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The Relationships Between Short-Term Memory, Word Decoding Skills and Language Competencies in Norwegian Fourth-Graders

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Foreword

This master's thesis is based on results from "The 10-year-old school project", which was run in spring 2011. The project was granted by The Faculty of Humanities (NTNU) with 100 000 NOK (H06212). It was lead by Prof. Mila Vulchanova (NTNU, Dep. of Modern Foreign Languages), Prof. Hermundur Sigmundsson (NTNU, Dep. of Psychology) and Ass. Prof. Randi Alice Nilsen (NTNU, Dep. of Scandinavian Studies and Comparative Literature). I was part of the project from the beginning, and was an active part in the planning. I helped with adapting the Test of Language Development – Intermediate (Hammill & Newcomer, 2008) from English to Norwegian, by proofreading it and suggesting changes. I also conducted the tests, together with two other students. The tests included a rapid automatized naming test, a motor competence test and two English tests, in addition to the Norwegian language development test, the word decoding test and the short-term memory test used in my thesis. When the testing was finished, I plotted most of the data in SPSS.

I would like to thank my supervisors, Prof. Hermundur Sigmundsson and Prof. Mila Vulchanova, for excellent help during my writing of this thesis. My main supervisor, Hermundur, has kept me focused on the right things, and has given me clear and good suggestions for improvement throughout the whole writing process. My co-supervisor, Mila, has constantly updated me on relevant findings in the linguistic field, as well as given me valuable writing advice. They have both been enthusiastic and supportive, and I have become more aware of what psychology on one side and linguistics on the other side has to offer when it comes to research on language and reading development.

I want to thank Ass. Prof. Randi Alice Nilsen, as well as Mila and Hermundur, for letting me be a part of the research project. I enjoyed it a lot, since I am especially interested in language development. I also learned very much from it.

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Abstract

84 Norwegian 9-10 year old children were tested in word decoding skills, short-term memory and language competence (semantics and grammar). Previous studies show mostly strong relationships between each of the skills, and among the language competencies. The aim was to discover if this also could be found in Norwegian children. The results indicated that language competence is related to word decoding skills and short-term memory, in support of previous studies. However, only a weak relation was found between word decoding skills and short-term memory, in spite of previous research findings of an association between short-term memory and reading skills. This suggests that short-term memory is less important for decoding skills than for other aspects of reading. In addition, morphological awareness showed weak connections to discourse oriented syntactic skills and to word decoding skills, but this may be due to the nature of the tasks.

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Introduction

Children face a variety of challenges when they grow up, especially at school where they are expected to acquire knowledge in several different areas. Skills in language competence, reading and memory are essential if the child is to process written and spoken knowledge, store it for later use, and manipulate it in different ways. In the current study, 84 Norwegian 9-10-year-olds participated in the research project "The 10-year-old school project". It was lead by Prof. Mila Vulchanova (NTNU), Prof. Hermundur Sigmundsson (NTNU) and Ass. Prof. Randi Alice Nilsen (NTNU). The participating children were tested in language development, word decoding skills and short-term memory. Word decoding skills are especially important in early reading acquisition (Juel, Griffith, & Goug, 1986; Tunmer, 1989, p. 120), short-term memory is passive, but still crucial in many areas (Gathercole & Alloway, in press), and development of grammar and vocabulary is vital for school children.

What is the relationship between these skills? Are they closely related? Can they build on each other? Is it possible to develop one skill more than the other skills? The fact that Norwegian children score low in reading skills among the OECD countries (Roe & Solheim, 2007), underpins the importance of investigating cognitive skills. The following section will show the background for the study, by first presenting each skill, and then presenting what former research says about the relationship between short-term memory and language development, between short-term memory and word decoding skills, and between language development and word decoding skills.

Memory

A model by Atkinson and Shiffrin (1968) assumes that information flows through three different stages before it gets stored in memory. The information first enters the *sensory memory*, which can hold large amounts of data for one or two seconds. Information that gets selected for further processing moves on to what Atkinson and Shiffrin call *short-term memory* (STM). It holds a limited amount of unrelated items for up to 15-30 seconds. If more items are added here, previous items are lost. The final destination is *long-term memory* (LTM), which can hold apparently unlimited amount of information for an unlimited amount of time (Atkinson & Shiffrin, 1968, Chapter 2). Long-term memories are semantic (e.g. words), episodic (e.g. what you ate for breakfast) or procedural (e.g. how to ride a bike) (Tulving, 1985). All the words a speaker knows are stored in LTM, in the so-called *mental lexicon*. A word is a stored association of phonological, syntactic, and semantic structures (Jackendoff, 2002, pp. 27-29).

Short-Term Memory vs. Working Memory.

Baddeley and Hitch (1974) found limitations in the Atkinson-Shiffrin model, especially concerning the STM/LTM distinction. They suggested that *working memory* (WM) could be added to the model, in the place of what Atkinson and Shiffrin called STM. The reason for this was that parts of WM are active in tasks such as learning, comprehension and reasoning, and retrieve information both from the outside world and from LTM. Thus, WM can do more than just store information; it can also manipulate it. Other parts of WM are more passive, as they hold information that then is transferred into the LTM. These parts thus do the job that Atkinson and Shiffrin suggested for STM in their model (Baddeley, 2003).

