory

Short-term memory was assessed by the Digit Span subtest from WISC IV (Wechsler, 2003).

Working memory

Working memory was also assessed by the backward Digit Span from WISC IV (Wechsler, 2003). Each correctly repeated digit span was scored.

Training Programmes

Omega–Interactive Sentences – Comprehension training

The comprehension training programme, Omega-IS (Heimann *et al*., 2004), uses a top–down strategy focusing on both word-level and sentence-level processing of written language. Immediate feedback is obtained for both words and sentences in the form of speech and animations, providing corresponding one-to-one semantic comprehension. In total, more than 1900 different sentences were possible to construct with feedback in speech and animations as described earlier. The language material of the programme is meant to be explored by the learner with help from – and in interaction with – a teacher or parent. This and the accompanying animations not only offer motivational literacy training but also give opportunities for conversations where the learner can express his or her imagination and thoughts.

COMputerized PHOnological Training – Phonological training

The phonological training programme, COMPHOT (Ferreira *et al*., 2003), has four sections: Position (eight exercises), Addition (five exercises), Rhyme (four exercises) and Segmentation (three exercises). Pictures accompany each word and the task of the child is to decide which pictures (and corresponding words) rhymed or had the same initial phoneme, or alternatively to combine or remove segments of words. COMPHOT therefore focuses on phonemes, phonemes linked to letters, word segments and words. No sentences or passages were presented to the participants. Although the focus of the programme was on phonological processing, the inclusion of pictures also added a semantic component to several of the exercises. The participant received immediate feedback after

each task with the inclusion of personal high-score lists where children could check their performances on the different exercises.

Both training programmes were computerized and had been developed with the assistance of professional programmers. The third intervention group involved combined training using both the Omega-IS and COMPHOT programmes. During the first 20 sessions of combined training, the programmes alternated every other session. During the last five training sessions, the students were allowed to choose which programme they wanted to use.

Training Procedure

The participants received a total of 25 one-to-one training sessions with their special education teacher as part of their scheduled sessions of special education in their regular schools. Before the intervention started, special education teachers had been instructed on how to use the training programmes, and information and educational suggestions were also included in a written manual for each programme. Special education teachers were able to individualize the degree of difficulty of the exercises in the computer programmes to the individual student's abilities. They were also encouraged to take an active part in supporting and encouraging the students' participation.

The ordinary special instruction consisted of a variety of activities related to reading and writing, such as reading aloud or silently, discussing stories, and instructions in spelling rules, phonological awareness training and occasional memory training. Compared with the other three interventions, the ordinary special instruction was less systematic, and the special education teachers decided how the lessons should be structured for each participant. However, the requirement was that all lessons were devoted to practising Swedish.

Most sessions lasted 15–25 min. The minimum time for a session was 10 min, but the teachers were informed that longer times were preferred. Children who received phonological training had an average total training time of 446.9 min ($SD = 92.3$, $n = 25$); for the comprehension training group, it was 463.1 min ($SD = 110.5$, $n = 25$); for combined training 474.4 min ($SD = 111.7$, $n = 25$); and for ordinary special instruction 516.0 min ($SD = 121.4$, $n = 25$). A one-way ANOVA showed that there was no significant between-group effect on training times.

Statistical Methods

The main aim of the study was to compare the progress made by each of the three intervention groups and in relation to the group that received ordinary special instruction and to the typical readers. Repeated-measures ANOVA was used to test whether the effects of the training groups differed from each other and from the typical readers.

Cohen's *d* (Cohen, 1988) was used in comparing the mean values of the difference scores to the standard deviation of the typical readers in the pre-test. Cohen's *d* was calculated as [*M* at T5 or T3 − (*M* at T1 + *M* at T2) / 2] / pooled *SD* for T1, T2, and T3 or T5. Original standard deviations were used in the calculations to avoid effect size overestimation (Dunlop, Cortina, Vaslow, & Burke, 1996).

RESULTS

An overview of the effects of the intervention on reading skills is presented in Table 1. Five mixed-effects repeated-measures ANOVAs were performed with group (five levels) as a between-subjects variable and test session (four levels) as a within-subjects variable.

The results showed statistically significant main effects of test session (i.e. improvements) for all measures of decoding skills, reading comprehension skills

Table 1. Results on the reading tests (*M*, *SD*) baseline [(T1 + T2) / 2], follow-up 1 after 5 weeks and follow-up 2 after 6 months for all five groups of participants (*N* = 130)

	Comprehension training (*n* = 25)		Phonological training (*n* = 25)		Combined training (*n* = 25)		Ordinary special instruction (*n* = 25)		Typical readers (*n* = 30)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Reading comprehension										
Baseline	7.90	4.03	10.45	3.65	9.70	4.58	9.57	3.23	25.19	7.68
Post-test	12.24	4.86	16.23	4.66	14.43	5.76	12.30	4.57	28.33	6.90
Follow-up 1	15.52	3.56	18.64	5.79	16.61	5.57	15.70	6.44	30.83	5.94
Follow-up 2	17.67	4.99	21.59	7.29	20.48	6.89	18.26	6.53	32.11	5.31
Cohen's *d* at T3	0.97		1.38		0.91		0.69		0.43	
Cohen' *d* at T5	2.15		1.93		1.84		1.69		1.05	
Word decoding										
Sight word reading										
Baseline	14.80	7.63	16.97	6.63	14.70	6.00	16.42	6.50	43.37	10.63
Post-test	23.69	8.81	25.15	8.77	23.84	7.97	24.33	10.22	49.60	11.90
Follow-up 1	27.23	10.42	28.70	8.77	28.14	10.13	26.10	10.53	52.28	11.38
Follow-up 2	32.90	13.06	34.24	11.40	37.89	8.64	28.92	12.24	55.59	10.53
Cohen's *d* at T3	1.08		1.05		1.30		0.92		0.55	
Cohen's *d* at T5	1.69		1.85		2.97		1.28		1.15	
Word recognition										
Baseline	6.00	2.82	6.74	3.03	6.52	2.40	6.78	2.57	15.28	6.06
Post-test	8.28	3.49	11.04	3.56	10.84	4.38	8.97	6.61	18.81	6.74
Follow-up 1	10.40	3.59	12.78	4.21	12.64	4.38	10.68	4.19	21.41	6.41
Follow-up 2	12.56	4.19	15.04	5.04	16.44	5.83	10.68	4.39	22.74	7.25
Cohen's *d* at T3	0.72		1.30		1.22		0.44		0.55	
Cohen' *d* at T5	1.86		2.0		2.23		1.08		1.12	
Phonological abilities										
Non-word reading										
Baseline	8.55	3.68	9.59	3.70	9.63	4.83	9.54	5.23	19.74	6.03
Post-test	12.52	4.72	12.95	3.80	14.96	5.84	13.04	5.60	22.78	7.37
Follow-up 1	14.90	3.56	14.00	5.05	17.09	5.06	13.13	6.62	23.74	8.10
Follow-up 2	15.95	6.33	16.50	6.06	20.65	6.77	15.26	6.59	25.37	7.53
Cohen's *d* at T3	0.93		0.90		0.99		0.65		0.45	
Cohen's *d* at T5	1.43		1.38		1.87		0.96		0.83	
Segment subtraction										
Baseline	4.08	1.88	5.43	2.50	5.12	2.68	4.90	2.18	8.43	2.44
Post-test	4.80	2.36	7.00	3.31	6.04	3.00	6.42	2.93	9.33	2.66
Follow-up 1	6.00	2.84	7.65	2.62	7.16	3.29	6.96	2.46	9.93	1.75
Follow-up 2	6.08	2.53	8.09	2.68	7.96	2.88	6.87	2.46	10.96	2.13
Cohen's *d* at T3	0.34		0.54		0.32		0.59		0.71	
Cohen' *d* at T5	0.90		1.03		1.02		0.85		1.10	

Cohen's *d* = [*M* at T5 – (*M* at T1 + *M* at T2) / 2] / pooled *SD* for T1, T2 and T5.

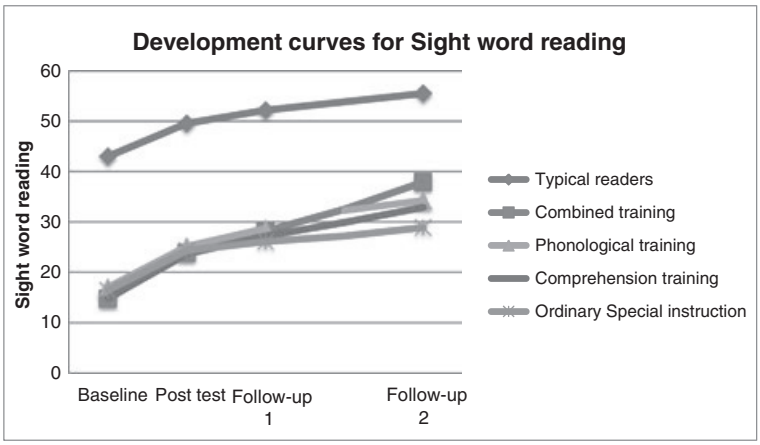

Figure 1. Development curves for sight word reading test for all five groups.

and phonological skills, the minimum *F* ratio obtained here was [$F(3, 94) = 3.58$, $p < .05$]. All ANOVAs also revealed main effects of group; with typical readers outperforming the other four groups, the minimum *F* ratio obtained here was [$F(4, 125) = 4.21$, $p < .05$]. A significant interaction of test session and group was obtained for the sight word reading test [$F(9, 28) = 3.48$, $p < .05$] (Figure 1), the reading comprehension test [$F(9, 28) = 2.39$, $p < 0.05$] (Figure 2) and the non-word reading test [$F(9, 26) = 2.57$, $p < .05$] (Figure 3). The results from these three tests are shown as development curves in Figures 1–3. Test session 1 in Figures 1–3 includes average data from both test sessions at the pre-intervention baseline.

The development curves for sight word reading from baseline to follow-up 2 show that the gap still exists between students with reading disabilities and typical readers but that the group differences decrease slightly, especially for the group receiving combined training. An independent samples *t*-test showed that the gain scores from baseline to follow-up 2 between typical readers and the combined group on sight word reading was 3.7.

Figure 2 contains data from three test sessions: baseline, post-test and follow-up 2. The development curves for reading comprehension show that a gap still

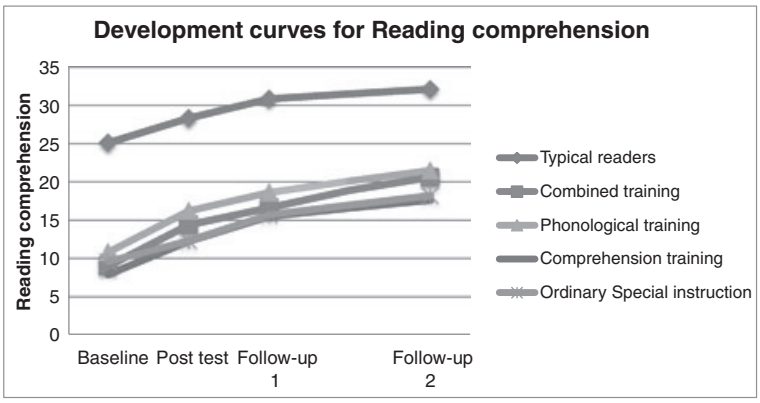

Figure 2. Development curves for reading comprehension test for all five groups.

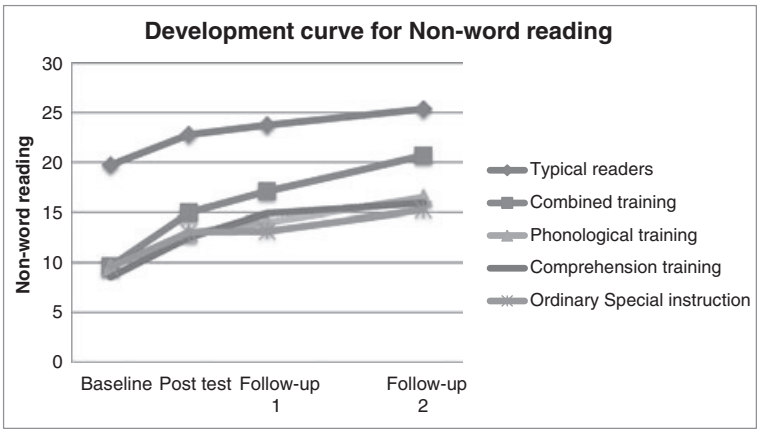

Figure 3. Development curves for non-word reading test for all five groups.

exists between students with reading disabilities and typical readers but that it decreases slightly from baseline to follow-up 2 especially for the group receiving combined training. The independent samples *t*-test showed that the gain scores between baseline and follow-up 2 between typical readers and the combined group was 5.4.

The development curves for non-word reading follow the same general pattern as the curves for sight word reading and for comprehension. An independent samples *t*-test showed that the gain scores from baseline to follow-up 2 between typical readers and the combined group on non-word reading was 2.9.

Table 2 shows the general effects of the intervention on reading-related abilities. Three mixed ANOVAs were performed with group (five levels) as a between-subjects variable and test session (two levels) as a within-subjects variable, the results

Table 2. Results on tests measuring Reading-related abilities (*M*, *SD*) baseline ((T1 + T2)/2), follow-up 1 after 5 weeks for all five groups of participants (*N* = 130)

	Comprehension training (*n* = 25)		Phonological training (*n* = 25)		Combined training (*n* = 25)		Ordinary special instruction (*n* = 25)		Typical readers (*n* = 30)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Processing speed										
Baseline	25.60	5.88	26.76	3.77	28.64	6.68	26.22	5.29	31.22	4.67
Follow-up 1	32.04	6.34	31.91	4.49	32.04	7.92	30.28	6.99	36.67	5.51
Cohen's *d* at follow-up 1	1.05		1.24		0.46		0.65		1.07	
Verbal fluency										
Baseline	8.04	4.03	12.17	4.91	11.36	4.57	9.36	5.08	17.07	5.59
Follow-up 1	11.32	4.62	16.21	6.26	13.76	4.33	12.20	5.79	19.57	7.59
Cohen's *d* at follow-up 1	0.76		0.72		0.54		0.52		0.38	
RAN, numbers, s										
Baseline	28.00	8.4	29.12	8.01	29.28	10.5	26.76	7.14	21.7	2.78
Follow-up 1	25.12	6.83	25.50	4.98	25.00	5.67	25.72	5.60	21.53	3.63
Cohen's *d* at follow-up 1	0.32		0.42		0.48		0.23		0.20	

Cohen's *d* = [*M* at T5 or T3 – (*M* at T1 + *M* at T2) / 2] / pooled *SD* for T1, T2 and T4. RAN, rapid automatized naming.

Table 3. Correlations (Pearson's *r*) between cognitive abilities pre-intervention and improvement in decoding (TOWRE; Torgesen, Wagner, & Rashotte, 1999) between baseline and follow-up 2

	Comprehension training ($n = 25$)	Phonological training ($n = 25$)	Combined training ($n = 25$)	Ordinary special typical instruction ($n = 25$)	Readers ($n = 29$)
Cognitive variables					
Non-verbal intelligence	−.23	.17	.47*	−.17	.06
Short-term memory	.13	.01	.11	−.16	.00
Working memory	.34	−.31	.65**	.33	.06
RAN	.11	−.42*	−.47*	−.03	−.36*
Verbal fluency	.18	.17	.33	.05	.17

RAN, rapid automatized naming.
*$p < .05$.
**$p < .01$.

showing statistically significant main effects of the test session (i.e. improvements) for all three tests (all $ps < .05$). There were also main effects of group such that typical readers outperformed the other four groups (all $ps < .05$). A significant session by group interaction was found on the RAN test, [$F(1, 124) = 2.68$, $p < .05$], with Tukey post hoc tests demonstrating that the typical readers outperformed the other four groups on RAN (all $ps < .05$).

Bivariate correlations were calculated to examine variables related to reading improvements in decoding and reading comprehension from baseline to the second follow-up and six cognitive variables measured at baseline (Tables 3 and 4).

Within the group who received comprehension training, there were significant positive correlations between improvement in reading comprehension and working memory ($p < .05$).

The group who received phonological training revealed a significant positive correlation between improvement in reading comprehension and the verbal fluency test ($p < .05$). This group also revealed a significant negative correlation between

Table 4. Correlations (Pearson's *r*) between cognitive abilities pre-intervention and improvement in reading comprehension (Woodcock, 1987) between baseline and follow-up 2

	Comprehension training ($n = 25$)	Phonological training ($n = 25$)	Combined training ($n = 25$)	Ordinary special typical instruction ($n = 25$)	Readers ($n = 29$)
Cognitive variables					
Non-verbal intelligence	−.24	.10	.48*	−.18	−.22
Short-term memory	.09	.00	.13	.12	−.18
Working memory	.44*	.31	.11	−.24	.39*
RAN	−.06	−.20	−.24	−.37	−.21
Verbal fluency	−.01	.41*	.17	−.01	−.14

RAN, rapid automatized naming.
*$p < .05$.
**$p < .01$.

improvement in decoding and the RAN test ($p < .05$). Note that a low score on RAN represents rapid naming measured in seconds, so higher performance following phonological training was associated with good initial performance on RAN. Both the combined group and the group of typical readers revealed a significant negative correlation between improvements in decoding and RAN ($p < .05$). The combined group also revealed three other significant results; positive correlations were obtained between the decoding skills and non-verbal intelligence and working memory as well as between the improvements in reading comprehension and non-verbal intelligence.