No consensus exists among researchers about the WM system. The current study will use Baddeley and Hitch's model (1974; Baddeley, 2000), as a basis. According to this model, WM consists of four components: The first one is *the central executive* (CE), which controls the attention and regulation of information flow within WM, and between LTM systems and WM. The two next components are *the phonological loop* (PL) and *the visuo-spatial sketchpad* (VSS). STM accesses these systems, which are slave systems of CE. PL offers temporary storage for verbal information, which can be stored for longer by a process of subvocal rehearsal. VSS provides limited storage for visual and spatial representations. The final WM component is *the episodic buffer* (EB). It integrates representations from the components of WM and from LTM in a multi-dimensional code (Gathercole & Alloway, in press, pp. 19-20).

The distinction between STM and WM is underscored by studies. For example, Gathercole, Tiffany, Briscoe, Thorn and ALSPAC (2005) found that children with poor verbal STM got average scores on tasks measuring WM. Further support comes from the finding that children with specific reading difficulties typically get lower scores on measures of WM than of verbal STM (Gathercole, Alloway, Willis, & Adams, 2006).

The capacities of WM and STM have to be measured by different kinds of tasks. In the backward digit recall task, a participant is presented with a sequence of digits and told to recall them in reverse sequence (Morra, 1994). This task measures WM capacity, because it places significant demands on both processing and storage. In contrast, the forward digit recall task involves significant storage but only minimal processing, and thus measures STM. In other words, STM tasks access only the specialized storage components of the WM system whereas performance on complex span tasks additionally requires central executive involvement (Gathercole & Alloway, in press, pp. 19-20).

Language Development

Children acquire languages in a unique way that is impossible for adults. According to some, it happens in the so-called critical or sensitive period that ends around puberty (Hurford, 1991). Some language learners are faster than others, but regardless of speed, most people acquire a rich vocabulary and can utter an infinite amount of sentences that follow subconscious grammatical rules. Language input from parents and other people plays a big role in language acquisition. Findings by Aukrust (2007) suggest that both quantity and quality of input are important when acquiring a language. In her study on Turkish-speaking children learning Norwegian, the results showed that a rich language environment in pre-school leads to a larger vocabulary in the following years. First-grade receptive vocabulary and word definition skills seemed to depend on amount, diversity and discourse complexity of teacher talk (Aukrust, 2007). Studies on child-directed speech showed that caretakers who provide rich and diverse input stimulate a larger and more sophisticated vocabulary in their children (Hoff-Ginsberg, 1991; Weizman & Snow, 2001).

Traditionally, language has been subdivided into phonology, grammar and semantics (Lyons, 1968, p. 54). Now, the new lexicalist perspective suggests that grammar and vocabulary are inseparable (Bates & Goodman, 1997). Evidence from research shows that developing grammar is dependent upon vocabulary size (e.g., Bates, Bretherton, & Snyder, 1988), and that grammar and vocabulary do not dissociate in early talkers and children with focal brain injury (e.g., Marchman, Miller, & Bates, 1991, review: Bates & Goodman, 1997). In the language test battery used in the current study, language competence is divided into semantics, grammar, phonology and pragmatics, but it only assesses phonology indirectly, and does not assess pragmatics (Hammill & Newcomer, 2008, pp. 2-6). This study will therefore mainly look at semantics and grammar. Vocabulary will be treated as an aspect of semantics, and syntax and morphology will be treated as aspects of grammar.

Morphology refers to the internal morpheme structure of words, with for example prefixes and affixes, whereas syntax refers to the internal constituent structure of sentences (Lyons, 1968, p. 133). To have morphological awareness is to be aware of and have access to what morphemes are in relation to words. It seems to be a good predictor of vocabulary knowledge (McBride-Chang, Wagner, Muse, Chow, Shu, 2005). As for syntax, findings suggest an association with vocabulary learning through syntactic bootstrapping, which entails that grammatical knowledge provides important cues for semantic learning. A study by Dionne, Dale, Boivin and Plomin (2003) supported this, and indicated as well that vocabulary and grammar share the same genetic influences, consistent with the lexicalist approach. Even though language can be divided into sub-levels of analysis (e.g. morphology, syntax and vocabulary) there are interfaces across all of these levels. However, when conducting tests, it is important exactly what area of competence is being tested.

Theories on Language Development.

There is a range of different theories on language development, from Chomsky's (1986) structural approach, to the usage-based theories by Tomasello (2000).

According to Chomsky's (1986) theory of Universal Grammar (UG), all humans are born with innate grammatical knowledge (p. 3). Allegedly, language input in itself is not enough for language to develop (Chomsky, 1986, pp. 7-9), but merely something that triggers an innate language device (Chomsky, 1986, p. 3). Grammar belongs to a part of the so-called language faculty in the brain, named the narrow language faculty. The language faculty excludes for instance memory, because it is necessary but insufficient for language (Hauser, Chomsky, & Fitch, 2002). Language input adjusts innate principles and parameters, so that the child's grammar competence approaches the rules of the target language in the long run (Chomsky, 1986, p. 221). However, the UG cannot explain everything about language development and language competence. For example, Chomsky claims that phonological and semantic language structure arises from syntactic structure, but later studies show that they instead are the products of autonomous generative phonological and semantic components (Jackendoff, 2002).