Within the group of typical readers, there was a significant positive correlation between improvement in reading comprehension and working memory ($p < .05$).

There were no significant correlations in the ordinary special instruction group.

Prior to the intervention, all 25 students in each intervention group received special education. One year after the intervention, seven students (28%) started in the combined training group, 20 students (80%) in the phonological training group, 20 students (80%) in the comprehension training group and 21 students (84%) in the ordinary special instruction group still receiving special education. A McNemar test showed that this change ($p < .05$) was significant in the combined group. No significant change in numbers of student receiving special education was observed for the other groups.

DISCUSSION

The main purpose of the study was to evaluate three different computerized intervention programmes for improving children's reading skills. The results demonstrated that gains in decoding, reading comprehension, and non-word reading can be achieved by intensive phonological training in combination with reading comprehension training and that these gains persist over a 1-year follow-up period. The development curves in Figures 1–3 show that the gap between typical readers and the combined group especially decreased from the baseline to the second follow-up. Cohen's *d* shows (Table 1) that this group (combined training) increased by nearly 3 *SDs* from the first to the last test session on the sight word reading test, compared with the group of typical readers, who increased by 1.15 *SD*. On the non-word reading test, the combined group also increased by more than one *SD*, compared with typical readers. These results were strengthened by the declining number of students in the combined group who were in need of special education after a period of 1 year.

In Sweden, it is common that the special education teacher, together with the classroom teacher, decide which students may receive special education after the identification of the students' strengths and weaknesses. The results showed that 20 out of 25 students in the comprehension and phonological training groups received special education, and 22 out of 25 in the group received ordinary special instruction 1 year after the interventions. In the combined group, the result was different in that only seven students out of 25 were still receiving special education. The intervention groups in our study continued to receive special education in small groups directly after the intensive intervention. This may be an important factor for the sustained gains in reading accuracy on tests that were made 1 year after intervention in both our study and the study by Torgesen *et al.* (2001).

Our results suggest that combined training was the most effective method in this study even though the total amount of training was equivalent between the intervention groups. In line with our results, several studies (e.g. Cohen & Brady, 2011; Hatcher *et al*., 2006; Lovett *et al*., 2000; Snowling & Hulme, 2011; Wolff, 2011) have also shown that an efficient reading intervention programme should combine explicit training in phonological awareness with highly structured reading instruction. Furthermore, because our participants had decoding problems, comprehension problems or both, an intervention covering both components might provide content for most of the children in this group (Aaron, Joshi, & Williams, 1999; Hoover & Gough, 1990). A contributing factor to why the combined training was the most effective intervention could be the variation it offered when using two different programmes. This may have resulted in maintaining motivation to a greater extent among the students who were part of the group receiving combined training.

Because the groups were randomly assigned to intervention programmes, we did not intend to match the students' specific needs to specific interventions. Several studies (e.g. Berninger, Raskind, Richards, Abbott, & Stock, 2008; Bowers, 1995; Lervåg & Hulme, 2009) have shown the importance of investigating more specific cognitive reading-related factors such as working memory, RAN and processing speed when examining individual differences in reading skills. The present study demonstrated the predictive validity of some reading-related cognitive tests for improvements in decoding skills and reading comprehension from baseline to follow-up 2. First, for the groups who received phonological training and combined training, greater improvement in decoding correlated with good initial performance in RAN. This was also found among the typical readers. These findings are in line with the results from previous studies by Warmington and Hulme (2012) and by Gustafson *et al*. (2011) that indicated the predictive value of RAN in the long term for reading outcomes. Second, higher scores on a test of working memory test, along with higher scores on a measure of non-verbal intelligence, were associated with larger improvements in decoding for the group receiving combined training. It is possible that the combined training requires additional cognitive flexibility acting to promote the benefits of this training. Third, the group who received comprehension training showed significant positive correlations between improvements in reading comprehension and their working memory scores measured at T1. The Omega-IS programme is constructed with the aim to support online information processing (e.g. working memory) by providing a cognitive support structure where the same information is presented in several different modalities within a short period (Heimann, Lundälv, Tjus, & Nelson, 2004).

Students with obvious reading and writing difficulties need to receive qualified educational assistance. By one-to-one teaching, one teacher to one student, it is possible to achieve the necessary effective time for learning the task. Studies have shown that such teaching can be effective (Torgesen *et al*., 2001; Vellutino *et al*., 1996; Wolff, 2011). The teacher can capture the students' attention and give instant confirmation or correction, which means effective guidance for using good reading strategies and avoiding incorrect practices (Gustafson *et al*., 2007; Hart & Riesly, 1995). In the present study, the special education teachers confirm the positive impact of one-to-one teaching. Unlike most other intervention studies (e.g. Hintikka *et al*., 2008; Lovett *et al*., 2000; Torgesen *et al*., 2001), teachers here had by definition limited freedom to choose the level of functions within each

programme so that the exercises are individualized in a way that benefited the student. In their view, it was possible to individualize the exercises in each computer programme and also the instructions for each exercise and the extent to which feedback was given so that they would suit the individual student.

There are limitations that should be taken into consideration in the interpretation of these results. The small size of the sample and the fact that we allowed some flexibility for the teachers in planning and selection of exercises for each individual student made the structure of the interventions differ somewhat from case to case. However, the results of this study show that the gap between typical readers and students with reading and writing difficulties can be decreased by well-planned and systematic interventions, results that are in line with previous findings (Snowling and Hulme, 2011; Torgesen *et al*., 2001; Wolff, 2011).

Readers are naturally different in terms of language skills, cognitive abilities and background, as well as in terms of their motivation and the strategic contribution they make to understand the text (Arnbak, 2010). Nonetheless, it is important to identify and target instruction at the weak areas of a child's reading. This study, along with others, shows that a computer-assisted intervention (e.g. Saine *et al*., 2011; Torgesen *et al*., 2001) targeting both phonological and reading comprehension training (e.g. Helland *et al*., 2011) can be an effective reading intervention.

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REFERENCES

Aaron, P. G., Joshi, M., & Williams, K. A. (1999). Not all reading disabilities are alike. *Journal of Learning Disabilities*, *32*, 120–137.

Arnbak, E. (2010). *Läsning av faktatexter. Från läsprocess till lärprocess. [Reading texts with facts. From reading process to learning process]*. Stockholm: Natur och Kultur.

Basil, C., & Reyes, S. (2003). Acquisition of literacy skills by children with severe disability. *Child Language Teaching and Therapy*, *1*, 27–48.

Berends, I. E., & Reitsma, P. (2006). Addressing semantics promotes the development of reading fluency. *Applied PsychoLinguistics*, *27*(02), 247–265.

Berninger, V., Raskind, V., Richards, T., Abbott R., & Stock, P. (2008). A multidisciplinary approach to understanding developmental dyslexia within working-memory architecture: Genotypes, phenotypes, brain, and instruction. *Developmental Neuropsychology*, *33:6*, 707–744.

Bowers, P. G. (1995). Tracing symbol naming speed's unique contributions to reading disabilities over time. *Reading and Writing: An Interdisciplinary Journal*, *7*, 189–216.

Catts, H. W., & Kamhi, A. G. (2005). *Language and reading disabilities*. Boston: Pearson Education, Inc.

Clay, M. (1993). *Reading recovery: A guidebook for teachers in training*. Auckland: Heinemann Education.

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

Cohen, J. E., & Brady, M. P. (2011). Acquisition and generalization of word decoding in students with reading disabilities by integrating vowel pattern analysis and children's literature. *Education and Treatment of Children*, *34*(1): 81–113.

Dunlop, W. P., Cortina, J. M., Vaslow, J. B., & Burke, M. J. (1996). Meta-analysis of experiments with matched groups or repeated measures designs. *Psychological Methods*, *1*, 170–177.

Ehri, L. C., Nunes, S. R., Willows, D. M., Valeska Schuster, B., Yaghoub-Zadeh, Z., & Shanahan, T. (2001). Phonemic awareness instruction helps children learn to read: Evidence from the National Reading Panel's meta-analysis. *Reading Research Quarterly*, *36*, 250–287.

Elbro, C. (1996). Early linguistic abilities and reading development: A review and a hypothesis about distinctness of phonological representations. *Reading and Writing: An Interdisciplinary Journal*, *16*, 505–5.

Elbro, C., & Petersen, D. K. (2004). Long term effects of phoneme awareness and letter sound training: An intervention study with children at risk for dyslexia. *Journal of Educational Psychology*, *96*, 660–670.

Fälth, L., Svensson, I., & Tjus, T. (2011). Improvement in reading among children with reading disabilities: The effects of two training programs. *Psychology*, *2*(3), 173–180.

Fast, C. (2007). *Sju barn lär sig läsa och skriva – Familjeliv och populärkultur i möte med förskola och skola. [Seven children learn to read and write – Family and popular culture in contact with preschool and school]*. Uppsala: Acta Univeritatis Upsaliensis Vällingby: Elanders Gotab AB.

Ferreira, J., Gustafson, S., & Rönnberg, J. (2003). *COMPHOT: Computerized phonological training*. Linköping: Institutionen för beteendevetenskap/Institutet för handikappvetenskap, Linköpings universitet.

Gillon, G. (2004). *Phonological awareness: From research to practice*. New York: Guilford Press.

Gough P., & Tunmer W. (1986). Decoding, reading and reading disability. *Remedial and Special Education*, *7*, 6–10.

Grigorenko, E. L. (2009). Dynamic assessment and response to intervention: Two sides of one coin. *Journal of Learning Disabilities*, *42*, 111–132.

Gustafson, S., Fälth, L., Svensson, I., Tjus, T., & Heimann, M. (2011). Effects of three interventions on the reading skills of children with reading disabilities in Grade 2. *Journal of Learning Disabilities*, *44*(2), 123–135.

Gustafson, S., Ferreira, J., & Rönnberg, J. (2007). Phonological or orthographic training for children with phonological or orthographic decoding deficits. *Dyslexia*, *13*, 211–229.

Hart, B., & Riesly, T. R. (1995). *Meaningful differences in the everyday experience of young American children*. Baltimore, MD: Brookes.

Hatcher, P. J., Goetz, K., Snowling, M., Hulme, C., Gibbs, S., & Smith, G. (2006). Evidence for the effectiveness of the Early Literacy Support programme. *British Journal of Educational Psychology*, *76*, 351–367.

Hatcher, P., Hulme, C., & Ellis, A. W. (1994). Ameliorating reading failure by integrating the teaching of reading and phonological skills: The phonological linkage hypothesis. *Child Development*, *65*, 41–57.

Hatcher, P. J., Hulme, C., Miles, J. N. V., Carroll, J. M., Hatcher, J., Gibbs, S., Smith, G., Bowyer-Crane, C., & Snowling, M. J. (2006). Efficacy of small group reading intervention for beginning readers with reading-delay: A randomised controlled trial. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *47*(8), 820.

Heimann, M., Lundälv, M., Tjus, T., & Nelson, K. E. (2004). *Omega–Interactive Sentences, a multimedia software for language exploration and play*. Göteborg: Topic Data & Språkbehandling HB. (Available from: www.omega-is.com)

Heimann, M., Nelson, K. E., Tjus, T., & Gillberg, C. (1995). Increasing reading and communication skills in children with autism through an interactive multimedia computer program. *Journal of Autism and Developmental Disorders*, *25*, 459–480.

Helland, T., Tjus, T., Hovden, M., Ofte, S., & Heimann, M. (2011). Effects of a bottom–up and a top–down intervention principle in emergent literacy in children at risk of developmental dyslexia. A longitudinal study. *Journal of Learning Disabilities*, *44*(2), 105–122.

Hintikka, S., Landerl, K., Aro, W., & Lyytinen, H. (2008). Training reading fluency: Is it important to practice reading aloud and is generalization possible? *Annals of Dyslexia*, *54*, 59–79.

Høien, T., & Lundberg, I. (2004). *Dyslexi. Från teori till praktik. [Dyslexia. From theory to practice]*. Stockholm: Natur och Kultur.

Hoover, W., & Gough, P. (1990). The simple view of reading. *Reading and Writing: An Interdisciplinary Journal*, *2*, 127–160.

Hulme, C., Snowling, M., Caravolas, M., & Carroll, J. (2005). Phonological skills are (probably) one course of learning to read: Comments by Castles and Coltheart. *Scientific Studies of Reading*, *9*(4), 351–365, 15p.

Irasquin, R. S., Drent, J., & Verhoeven, L. (2005). Benefits of computer-presented speed training for poor readers. *Annals of Dyslexia*, *55*, 246–265.

Jacobson, C. (1993). *Manual till Ordkedjetestet [The Wordchains test; manual]*. Stockholm: Psykologiförlaget.

Jacobson, C. (2001). *Läskedjor. [Wordchains]*. Stockholm: Psykologiförlaget.

Jiménez, J. E., Hernández-Valle, M., Ramírez, G., del Rossario Ortiz, M., Rodrigo, M., Estévez, A., *et al.* (2007). Computer speech-based remediation for reading disabilities: The size of spelling-to-sound unit in a transparent orthography. *Spanish Journal of Psychology*, *10*, 52–67.

Kjeldsen, A.-C., Niemi, P., & Olofsson, Å. (2003). *Training phonological awareness in kindergarten level children: Consistency is more important than quantity*. Åbo: Department of Special Education.

Lervåg, A., & Hulme, C. (2009). Rapid automatized naming (RAN) taps a mechanism that places constraints on the development of early reading fluency. *Psychological Sciences*, *20*, 1040–1048.

Lovett, M. W., Lacerenza, L., Borden, S. L., Frijters, J. C., Steinbach, K. A., & De Palma, M. (2000). Components of effective remediation for developmental reading disabilities: Combining phonological and strategy-based instruction to improve outcomes. *Journal of Educational Psychology*, *92*, 263–283.

Macaruso, P., Hook, P. E., & McCabe, R. (2006). The efficacy of computer-based supplementary phonics programs for advancing reading skills in at-risk elementary students. *Journal of Research in Reading*, *29*(2), 162–172.

Magnan, A., & Ecalle, J. (2006). Audio-visual training in children with reading disabilities. *Computers in Education*, *46*, 407–425.

Moreno, R. (2006). Learning in high-tech and multimedia environments. *Current Directions in Psychological Science*, *15*, 63–67.

Morris, R., Lovett, M., Wolf, M., Sevcik, R., Steinbach, K., Frijters, J., & Sharpio, M. (2012). Multiple-component remediation for developmental reading disabilities: IQ, socioeconomic status and race as factors in remedial outcome. *Journal of Learning Disabilities*, *45*: 99.

Nelson, K. E., Welsh, J. M., Camarata, S. M., Tjus, T., & Heimann, M. (2001). A rare event transactional model of tricky mix conditions contributing to language acquisition and varied communicative delays. In K. E. Nelson, A. Aksu-Koç, & C. E. Johnson (Eds.), *Children's language, volume 11: Interactional contributions to language development* (pp. 165–195). Mahwah, NJ: Erlbaum.

Parker, D. M., & Crawford, J. R. (1992). Assessment of frontal lobe dysfunction. In J. R. Crawford, W. McKinlay, & D. M. Parker (Eds.), *Handbook of neuropsychological assessment* (pp. 267–291). Hove: Erlbaum and Associates.

Regtvoort, A. G. F. M., & van der Leij, A. (2007). Early intervention with children of dyslexic parents: Effects of computer-based reading instruction at home on literacy acquisition. *Learning and Individual Differences*, *17*(1), 35–53.

Saine, N. L., Lerkkanen, M.-K., Ahonen, T., Tolvanen, A., & Lyytinen, H. (2011). Computer-assisted remedial reading intervention for school beginners at risk for reading disability. *Child Development*, *82*, 1013–1028.

Shayne, B., & Wagne, R. (2010). Learning letter names and sounds: Effects of instruction, letter type and phonological processing skill. *Journal of Experimental Child Psychology*, *105*(4), 324–344.

Snowling, M. J., & Hulme, C. (2011). Evidence-based interventions for reading and language difficulties: Creating a virtuous circle. *British Journal of Educational Psychology*, *81*(1), 1–23.

Taube, K., Tornéus, M., & Lundberg, I. (1984). *UMESOL: Fonologisk medvetenhet: Handläggning för kartläggning och utveckling*. Stockholm: Psykologiförlaget AB.

Tjus, T., Heimann, M., & Nelson, K. E. (1998). Gains in literacy through the use of a specially developed multimedia computer strategy: Positive findings from thirteen children with autism. *Autism*, *2*(2), 139–156.

Tjus, T., Heimann, M., & Nelson, K. E. (2001). Interaction patterns between children and their teachers when using a specific multimedia and communication strategy: Observations from children with autism and mixed intellectual disabilities. *Autism*, *5*(2), 175–187.