On the other hand, Tomasello (2000) advocates a view in which children's speech is not composed of abstract categories and rules, but where specific words and specific utterance patterns are the building blocks. Language input may after all be enough for language development to take place, without the need for Chomsky's innate language device. In fact, grammar competence arises and is constructed in the process of language acquisition. According to Tomasello, both naturalistic observation and systematic experimentation support this view. Not only what children do, but also what they do *not* do with particular words and phrases, make it clear that children's linguistic competence is much more concrete and item-based than adults' competence (Tomasello, 2000).

Word Decoding Skills

According to 'The simple view of reading' (Gough & Tunmer, 1986), reading has two main components: *Word decoding* and *listening comprehension*. Decoding is a technical skill that normally works automatically. One who masters decoding can "read isolated word quickly, accurately and silently" (Gough & Tunmer, 1986, p. 7), and can read nonwords. Listening comprehension requires processing at higher cognitive levels. This involves interpreting sentences and discourses from lexical information (i.e., words) (Gough & Tunmer, 1986). Children are supposed to relate text to their own experiences, make their own interpretations, draw conclusions, et cetera. They need both reading components to develop good reading skills. If one is missing, the competence will decrease (Høien & Tønnesen, 1997). Most children develop both skills. Still, some children with Autism Spectrum Disorder show a large discrepancy between these two components. They are called hyperlexic because they are outstanding at word reading, which heavily depends on decoding, but at the same time they often display poor text comprehension (Saldaña, Carreiras, & Frith, 2009). There are also children who show competence in listening comprehension, but not decoding, and they are considered dyslexics. Finally, some children display both poor listening comprehension and poor decoding skills, and are said to have garden-variety reading disability (Gough & Tunmer, 1986).

Longitudinal studies of children in first and second grade suggest that decoding skills are more important than listening comprehension skills for beginning readers. Listening comprehension skills become important at a later stage, when children have begun to master basic decoding skills (Juel et al., 1986; Tunmer, 1989, p. 120).

How do children learn to derive sound and meaning from a written word? According to a developmental framework by Frith (1986), three strategies can be used: *The logographic*, *the alphabetic* and *the orthographic*. When a child reads her first words, she uses the logographic strategy. With this strategy, the child may recognize the string of letters "lego" as the word *lego* because of the first letter "L" or the familiar red box surrounding the letters. At this stage, the child associates salient graphic (visual) features with words, and the order of the letters is irrelevant. This strategy is then accompanied by the alphabetic strategy, where both letter sound and letter order is important. Here, the child reads one letter at a time, and puts together the sounds so that they form a word. The word *cat* can be read "kuh-a-tuh", and this reminds the child of how the word actually sounds. After a while, the orthographic strategy is built on top of the other strategies. At this stage, letter order is important, and morpheme sound and word sound is more relevant than the letter sound. This is because the whole word sound or large parts of it is read off instantly from the written word. In the word *signatures* the child may recognize the morphemes "sign" and "ture", and plural "s", and thus know the word. The orthographic strategy and the logographic strategy have in common that they develop from reading practice, whereas for the alphabetic strategy, writing is the pacemaker, according to Frith. She further claims that the points where an old strategy must be synthesized with a new one are vulnerable. They can be breakthroughs or breakdowns. Children who do not succeed in acquiring the new strategy may develop the old one or try to compensate in other ways. Later breakdowns give milder disorders than early breakdowns (Frith, 1986).

Later studies suggest that *phonemic awareness* (to identify and/or manipulate each of the phonemes that constitute a word) and letter knowledge skills should be a priority in schools, since these factors appear to be the most important ones for reading success (Caravolas et al., 2012; Lervåg, Bråten, & Hulme, 2009; Muter, Hulme, Snowling, & Stevenson, 2004; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004; Sprugevica & Høien, 2003). Teaching just one skill, instead of many skills at the same time, diminishes gender differences in reading skills (Johnston & Watson, 1998; review: Macmillan, 2004). This skill should be letter-sound correspondences, as in the so-called phonics teaching method, to break children away from the logographic whole-word strategy they are prone to begin with (Macmillan, 1997, p. 28). Furthermore, they should be taught letter-to-sound knowledge instead of sound-to-letter knowledge (Macmillan, 1997, p. 92). Boys and girls perform this transition equally well, because it begins with right-hemisphere processing, which is easier for boys than left-hemisphere processing is (McGuinness & Courtney, 1983; Pugh et al., 1996). In Norway, girls perform better than boys in reading (Roe & Solheim, 2007; UNESCO & OECD, 2003), probably due to a mixed-method approach in Norwegian schools.

The compensatory-encoding theory (Walczyk, Wei, Zha, & Griffith-Ross, 2006) postulates that increasingly advanced reading skills help to maintain automatic processes. It also says that when automatic processes fail, advancing skills helps to compensate by providing timely and accurate data to working memory by pausing, looking back and rereading. Walczyk et al. (2007) tested third graders, fifth graders and seventh graders on different reading tasks, to investigate whether the theory was right. They found that, in general, verbally inefficient readers compensated most. However, verbally inefficient seventh graders with poor comprehension did rarely compensate. Overall, verbally efficient readers compensated infrequently, whereas inefficient readers compensated frequently. In addition, older readers compensated most efficiently. This shows that the pathways to good comprehension can be diverse (Walczyk et al., 2007).