Tjus, T., Heimann, M., & Nelson, K. E. (2004). Reading acquisition by implementing a multimedia intervention strategy for fifty children autism or other learning and communication disabilities. *Journal of Cognitive and Behavioural Psychotherapies*, *4*(2), 203–221.

Torgesen, J. K., Alexander, A. W., Wagner, R. K., Rashotte, C. A., Voeller, K. K. S., & Conway, T. (2001). Intensive remedial instruction for children with severe reading disabilities: Immediate and long-term outcomes from two instructional approaches. *Journal of Learning Disabilities*, *34*, 33–58.

Torgesen, J., Wagner, R., & Rashotte, C. A. (1999). *A Test of Word Reading Efficiency (TOWRE)*. Austin: TX PRO-ED.

Tunmer, W., & Greaney, K. (2010). Defining dyslexia. *Journal of Learning Disabilities*, *43*, 2009.

Van Daal, V., & Reitsma, P. (2000). Computer-assisted learning to read and spell: Results from two pilot studies. *Journal of Research in Reading*, *23*, 181–193.

Vellutino, F. R., Scanlon, D. M., Sipay, E. R., Small, S. G., Chen, R., Pratt, A., & Denckla, M. B. (1996). Cognitive profiles of difficult-to-remediate and readily remediated poor readers: Early intervention as a vehicle for distinguishing between cognitive and experiential deficits as basic causes of specific reading disability. *Journal of Educational Psychology*, *88*, 601–638.

Warmington, M., & Hulme, C. (2012). Phoneme awareness, visual–verbal paired-associate learning, and rapid automatized naming as predictors of individual differences in reading ability. *Scientific Studies of Reading*, *16:1*, 45–62.

Wechsler, D. (2003). *Wechsler Intelligence Scale for Children – 4th Edition (WISC-IV®)*. San Antonio, TX: Harcourt Assessment.

Wise, B. W., Ring, J., & Olson, R. K. (1999). Training phonological awareness with and without explicit attention to articulation. *Journal of Experimental Child Psychology*, *72*, 271–304.

Wolf, M., & Denckla, M. B. (2005). *Rapid Automatized Naming and Rapid Alternating Stimulus tests (RAN/RAS)*. Austin, TX: PRO-ED.

Wolff, U. (2011). Effects of a randomised reading intervention study: An application of structural equation modelling. *Dyslexia*, *17*, 295–311.

Woodcock, R. (1987). *Woodcock Reading Mastery Tests – Revised*. Circle Pines MN: American Guidance Service.

IV

The Need of Variation – Pupils' and Teachers' Experiences of Participating in a Reading Intervention Study

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Short title: Reading interventions and the need of variation

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Abstract

Several studies have explored different methods with a view to developing written language ability in pupils with reading and writing disability. However, few, if any, studies have examined how participating teachers and pupils have experienced their participation and what experiences they have drawn from taking part in these studies. In an earlier study (Gustafson et al., 2011; Fälth et al., 2013) results showed that pupils who received a combination of phonological and reading comprehension training made greater progress on tests measuring word decoding, phonological ability and reading comprehension than the comparison groups. The latter groups received either purely phonological or reading comprehension training, or regular special needs teaching. The aim of this study is to take part of pupils 'and teachers' experiences in participating in the above mentioned intervention study in order to elucidate the quantitative results which are reported from the study. In this present study 25 pupils and 18 teachers have been interviewed. The participants selected were pupils in need of special instruction in reading. The results showed that the firm external structure of this study and the flexibility of each intervention were experienced by both pupils and teachers as positive and as an essential contributory factor for the reading success of these pupils. They also showed that the combined training benefited both pupils' and teachers' motivation for the intervention. The conclusion is that computer-based intervention in reading training with a strict framework, combined with individually adapted contents, may be both beneficial and motivating and also have a influence on the success of the interventions.

Keywords: Pupil, computer-assisted intervention, experiences, reading disability, teacher

The Need of Variation – Pupils' and Teachers' Experiences of Participating in a Reading Intervention Study

A challenge for both researchers and practising teachers is to develop, disseminate and implement methods to help all pupils to acquire good reading skills (Morris et al., 2012; Torgesen, Alexander, Wagner, Rashotte, Voeller, & Conway, 2001). One way to do this is to conduct intervention studies. Intervention can take different forms; the length of operation may vary as well as the intensity and content. Generally, intervention studies in the literacy field show that phonological training has positive effects on pupils' reading abilities (e.g. Ehri et al., 2001; Elbro & Petersen, 2004; Torgesen et al., 2001). It has also been demonstrated that the most efficient reading intervention programs combine explicit training in phonological awareness with highly structured reading instruction (e.g., Hatcher, Hulme, & Ellis, 1994; Hatcher, Hulme, Miles, Carroll, Hatcher, & Gibbs 2006; Wolff, 2011). Results from various studies also demonstrate that interventions should be systematic (Kjeldsen, Niemi, & Olofsson, 2003) and intensive (Denton, Fletcher, Anthony, & Francis, 2006). Meta-analyses show that it is better to compress the training rather than spreading the same amount over longer periods of time (Bus & van Ijzendoorn, 1999; Ehri et al., 2001).

In order to help pupils with reading and writing difficulties to an appropriate reading and writing ability, special efforts in terms of structured reading and writing instructions are required. Even with good teaching, however, a large number of children require instructional interventions beyond the capability of the regular classroom teacher (Torgesen et al., 2001; Torgesen, 2005). According to a meta-analysis conducted by the National Reading Panel (Ehri et al., 2001), an effective intervention should include explicit instruction in phonemic awareness, fluency, construction of meaning, phonics, vocabulary and reading comprehension strategies.

There are several studies focusing on interventions linked to the ability to read and write (e.g. Hintikka, Landerl, Aro, & Lyytinen, 2008; Morris, et al., 2012; Torgesen et al., 2001), but few, if any, have focused on the experience of participating in such a study. This study makes visible teachers' and pupils' experiences of participating in an intervention study whose aim is to promote the reading development of pupils in Year 2. Its background is a recent intervention study (Fälth, Gustafson. Thus, Heimann, & Svensson 2013; Gustafson, Fälth, Svensson, Tjus, & Heimann, 2011). Altogether, 130 pupils and 42 teachers took part. An experiment group consisting of one hundred pupils were selected after being identified by class teachers and special needs teachers as pupils in need of special needs education efforts in Swedish in Year 2. The remaining 30 pupils are "typical readers" forming a control group. The participants in the experiment group were randomized into four groups with 25 pupils in each. The groups received interventions of different types during 25 sessions. The interventions consisted of two computer-based programs in reading training. The first group received a program (Omega-IS) focusing on reading comprehension (Heimann, Lundälv, Tjus, & Nelson, 2004), the second group used a phonologically based program (Comphot) (Ferreira, Gustafson, & Rönnberg, 2003), the third group was given a combination of the above, and the fourth group participated in regular special needs instruction, which was individually adapted by each special needs teacher. All tutoring was made on a one-to-one basis and the pupils underwent a battery of different reading and writing tests on five different occasions (for detailed information, see Gustafson et al., 2011). The results of that study (Gustafson et al., 2011) showed that the pupil group which received the combination training by alternating between the two programs every second time achieved the best results on tests measuring word decoding, phonological ability and reading comprehension.

Computer-based instruction has been found to be beneficial for pupils with reading and writing disabilities (Jimenez et al., 2007; Magnan & Ecalle, 2006; Nicolson, Fawcett, & Nicolson, 2000; Regtvoort & van der Leij, 2007). In addition, Wise, Ring, and Olson (2000) showed that computer-based phonological training resulted in improved word reading for pupils in lower grades. It needs emphasizing that it is not the computer or method per se that is important but *how* and *in what context* the computer serves as a method (Folkesson & Swalander, 2007; Sutherland, Armstrong, Barnes, Brawn, Breeze, & Gall, 2004). As the role of computers today in special needs education is central, it has become increasingly important to evaluate under what conditions and for what pupils the software applied leads to better reading and writing abilities. Computers may offer specific and valuable opportunities for training within special needs education, but guidance is still required, both about the effects of the software and about how to structure the computer training to provide the optimal effects for the individual pupil (Torgesen, Wagner, Rashotte, Herron, & Lindamood, 2010). The results from the present study must be qualified by the fact that the computer-based instruction was offered as a supplement, rather than as a replacement for teacher-led instruction. The role of the teacher is important in guiding pupils, just as discussions between teachers and pupils about the aim and contents of the exercises fulfil an important function (Gibbons, 2006; Moreno, 2006; Torgesen et al., 2010).