How are words processed when they are read? Researchers disagree about this. One approach is that words are processed in one single route. Another approach is the dual-route processing, which holds that when a person reads a word that exists in the mental lexicon, she accesses the word's lexical entry and gets the word's pronunciation from there. When a new word that is not in the mental lexicon is read, a non-lexical route is taken, which uses rules about the letter-sound-relationship and retrieves the correct pronunciation that way (but not for "irregular" words that do not follow the rules, like *pint*) (Coltheart, Curtis, Atkins, & Haller, 1993). However, no proof of a dual-route was found when young Norwegian readers were tested. This may be because the Norwegian language has a more shallow orthography than the English language (Lervåg & Bråten, 2002).

Reading Acquisition in Norwegian.

How is reading acquisition in Norwegian different from the reading acquisition in other languages? The Norwegian language has complex syllabic structure properties, with for example complex consonant clusters in both onset and coda position of words (e.g. *sendt*, *skje*). At the same time, it has shallow orthography, with an almost consistent 1:1 mapping between letters and sounds (e.g. *vaske* (pronounced [ʋaskə]), *bråke* (pronounced [bro:kə]) (Seymour, Aro, & Erskine, 2003). However, exceptions are quite common (e.g. *jeg* (pronounced [jæi]), *de* (pronounced [di:])). According to Seymour et al. (2003), syllabic complexity selectively affects decoding, whereas orthographic depth affects word reading and nonword reading. Acquisition of shallow orthographies, like Norwegian, needs only an alphabetic foundation, whereas acquisition of deep orthographies requires that children form both an alphabetic and a logographic foundation (Seymour et al., 2003). Thus, studies involving Norwegian children may yield different results from studies of children speaking a language with a deep orthography, like English. For example, the speed of acquisition of decoding skills may be slower when the orthography is deep (Seymour & Evans, 1999).

Relationships Between the Factors

Short-Term Memory and Language Development.

The PL is accessed by the verbal STM, and is as such an STM system (Gathercole & Alloway, in press, p. 19). It has been found to support language learning, including both first and second language (Masoura & Gathercole, 1999). One way to tap only PL is by using nonword-repetition tasks, as they provide a relatively pure measure of its capacity, and the size of the acquired vocabulary (Baddeley, Gathercole, & Papagno, 1998). Another way is to use the before-mentioned forward digit span, which is less complex than nonword-repetition, and gives a clearer measure of PL (Gathercole & Alloway, in press, pp. 19-20).

Short-Term Memory and Semantics.

Gathercole, Hitch, Service and Martin (1997) used experimental word learning tasks to tap the cognitive components in vocabulary acquisition in 5-year olds. Their findings indicated that the learning of new words is mediated by both the PL and long-term knowledge of the native language, such as the sound patterns of familiar words. They also found that a larger PL capacity makes it easier for children to learn new words, but that the learning of associate pairs of familiar words is quite independent of the PL function.

Baddeley and his colleagues' (1998) review of different studies showed direct links between PL function and word learning, and suggested that the primary purpose of PL is to store unfamiliar sound patterns. However, a Norwegian longitudinal study on children from 4 to 7 years old showed no influence from nonword-repetition ability on later vocabulary knowledge. The researchers speculated that non-word repetition ability is a consequence of vocabulary knowledge instead of a cause (Melby-Lervåg et al., 2012). Nevertheless, a review by Gathercole, Willis, Emslie and Baddeley (1992) stated that the relationship between phonological memory skills and vocabulary development is strong, but complex. For children from 4 to 5 years old, phonological memory influences vocabulary development more than vice versa, whereas for 5 to 8 year old children, vocabulary knowledge seems to have more influence on further vocabulary development than does phonological memory.

For the acquisition of language on the whole, the WM function associated with the central executive has a greater impact than PL. As mentioned earlier, this was the result when children were tested repeatedly on measures of WM, phonological awareness, vocabulary, language, reading and number skills (Gathercole et al., 2005).

In vocabulary development, it may be increasingly important to acquire the meaning of new concepts. Since abstract words are harder to understand than words referring to physical objects, they are acquired later in vocabulary development. The ease of acquiring abstract words may depend on the semantic skills of each child, and as their semantic skills get better, their phonological memory gets less important (Gathercole et al., 1992).

Short-Term Memory and Grammar.

A study on an patient with impaired STM suggested that the rehearsal component of the PL is involved in replaying syntactically complex sentences, and thus makes such sentences easier to comprehend (Papagno, Cecchetto, Reati, & Bello, 2007). Further support for an association between STM and syntax comes from Majerus and Lorent (2009), whose findings suggested that the capacities of *phonological STM* (which stores speech sounds) are active in phonological analysis during sentence processing. It also seems like the PL may mediate syntactic learning (Baddeley et al., 1998). This is supported by studies showing that 3- and 4-year-old children with good phonological STM have a larger vocabulary, and produce longer utterances and a greater range of syntactic constructions than children with poor phonological STM (Adams & Gathercole, 1995; Adams & Gathercole, 2000).

Short-Term Memory and Word Decoding Skills.

Measures of children in kindergarten showed that their reading skills are predicted mainly by *phonological awareness* (explained in the next section), because it is important when children learn about letter-sound correspondence. However, for children at the end of first grade, *phonological memory* appears to be the main predictor. Phonological memory consists of STM, long-term phonological knowledge and memory for serial order, and seems to be important when children shall gather the phonemes to identify words, because this requires a larger storage capacity (Nithart et al., 2011; Wagner and Torgesen, 1987). Nation (1999) suggests that verbal STM is important for word recognition skills, which is defined as the ability to pronounce single words presented out of context. She found that a good STM is present in language-impaired hyperlexic children (who are superior in word recognition), but not in language-impaired children without hyperlexia.

Phonological STM may be important for children's acquisition of the letter-sound correspondences that allow them to decode novel words, according to Brunswick, Neil Martin and Rippon (2012). They used the digit span test in a longitudinal study, and found that it correlated with reading skills. Still, other studies show low correlations between STM and decoding skills (Caravolas et al., 2012; Lervåg et al., 2009; Sprugevica & Høien, 2004).

Word Decoding Skills and Language Development.

For a long time, poor reading skills were believed to be caused mainly by a deficit in visual perception. Now, it appears that both language and vision play their parts. Poor sensitivity to orthographic structure is caused by lack of dynamic visual sensitivity, whereas phonological skills are affected by auditory sensitivity, according to Talcott and Witton (2002). As mentioned earlier, many languages have nearly a 1:1 mapping between letters and sounds (Seymour et al., 2003), and phonological awareness has been found to be important for a positive reading development (Goswami, 2008; Wagner & Torgesen, 1987). Phonological awareness is considered a part of language competence, and can be described as the ability to detect and manipulate the sounds that different words consist of. This is harder in languages with complex syllabic structure than in those with simple syllabic structure. Therefore, phonological awareness develops at different paces for children with different mother tongues (Goswami, 2008) Studies also show that individual differences in phonological awareness predict individual reading development (Ho & Bryant, 1997; Høien, Lundberg, Stanovich, & Bjaalid, 1995; Wimmer, Landerl, & Schneider, 1994). In addition, phonological impairment seems to be a common underlying factor in people with speech sound disorder, language impairment and reading disability (Pennington & Bishop, 2009).

Word Decoding Skills and Semantics.

A longitudinal study showed that phoneme sensitivity and letter knowledge are important for early word decoding skills, whereas vocabulary knowledge, together with prior word decoding and grammatical skills, influence reading comprehension (Muter et al., 2004). Garlock, Walley and Metsala (2001) found that vocabulary growth and its associated changes in speech processing contribute to phonological awareness and early reading skills. It can also go the other way around: Children with word comprehension problems miss contextual information when they read, and their reading experiences thus lead to less improvements in vocabulary than good comprehenders achieve (Nation & Snowling, 1998).

In a review, Nation (2005) reported that both dyslexic children (i.e. poor decoders) and children with poor reading comprehension had difficulties with picture naming tasks. For example, dyslexic children managed tasks where they had to match picture with word, but struggled in tasks where they had to name a picture correctly (Snowling, Goulandris, Bowlby & Howell, 1986). This suggested impairments at the level of phonological representations (Nation, 2005). Poor comprehenders, on the other hand, seemed to have problems with picture naming because of poor word knowledge as well as ineffective and inaccurate at accessing and retrieving the meaning of words (Nation, 2005).

All of these findings imply that semantics is more important for comprehension than for decoding, which seems logical. Nonetheless, according to the connectionist model, semantics links orthography and phonology together. One normally generates the pronunciation of a letter string directly from orthography to phonology. However, in a study by Howard and Best (1996), a brain injury patient with a disabled pathway between orthography and phonology managed to pronounce familiar words with computation from orthography via semantics to phonology. This was not possible with nonwords, because they are not represented in semantics (Harm & Seidenberg, 1999). This finding shows that semantics can be important for the decoding of familiar words. All of this is task-dependent.

Word Decoding Skills and Grammar.

Bentin, Deutsch and Liberman (1989) tested children in syntactic competence and reading ability (including word decoding). They found that severely disabled readers had problems with correcting syntactic errors as well as judging if sentences were correct. Poor readers only had problems with correcting syntactic errors. Both findings suggest a relationship between syntactic impairment and reading skills. Willows and Ryan (1986) give this further support with their finding that grammatical sensitivity is related to word decoding skills and other reading skills. However, they were unsure about the direction of the causality, and whether the factors are influenced by a common underlying factor. Further doubt comes from Bowey's

(2005) findings from a longitudinal study. They indicated that grammatical awareness has no substantial influence on the reading skills of beginning readers, as opposed to phonological awareness and nonword-repetition, which were found to predict reading skills.

Even though syntactic skills and word decoding skills seem to be related, a strong relationship between morphological skills and word decoding skills is more doubtful. Casalis and Louis-Alexandre (2000) found a relation between the two, but it was weaker than the one between morphological skills and word comprehension. Fowler (1988) discovered an association between word decoding and correction of morphological errors, but no relation between word decoding and judgment of morphological errors. The reason for this may have been that the correction task required more meta-linguistic knowledge and more use of short-term memory than the judgment task, according to Fowler.

The Aims of the Current Study

In the current study, 84 Norwegian fourth-graders were tested in word decoding skills, STM and language competence (including semantics and grammar).

As evident in the presented research findings, many connections between language development, STM and word decoding skills have been found. Some are quite vague, like the relationships word decoding skills have with STM and with morphology, but parts of the research have still found a strong connection (e.g. Brunswick et al., 2012). More research is nevertheless needed to assess the cognitive development of Norwegian children, and to establish the role of the mentioned factors.