Given the importance of reading skill for educational success, researchers have focused on identifying ways to improve children's reading by examining the abilities that support this learnt skill. Motivation is an example of such a supporting factor which is important for most of the activities we are doing and reading is no exception. A number of studies have illustrated that children's reading skill is associated with their motivation to read (Baker & Wigfield, 1999; Jenner, 2004; Morgan & Fuchs, 2007; Wang & Guthrie, 2004).

The aim of the study was to describe and analyze pupils' and teachers' experiences in participating in the above mentioned intervention study in order to elucidate the quantitative results previously reported from that study.

Method

Participants

Twenty-five pupils and their 18 teachers participated in this interview study. The pupils and their teachers were part of an intervention study comprising a total of 130 participants. The aim of that study was to promote reading development among the pupils. One hundred of the participants were selected by their teachers as being children who were in need of special instruction in reading. The other 30 pupils formed a control group. The participants were randomly assigned to four groups: Phonological training (25 pupils), Comprehension training (25 pupils), Combined training (25 pupils), and Ordinary special instruction (25 pupils) (for more information, see Gustafson et al., 2011). The distribution of the 25 pupils participating in the present interview study was: Phonological training (7 pupils), Comprehension training (6 pupils), Combined training (8 pupils), and Ordinary special instruction (4 pupils). Of the 18 participating teachers, 11 had one participating pupil each in the study, while 7 of the teachers had 2 pupils each.

Materials and Procedure

Training programs: The computerized phonological training program, named COMPHOT (Ferreira, Gustafson, & Rönnberg, 2003), had four sections comprising between three and eight exercises: *Rhyme, Position, Addition*, and *Segmentation*. Most of the exercises were phonological and sound-based. Pictures were included in the exercises and

when the participants clicked on them they could listen to the corresponding words. The language units that were focused on in COMPHOT were phonemes, word segments and words. No sentences or passages were presented to the participants. The participants got immediate feedback after each task and were also given individual high-score lists where they could check their performances on the different exercises.

The comprehension training program used in this study, Omega-IS (Heimann et al., 2004) is a multimedia program offering a top-down strategy including both word- and sentence-level processing of written language. Immediate feedback is obtained for both words and sentences in the form of speech and animations providing corresponding one-to-one semantic comprehension, thus inviting the child to explore written text. The lessons included in the program went from two- (noun + verb) and three-word (noun + verb + noun) sentences up to stories within which the child could construct their own stories and choose different actors and scenarios. In total, more than 1900 different sentences were possible to construct with feedback in speech and animations as described above. The language material of the program was meant to be explored by the learner with help from - and in interaction with – a teacher or parent. The goal is to achieve an errorless co-construction of meaning from a text through multimedia and supportive interaction.

The third intervention group, Combined training, used both COMPHOT and Omega-IS. During the first 20 sessions the programs were used every other session, and during the last five training sessions the pupils were allowed to choose which program to use.

After the intervention, i.e. when each pupil had used the individualized training program on 25 occasions, all pupils and teachers were interviewed separately. These interviews, on

average 20 minutes with the pupils and 45 minutes with the teachers, were recorded. The interviews were processed on the basis of inductive thematic analysis (Hayes, 2000) which involves searching through data to identify any recurrent patterns. A theme is a cluster of linked categories conveying similar meanings. Thematic analysis attempts to represent a view of reality via systematically working through text to identify topics that are progressively integrated into higher order themes. The work started with that the interview answers were transcribed and read in its entirety. After I had established me an overview of the interviews I was able to find keywords. The keywords I found were: variety, structure, motivation, individualization, level adjustment, systematics, pause, computer-based training. The key words were then grouped to various themes. The texts were read back through and quotes were selected from each interview to represent each theme. Thereafter the material was summarized and quotes from the interviewees were used to illustrate and clarify the text. The interview answers cited here has been translated from Swedish to English.

Teacher interviews: The questions to the teachers focused on their participation and experiences of being included in the study. A thematically structured interview guide was used to check that the intended areas were covered. This interview guide included research areas: questions related to the content of the interventions and questions concerning the form and arrangement of the interventions. Examples of questions related to the contents of the intervention were for example: How well did they think this intervention had suited their particular pupil? To what extent did they experience an improvement in their pupil's reading by means of this intervention?

The issues concerning the form and arrangement of the study contained questions about their experience of the framework, variation and degree of difficulty. Intensity and duration were also discussed.

Pupil interviews: The questions used when interviewing the pupils contained statements about their participation and experience of being included in the study. A thematically structured interview guide was used to check that all intended areas were covered. The pupils answered questions on the contents and the form of the interventions. For example, they were asked: Did they experience that their reading ability had improved thanks to the interventions? How did they experience the framework: the intensity of the intervention and the length of the sessions? The degree of difficulty within each intervention was also elucidated.

Results, analyses and discussion

Starting from a pupil and teacher perspective, the results of this study elucidate the results found in Gustafson, et al. (2011) and Fälth, et al. (2013), where the combination group turned out to be the most effective with regard to the development of word decoding, phonological ability and reading comprehension. In the following, the main themes that emerged from the interviews will be highlighted and discussed.

The framework is important – but, within that, flexibility and individual adaptation are required

First of all, the teachers emphasize the importance of the solid framework of the intervention. The external structure the participants could relate to create a peaceful atmosphere:

"I think that for my pupils it was the form with its intensive structure which somehow made us actually bind ourselves to work at a certain fairly high speed that affected the result positively. The structure was not negotiable like."

The teachers felt that they were able to influence the contents of the intervention, because the lessons were not predetermined. They had certain given parameters to stay within, as concerned the number of sessions, the length of each lesson, as well as which of the computer-based programs to use. The choice of exercises within each program was their own, on the basis of the needs of the pupil they were to work with. This meant that some pupils worked through practically all the exercises included in their program, while others worked longer with fewer exercises. The teachers were very positive to being allowed to choose their own exercises on the basis of their knowledge about their pupil/s:

"For one of my pupils it was quite enough to use the first couple of modules in the program and stay there until he felt sure. It was crucial for this boy's self-esteem that we hadn't hurried and progressed too quickly, but that I had been able to consciously keep the degree of difficulty on a level that he felt he would manage. For my second pupil it was important, however, that I as a teacher made sure that the exercises offered some resistance so that she wouldn't become blasé and think it was too easy. I thus had to skip several of the first few stages in the program." (Teacher)

To feel at what stage the pupil was and adapt the exercises to offering the right amount of challenge all the time, in line with the zone of proximal development (Vygotsky, 1934/1962), was positively received by all the teachers. Some of them claimed that this very individual level adaptation was absolutely crucial for the pupils' continued learning.

According to Damber (2009), teacher observations during interventions provide valuable information on how to modify contents and structure. Teachers have to view their job as an interplay between themselves and their pupil, where both have to be active during the learning process (Gibbons, 2006). One teacher told us that she knew that her pupil had great phonological difficulties and that it was fortunate for this very pupil to be assigned the phonological program. Taking part in the study led to more individual "time on task", which also, according to the teacher, gave this pupil a more self-assured phonological ability after the intervention. These results are in line with findings from i.e. Johansson, 1992; Olson and Wise, 1992; Riis, 1991; Roth and Beck, 1987. The teacher also emphasizes that if she had not been able to adapt this pupil's exercises to the right level, she did not think the result would have been as good. A study by Reichenberg (2008) highlights the importance of teachers trying to bridge pupils' resistance to difficult texts, so that they do not get stuck on their own comfort level, but are instead, as the teacher above expresses it: "offered some resistance."

Asked whether it was primarily the form or the contents that had the greatest importance for pupils' success, all teachers responded that it was a combination of both, but if they had to rank the two, it would be the form, i.e. the intensity and duration of the intervention, that was the more important, rather than the contents. They argued that of course the contents were important, but that the very programs they worked with in this intervention study could be interchangeable with other types of reading training methods:

> *"Looking back, this intensive structure was positive for both my pupils. As a teacher I was forced to earmark these pupils' schedule for working with their computer programs. I also think that the computer-based training programs have been good for*

my pupils but I realize that there may be other similar contents that would also have worked." (Teacher)

Teachers expressed that the intensity of the arrangement this study represented had the result that they trained phonological skills and reading comprehension more intensively than they would if they had not participated in this study:

"I always use elements of this type of training but never during my 25 years as a teacher have I worked so intensively during such a relatively long period. If you add up the minutes this efficient training has become a big thing thanks to the structure of the arrangement." (Teacher)

When asking teachers how they could benefit from being involved in this intervention study in their future work, it revealed that they would reorganize their special education after participating in the study:

"The next term I will structure my special needs instruction in an entirely different way. I will organize it into shorter and more intensive periods with special needs instruction for each pupil and then let go of the pupil altogether for a time and evaluate if one more period will be needed later. Besides, each session must not necessarily last a whole hour. As it is today, it is the timetable modules that largely control the teaching arrangement and I'll try to change that. " (Teacher)

Teachers pointed out in the interviews that they were now going to reorganize their special needs instruction. They intend to plan to teach more intensively for a limited period and then

break off to evaluate the period that has passed. The interviews reveal that the teachers experience that both the systematics which Kjeldsen, Niemi, and Olofsson (2003) advocate and the intensity (Denton, et al., 2006) of special needs instruction have been made visible during the time of the intervention study. The idea of allowing pauses to prevent the special needs instruction from automatically proceeding with the same intensity for a whole term or school year has been an eye-opener for several teachers participating in this study. It emerged from Underwood's study (2000) that schools where the training sessions were 15-20 minutes long and took place three or more times a week achieved better reading results than schools with hour-long sessions once a week.