Therefore, on the basis of previous findings, the main hypothesis for the current experiment is as follows:

We expect to find high correlations between language competencies (including the specific competencies semantics and grammar) in the native language (Norwegian) and word decoding skills, between the language competencies and short-term memory, and between word decoding skills and short-term memory in the group of fourth-graders attending the study, as well as high internal correlation among the language competencies (semantics and grammar).

Method

Participants

A group of 87 Norwegian children were asked to participate in the study, and 84 of them got permission from their parents. They attended fourth grade at two different primary schools; one located in the countryside (14 children) and one located in the city (70 children). The children's mean age was 9.8 (SD=0.29), and the overall range was 9.3 to 10.3 years. 44 girls and 40 boys participated. The girls' mean age was 9.8 (SD=0.29), and the boys' mean age was 9.8 (SD=0.29). All children had Norwegian as their first language. A few of the children had dyslexia and/or AD/HD. They were still included in the participant group, because these conditions are quite common in the population, and this study aims to assess a regular group of children, in order to provide conclusions that can make future child education better.

9-10 year olds were chosen as participants because studies on rapid automatized naming indicate that the differences between children with and without learning difficulties are largest in this age group (Denckla & Rudel, 1976). Afterwards, the gaps begin to close. In addition, 9-10 year old children have attended school for a few years, and thus have some knowledge in several different school subjects, and their language skills have developed sufficiently well.

Procedure

The participants were tested in language development with Test of Language Development-Intermediate (TOLD-I) (Hammill & Newcomer, 2008), in STM with the Forward Digit Recall test from the Working Memory Test Battery for Children (Pickering & Gathercole, 2001) and in word decoding skills with the Wordchains test

(Høien & Tønnesen, 1997). The testing was part of a larger research project run in the spring 2011 by the Language Acquisition and Language Processing Lab, NTNU. Three students, including myself, conducted the testing, which also included measuring motor development and second language development.

The testing was conducted at the schools, during the school hours. The children's parents filled out a form and agreed to their child's participation in the research project. The research project was also approved by The Norwegian Data Protection Authority (NSD).

For the Test of Language Development and the Forward Digit Recall test, the children were taken out of class one by one, and the experimenter conducted the test in a separate, quiet room. The Wordchains test was conducted in a classroom where the whole class was gathered. For all the tests, the children were informed that they could quit the test at any time.

Tests

TOLD-I.

Language development was tested with Test of Language Development - Intermediate: Fourth Edition (Hammill & Newcomer, 2008), which is a standardized, norm-referenced test of oral language development. It is used to identify students' abilities, and for research purposes. It measures all parts of language, except pragmatics, which requires other test methods. Also, it does not measure phonological abilities separately, because in fourth-graders they have become so integrated with semantic and grammatical skills that they are difficult to measure alone (Hammill & Newcomer, 2008, p. 5).

The test was adapted from English to Norwegian by the research team involved in the project. The test items were directly translated whenever possible, or changed into a more appropriate Norwegian counterpart if necessary, due to grammatical and semantic differences between the languages. The Norwegian TOLD-I is not yet standardized.

TOLD-I consists of six subtests:

1. Sentence Combining (grammar): The experimenter read minimum two short sentences, and the child was told to combine them into one complex sentence, which should be as short as possible. The subtest measures the syntax aspect of grammar. The testing was discontinued after three consecutive errors.

   Example: Simple sentences: *Jeg liker kake. Jeg liker is.* (I like cake. I like ice cream). Complex sentence: *Jeg liker kake og is.* (I like cake and ice cream.)

2. Picture Vocabulary (semantics): The experimenter presented cards with six pictures, and read words that described some of them. For each word, the child had to choose the picture that corresponded best. The subtest measures semantic comprehension and the vocabulary aspect of semantics. For each picture card, the testing was discontinued after two consecutive errors.

Example: Description: *Jakter på fugler.* (Hunts birds.) Picture: Cat.

3. Word Ordering (grammar): The experimenter read sentences where the words were in the wrong order, and the child was told to reorder the words to form correct Norwegian sentences. The subtest measures the syntax aspect of grammar. The testing was discontinued after three consecutive errors.

   Example: Words: *Heter, Mona, jeg*. (Is, name, Mona, my). Sentence: *Jeg heter Mona / Heter jeg Mona?* (My name is Mona / Is my name Mona?)

4. Relational Vocabulary (semantics): The experimenter read groups of three words belonging to the same category (e.g., the categories colors, fishes, religions). The child was told to either name the category that each group of words belonged in, or describe the relationship among the words. The subtest measures organization skills, and the vocabulary aspect of semantics. The testing was discontinued after three consecutive errors.

   Example: Words: *Nord, sør, øst.* (North, south, east.) Category: *Retninger.* (Directions).

5. Morphological Comprehension (grammar): (The name of this subtest is misleading, as the subtest measures meta-linguistic awareness rather than comprehension (Lust, 2007, p. 129).) The experimenter read sentences; a few correct and most incorrect. Some errors were syntactic, but most errors were morphological, and they could be noun-verb agreement, pronouns,

comparative and superlative adjectives, negatives, plurals, and adverbs. For each sentence, the child was told to judge if it was morphologically correct. The subtest measures meta-linguistic skills, and the morphology aspect of grammar. The testing was discontinued if the child missed three out of consecutive five tasks after task 11. If she missed more than one correct sentence, she was given 0 points on the subtest.

Example: *Vi stjelte to epler*. (We stealed two apples). Answer: Wrong.

6. Multiple Meanings (semantics): The experimenter read words with several meanings (homophones), and the child was told to provide as many meanings as possible for each word. The subtest measures the vocabulary aspect of semantics. The whole subtest was run for all participants.

   Example: Word: *Ris*. (Rice.) Meanings: *Mat/kornsort, bank/pryl/juling, pisk*. (Food/grain, get higher (in English).)

The children were allowed to get the words/sentences repeated once. They were also allowed to think up answers for as long as they wanted. They were given 1 point for each correct answer.

Forward Digit Recall from WMTB-C.

Short-term memory was tested with the Forward Digit Recall from the Working Memory Test Battery for Children (Pickering & Gathercole, 2001). The battery in its whole is used for assessing working memory capacities in children between 5 and 15 years. It contains nine subtests. Forward Digit Recall tests only short-term memory, because this test requires significant storage, but only minimal processing (Gathercole & Alloway, in press, pp. 19-20).

In Forward Digit Recall, the child heard spoken presentations of sequences of digits, and had to repeat the digits in the order they were presented. Maximum eleven blocks of six sequences were presented, and the sequences were one digit longer for each block; the first block contained six single digits, the second block contained six sequences of two digits, and the eleventh block contained six sequences of two digits. The test was stopped if the child failed to repeat the sequences correctly in more than two whole blocks. Total score corresponds to the maximum number of digit sequences the child was able to repeat correctly.

The Wordchains Test.

The Norwegian *Ordkjeder* (Wordchains) Word Recognition Test is used for screening of word decoding skills (Høien & Tønnesen, 1997). Where the process of understanding requires the work of higher mental levels, word decoding is normally automatic. Both factors must be present for the reading development to be positive (Høien & Tønnesen, 1997).

The Wordchains test measures both speed and accuracy of word recognition (Miller-Guron & Lundberg, 2000), and has proven to be a reliable and valid test of isolated word decoding proficiency (Jacobsen, 1993; Miller-Guron, 1999).

The child got a booklet containing 90 wordchains, where each chain consisted of four familiar words, e.g. *ordpilvedhvem* (wordarrowbywho), *treoverlivse* (treeoverlifesee). The child got 4 min to divide as many wordchains as possible into their component words, by drawing lines where each of the gaps should be (e.g. *ord│pil│ved│hvem)*. The child was given one point for each correctly marked wordchain.

Data Reduction and Analysis

SPSS version 20.0 was used for statistical analysis. A Pearson's correlation analysis on the participants' scores on the three tests showed whether there was a relationship between the factors. Both the total scores and the subtest scores were analyzed. For the Forward Digit Span, number of correct digit sequences/trials was used as score.

Sentence Combining and Word ordering from the TOLD-I battery have been suggested to test working memory alongside language development (Sabers, 1996), and this has been taken into account in the discussion.

Results

The means and standard deviations for age, score on the Forward Digit Recall test, score on the Wordchains test and total score on TOLD-I are shown in Table 1. The standard deviations seemed normal, but among the TOLD-I subtests, Morphological Comprehension had a larger standard deviation than the other subtests.

Table 1

Number of participants (N), and means and standard deviations on the Forward Digit Recall test (FDR), the Wordchains test (WCT), the TOLD-I total, and the TOLD-I subtests: Sentence Combining (SC), Picture Vocabulary (PV), Word Ordering (WO), Relational Vocabulary (RV), Morphological Comprehension (MC) and Multiple Meanings (MM).

	Total (*n* = 84)		Female (*n* = 44)		Male (*n* = 40)	
Variables	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
FDR	31.080	3.989	30.770	3.627	31.430	4.373
WCT	21.290	7.458	22.860	7.970	19.550	6.516
TOLD-I	149.024	30.079	146.034	24.847	152.311	33.089
SC	16.429	6.141	16.341	6.202	16.525	6.150
PV	58.643	7.302	57.386	7.516	60.025	6.890
WO	14.631	4.341	14.545	3.353	14.725	5.262
RV	14.571	6.366	14.136	5.692	15.050	7.077
MC	15.464	11.929	13.705	10.913	17.400	12.813
MM	29.286	4.8223	29.920	4.399	28.588	5.2157

Correlations between scores on the Forward Digit Recall test, the Wordchains test and the total score and subtest scores on TOLD-I are shown in Table 2.

Table 2

Correlations between score on the Forward Digit Recall test (FDR), score on the Wordchains test (WCT), total score on TOLD-I, and scores on the TOLD-I subtests: Sentence Combining (SC), Picture Vocabulary (PV), Word Ordering (WO), Relational Vocabulary (RV), Morphological Comprehension (MC) and Multiple Meanings (MM).

	FDR	WCT	TOLD-I	SC	PV	WO	RV	MC	MM
FDR	1	.198	.485*	.422*	.370*	.440*	.306*	.296*	.396*
WCT		1	.348*	.423*	.314*	.402*	.298*	.043	.295*
TOLD-I			1	.637*	.809*	.765*	.717*	.776*	.646*
SC				1	.472*	.475*	.443*	.211	.455*
PV					1	.617*	.526*	.479*	.496*
WO						1	.432*	.544*	.416*
RV							1	.416*	.375*
MC								1	.335*
MM									1

*Correlation is significant at the 0.01 level ($P < 0.01$).