Variation within a strict framework maintains pupil motivation

Teachers with pupils who participated in different intervention groups described the training provided in the combined group as offering the best motivation for the pupils, as was also stated by the pupils in their interviews. Pupils whose intervention program contained a combination of phonological and reading comprehension training experienced the greatest satisfaction and the highest level of motivation:

> *"I used both computer programs, one program was more fun, I thought, but I know one classmate who was only allowed to use this particular program all the time and in the end he thought it was boring so I guess I was lucky to draw the ticket that said I should use both programs."* (Pupil)

Their combined-group teachers were highly satisfied with the form of the intervention and with feeling that their pupils were also pleased. Both teachers and pupils thought that the

variation the combined training provided made them feel motivated throughout the training period:

> *"To be allowed to use both training programs kept my pupil's spirit up, I think he would have lost heart long ago if it hadn't been for this variation. I guess there is a point in training the same thing for a long time to drill something into your head but for this boy and probably many with him it's a matter of keeping their motivation up to make it all work and then some variation is necessary I think. I am also willing to confess that my motivation, too, was positively affected by the variation offered to the combined group."* (Teacher)

Moreno (2006) argues that it is important to have a discussion with the pupil and explain why and how the different elements of training occur in order to increase the motivation for the training. In line with Moreno, several of the teachers stress the importance of informing the pupils and making it clear to them what the various exercises include and why. One of the training programs (Comphot) had a clear structure with headings of different levels introducing the exercises and what pupils should train in each particular exercise. Several teachers declared that this information was appreciated by the pupils.

The five teachers whose pupils had participated in both the combination group and one of the other groups are convinced that it is thanks to the variation that the motivation was kept up throughout the intervention. They admit that they were not as clearly aware of the importance of variation in teaching before and that this new insight has been useful for them even in other contexts:

"Especially for those pupils who really need this training I have become aware of the importance of varying the training; there seems as if a degree of saturation sets in when a pupil has to focus on something new so as not to lose focus and enthusiasm. To use two different approaches to reading training enabled me, too, to keep up my motivation as a teacher." (Teacher).

As motivation is an important factor for children learning to read (Gillon, 2004; Taube, 2007), the pupils stated that the variation involved in the combined training kept them from losing their motivation. However, the interview answers also point to the importance of variation for maintaining teacher motivation. Motivation functions as an engine of progress, which may make pupils keep the concentration and persistence needed for this type of interventions. The training must then be perceived as stimulating and meaningful, since being motivated is not enough unless the motivation leads to activity. This in turn may, for instance, in the long run improve reading ability (Baker & Wigfield, 1999).

Computer training systematics creates confidence and enables following the development

Knowing what is expected of me and feeling that the tasks are on a level just for me was what several pupils stated:

"I thought it was good that I knew right from the beginning exactly what I was supposed to do each time, that felt good. I worked really hard when I took part in the project but I never worked with too difficult things. The other thing that was good to know was that it was 25 times I had to train and I marked a cross in a square after

each class so that I could see how many times there were left. Just the way I do before Christmas Eve, a countdown like." (Pupil)

Working systematically and thus feeling familiar with the arrangement made it possible to get an overview of the pupils' progress. The importance of following one's own successful results in different ways was emphasized by the pupils:

"I thought the computer was useful because I could then compare the number of correct answers I had yesterday with how many I had today and I actually improved towards the end. The computer does it the same way every day and I like that." (Pupil)

"I know that when I did the exercise where you were supposed to remember a sequence of events the first time it didn't work out at all but when I did the same exercise again now at the end I got all questions right. I told my dad this." (Pupil)

The feeling that as a pupil you cannot exert much influence during the intervention was not looked upon as a limitation but as something that created confidence, which is in line with what Jenner (2004) and Dysthe (1996), for example, write about how pupils experience the expectations made on them. According to Jenner (2004), pupils who feel that the goals are possible to achieve also want to try and are thus given the chance to succeed and strengthen their belief in their own abilities. Being able, further, to watch one's own progress was a positive experience for all the pupils, which was facilitated, by the training programs being computer-based. The feeling among the pupils of working hard during the intervention period, even if several of them did not receive more special needs instruction than they used to, is in line with what is reported in a study by van Daal and Reitsma (2000), which showed

that computerized training contributed to providing *more time on task*. According to Riis (1991), computer support meant a better use of teaching time and, in addition, the pupils seemed satisfied with being drilled by computers. Even in this study both teachers and pupils testify that drilling by computers was not looked upon negatively:

> *"Some exercises I did an awful lot of times and in the end I hardly have to think about reading like even though it said "dinosaur", which is a super long word and this is how I have figured out what grownups and teachers do – they don't read like but just look ...smart."* (Pupil)

General discussion

The results of this study elucidate the quantitative results we found (Gustafson et al., 2011; Fälth et al., 2013), where a method for reading training entailing a combination of phonological training and reading comprehension training turned out to be the most effective in promoting pupils' reading development both in the short and the long run. This combined training was experienced as motivating by the pupils who trained with both programs and not as monotonous as what the pupils from the other two groups maintain. Several studies (e.g. Catts & Kahmi, 2005; Elbro, 2004; Snowling, 2000) report that pupils with reading and writing disabilities should train their phonological ability. This study has demonstrated that a combination of phonological and comprehension training was felt by both pupils and teachers to be the very best method for improving reading, which has also been confirmed by, e.g., Ehri et al. (2001) and Hatcher et al. (1994). The importance of flexibility within the intervention is a clear result of this study. In this context it includes both *variation* and *level adaptation*, but also flexibility insofar as it enables *individual adaptation* of the contents in

accordance with the needs of the pupils at the session in question. *Variation* here means that the contents are so varied that the motivation is kept up. However, it must be emphasized that this variation takes place within the given framework, since the consistent behaviour of the computer throughout the intervention is experienced as something positive. Despite the given external structure, the freedom still exercised by the teachers made the internal validity lower than it would have been if all the pupils had had exactly the same arrangement within the framework. The counterpoise to the internal validity problems is created by the added positive value, including the flexibility enabling us in the research team to draw advantage of every single special needs teacher's knowledge about the individual. Every participating pupil worked with tasks within the program that his or her special needs teacher had explicitly chosen for this particular pupil on this particular occasion. By *level adaptation* is meant that the contents are on such a level that the pupils are challenged where they are currently standing in their reading development, cf. Vygotsky's (1962) zone of proximal development. To be able to *individually adapt* the contents to the needs of the pupil does not necessarily mean that the whole set-up of the intervention must be gone through with each pupil. For some pupils it is enough to dive into essentials and revise some exercises instead. Other pupils may require another matching of the contents with more exercises within a certain area but skipping certain exercises that are too difficult or too easy at this particular stage. This serves to maintain motivation and to make every individual feel that the work leads to improvement. To find the optimal choice for each individual on each occasion is a challenge. A good knowledge of the pupil's strengths and weaknesses underpins that the pedagogical measures will be successful. This is of course equally important in everyday practice as in intervention studies.

Limitations

The number of participants in this study is limited. Out of the 130 participants in the main study, 25 participated in this study, which means that the results should be interpreted with some caution. In the current study all the pupils are between 8 and 9 years old and have been selected because they are pupils in need of special support in Swedish. For this reason it is impossible to make general statements about 8-9-year-olds or to generalize these results to younger or older pupils. Two specific computer-based training programs have been used in the study, and we do not make any claims about other than these.

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References

Baker, L., & Wigfield, A. (1999). Dimensions of children's motivation for reading and their relations to reading activity and reading achievement. *Reading Research Quarterly, 34,* 452-477.

Bus, A. G., & van IJzendoorn, M. H. (1999). Phonological awareness and early reading: A meta-analysis of experimental training studies. *Journal of Educational Psychology, 91*, 403- 414.

Catts, H., & Kamhi, A. (Eds.). (2005). *Language and Reading Disabilities*. 2. ed. Boston, Mass. Pearson Education Inc.

van Daal, V.H.P., & Reitsma, P. (2000). Computer-assisted learning to read and spell: Result from two pilot studies. *Journal of Research in Reading, 23*, 181-193.

Damber, U. (2009). Using inclusion, high demands and high expectations to resist the deficit syndrome: A study of eight grade three classes overachieving in reading. *Literacy, 43*, 43-49.

Denton, C. A., Fletcher, J. M., Anthony, J. L., & Francis, D. J. (2006). An evaluation of intensive intervention for students with persistent reading difficulties. *Journal of Learning Disabilities*, *39*, 447–466.

Dysthe, O. (1996). *Det flerstämmiga klassrummet*. Lund: Studentlitteratur.

Ehri, L. C., Nunes, S. R., Willows, D. M., Valeska Schuster, B., Yaghoub-Zadeh, Z., & Shanahan, T. (2001). Phonemic awareness instruction helps children learn to read: Evidence from the National Reading Panel's meta-analysis. *Reading Research Quarterly, 36*, 250–287.

Elbro, C. (2004*). Läsning och läsundervisning*. 1. Ed. Stockholm: Liber Forssell.

Elbro, C., & Petersen, D. K. (2004). Long term effects of phoneme awareness and letter sound training: An intervention study with children at risk for dyslexia. *Journal of Educational Psychology, 96*, 660–670.

Ferreira, J., Gustafson, S., & Rönnberg, J. (2003). *COMPHOT: Computerized Phonological Training*. Linköping, Sweden: Department of Behavioural Sciences and Learning/Swedish Institute for Disability Research, Linköping University, Sweden.

Folkesson, A-M., & Swalander, L. (2007). Self-regulated learning through writing on computers: consequences for reading comprehension. *Computers in Human Behavior 23*(5), pp. 2488-2508.

Fälth, L, Gustafson, S., Tjus, T. Heimann, M., & Svensson, I. (2013). Computer- assisted interventions targeting reading skills of children with reading disabilities – A longitudinal study. *Dyslexia*, *19*, 37-53.

Gibbons, P. (2006). *Bridging Discourses in the ESL Classroom. Students, Teachers and Researchers.* London: Continuum.

Gillon, G. (2004). *Phonological awareness: From research to practice*. The Guilford Press. New York.

Gustafson, S., Fälth, L., Svensson, I., Tjus, T., & Heimann, M. (2011). Effects of Three Interventions on the reading skills of children with reading disabilities in grade 2. *Journal of Learning Disabilities, 44*, 123-135.

Hatcher, P., Hulme, C., & Ellis, A. W. (1994). Ameliorating reading failure by integrating the teaching of reading and phonological skills: The phonological linkage hypothesis. *Child Development, 65*, 41–57.

Hatcher, P. J., Hulme, C., Miles, J. N. V., Carroll, J. M., Hatcher, J., Gibbs, S., et al. (2006). Efficacy of small group reading intervention for beginning readers with reading-delay: A randomized controlled trial. *Journal of Child Psychology & Psychiatry* (47).

Hayes, N. (2000). *Doing psychological research*. Taylor & Francis Group.

Heimann, M., Lundälv, M., Tjus, T., & Nelson, K. (2004). *Omega–Interactive Sentences, a Multimedia Software for Language Exploration and Play*. Göteborg, Sweden: Topic Data & Språkbehandling HB.

Hintikka, S. Landerl, K., Aro, W., & Lyytinen, H. (2008). Training reading fluency: Is it important to practice reading aloud and is generalization possible? *Annals of Dyslexia*, *54*, 59-79.

Jiménez, J. E., Hernández-Valle, M., Ramirez, G., del Rossario Ortiz, M., Rodrigo, M., Estévez, A., et al. (2007). Computer speech-based remediation for reading disabilities: The size of spelling-to-sound unit in a transparent orthography. *Spanish Journal of Psychology, 10*, 52–67.

Jenner, H. (2004). *Motivation och motivationsarbete i skola och behandling.* Myndigheten för skolutveckling. Stockholm: Liber.

Johansson, M-G. (1992). Synpunkter och erfarenheter av datorstöd i läs och skriv. *Nordisk Tidsskrift, for Spesialpedagogikk, 2*, 108-113.

Kjeldsen, A-C., Niemi, P., & Olofsson, Å. (2003). *Training Phonological Awareness in Kindergarten Level Children: Consistency is More Important than Quantity*. Åbo: Department of Special Education.

Magnan, A., & Ecalle, J. (2006). Audiovisual training in children with reading disabilities. *Computers & Education, 46,* 407–425.

Moreno, R. (2006). Learning in high-tech and multimedia environments. *Current Directions in Psychological Science, 15*, 63–67.

Morgan, P. L., & Fuchs, D. (2007). Is There a Bidirectional Relationship between Children's Reading Skills and Reading Motivation?. *Exceptional Children*, *73*(2), 165.

Morris, R., Lovett, M., Wolf, M., Sevcik, R., Steinbach, K., Frijters, J., & Sharpio, M. (2012). Multiple-component remediation for developmental reading disabilities: IQ, socioeconomic status and race as factors in remedial outcome. *Journal of Learning Disabilities, 45*: 99.

Nicolson, R., Fawcett, A., & Nicolson, M. (2000). Evaluation of a computer-based reading intervention in infant and junior schools. *Journal of Research in Reading, 23,* 194–209.

Olson, R., & Wise, B. (1992). Reading on the computer with orthographic and speech feedback. *Reading and Writing: An Interdisciplinary Journal, 4,* 107-144.

Regtvoort, A. G. F. M., & van der Leij, A. (2007). Early intervention with children of dyslexic parents: Effects of computer-based reading instruction at home on literacy acquisition. *Learning and Individual Differences*, *17*, 35–53.

Reichenberg, M. (2008) "But before you said you believed that…" A longitudinal study of text talks in small groups. *The Reading Matrix. Vol. 8, No1*, pp. 158-185.

Riis, U. (1991). *Skolan och datorn. Satsningen datorn som pedagogiskt hjälpmedel 1988-1991*. Linköpings universitet, Tema T Rapport 24.

Roth, S.F., & Beck, I.L. (1987). Theoretical and instructional implications of the assessment of two microcomputer word recognition programs. *Reading Research, 12*, 197-218.

Snowling, M. (2000*). Dyslexia.* Oxford: Blackwell Publishers Ltd.

Sutherland, R., Armstrong, V., Barnes, S., Brawn, R., Breeze, N., & Gall, M. (2004). Transforming teaching and learning: Embedding ICT into everyday classroom practices. *Journal of Computer Assisted Learning*. *20(6),* pp. 413-425.

Taube, K. (2007). *Läsinlärning och självförtroende. Psykologiska teorier, empiriska undersökningar och pedagogiska konsekvenser.* 4. Ed. Stockholm: Nordstedts Akademiska förlag.

Torgesen, J. K., Alexander, A. W., Wagner, R. K., Rashotte, C. A., Voeller, K. K. S., & Conway, T. (2001). Intensive remedial instruction for children with severe reading disabilities: Immediate and long-term outcomes from two instructional approaches. *Journal of Learning Disabilities, 34*, 33–58.

Torgesen, J. K., Wagner, R. K., Rashotte, C. A., Herron, J., & Lindamood, P. (2010). Computer-assisted instruction to prevent early reading difficulties in students at risk for dyslexia: Outcomes from two instructional approaches. *Annals of Dyslexia*, *60(1),* 40-56.

Torgesen, J. K. (2005). Recent discoveries on remedial interventions for children with dyslexia. In M. J. Snowling & C. Hulme (Eds.). *The Science of Reading: A Handbook* (pp. 521–537). Oxford, UK: Blackwell.

Underwood, J.D.M. (2000). A comparison of two types of computer support for reading development. *Journal of Research in Reading, 23*, 136-148.

Vygotsky, L. S. (1962). *Thought and Language*. Cambridge, MA: MIT Press. (Original work published in 1934).

Wang, J. H., & Guthrie, J. T. (2004). Modeling the effects of intrinsic motivation, extrinsic motivation, amount of reading, and past reading achievement on text comprehension between U.S. and Chinese students. *Reading Research Quarterly*, 39(2), 162-186.

Wise, B., Ring, J., & Olson, R. (2000). Individual differences in gains from computer-assisted remedial reading with more emphasis on phonological analysis or accurate reading in context. *Journal of Experimental Child Psychology 77*, 197-235.

Wolff, U. (2011). Effects of a randomised reading intervention study: An application of structural equation modelling. *Dyslexia, 17*: 295-311.

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