The total scores on TOLD-I were significantly correlated with the scores on the Forward Digit Recall test, $r = .485$, and the scores on the Wordchains test, $r = .348$ (both *p*s < .001). The correlation between the scores on the Wordchains test and the Forward Digit Recall test was not significant.

The scores on the Forward Digit Recall test were significantly correlated with the scores on all TOLD-I subtests (all *p*s < .01) (see Table 2 for r-values).

The scores on the Wordchains test were significantly correlated with the scores on the TOLD-I subtests (all *p*s < .01), except for the correlation with Morphological Comprehension (see Table 2 for r-values).

The scores on the TOLD-I-subtests were significantly correlated with each other and the total TOLD-I score (all *p*s < .01), except for the score on Sentence Combining with the score on Morphological Comprehension (see Table 2 for r-values).

Discussion

This study looked at the relationships between STM, word decoding skills and language development, as well as the internal relationships between various aspects of language development (grammar and semantics) in Norwegian fourth-graders. The expectations were that correlations would be found between all of the factors. The results show significant correlations between nearly all of them. However, the correlations were low between word decoding skills and STM, between word decoding skills and Morphological Comprehension (grammar), and between Morphological Comprehension and Sentence Combining (grammar). Because the current study used correlation analysis on the data, the unique contributions of the different factors onto each other are unknown.

Short-Term Memory and Language Development

According to the results, the overall language competence is more closely related to STM than to word decoding skills. STM also shows medium sized correlations with each of the subtests in TOLD-I. This supports the findings by Baddeley et al. (1998) of the PL as a device for storing unfamiliar sound patterns. According to Baddeley et al., both vocabulary and syntax are mediated by PL.

Among the TOLD-I subtests, Sentence Combining and Word Ordering show the highest correlations with STM, whereas Morphological Comprehension shows the lowest, but still significant, correlations with STM. These three subtests all measure grammar, which at first sight makes the divergent results a bit surprising. An explanation may be that Sentence Combining and Word Ordering measure syntax, and as such depends more heavily on the PL than does Morphological

Comprehension. Indeed, Fowler (1988) found only a weak correlation between STM and judgment about morphology errors in second-graders, and Baddeley et al.'s (1998) review suggests that PL mediates syntactic learning. The lower correlation may be due to the fact that Morphological Comprehension is a meta-linguistic task, and thus not so directly linked to STM and memory processes (Lust, 2007, p. 129).

Another reason for the high correlation between syntax and STM may be that Sentence Combining and Word Ordering seem to measure WM in addition to grammar (Sabers, 1996). Since STM tasks access specialized storage components of WM (Gathercole & Alloway, in press, pp. 19-20), high correlations between the two are to be expected. The high correlations between syntax and STM suggest that PL is important for syntactic learning not only for 3-4-year-olds (Adams & Gathercole, 1995; Adams & Gathercole, 2000), but also for the 9-10-year-olds in the current study. The results also suggest failures in Chomsky's (1986) theory about grammar belonging to a narrow language faculty, and not being particularly influenced by memory (Hauser et al., 2002).

All the three semantic tasks are significantly correlated with STM, but Multiple Meanings shows the highest correlations and relational vocabulary shows the lowest. In Multiple Meanings, the children were to suggest as many meanings as possible to the words they were read (homophones), whereas in Relational Vocabulary they were to suggest categories for groups of words. The tendency for these competencies to be differently related to STM is surprising, given that they both measure organizational skills. However, it is consistent with Gathercole et al.'s (1997) finding that the learning of associate pairs of familiar words is linked with existing vocabulary but independent of PL function. The results may be explained by the nature of the tasks. In Multiple Meanings, all the children could suggest meaning for all the words, whereas in Relational Vocabulary, children who failed to answer correctly on three preceding categories were stopped. In addition, Multiple Meanings is directly semantic and linked to categorization, whereas Relational Vocabulary is more mechanical and linked to the organization of the mental lexicon. They thus tap different parts of cognition. The differences in standard deviations are consistent with this notion.

On the whole, the correlation between semantics and STM are in line with the previous findings of Baddeley et al., (1998) and Gathercole et al. (1992) that there is a strong relationship between vocabulary development and STM.

Short-Term Memory and Word Decoding Skills

The results show a low correlation between STM and word decoding skills. This is consistent with what Sprugevica and Høien (2004) found in a longitudinal study. They used the same digit span test as in the current study, together with a letter span test. However, Brunswick et al. (2012) used the digit span test in a longitudinal study, and found that it correlated significantly with reading skills. According to them, phonological STM is needed when children learn the letter-sound correspondences that allow them to decode novel words. If children have problems with learning these correspondences, they are unable to acquire the alphabetic strategy (Frith, 1986). The correlation between STM and word decoding skills might have been higher if a nonword-repetition test had been run in addition to the digit recall test, because it contains words instead of digits. Indeed, children's ability to repeat sentences can better predict their future reading achievements than their scores on the digit span test (Scarborough, 1998, p. 90). Scarborough further suggested that this happens because sentence repetition taps both memory and sentence processing abilities.

Importantly, the current findings do not suggest that STM is unimportant for reading skills in general; they only suggest that it is weakly related to word decoding skills. STM may still be important for word recognition skills (the ability to pronounce single words presented out of context), as Nation (1999) suggested. As a component in phonological memory, STM may also be vital for gathering the phonemes in a word to identify it (Nithart et al., 2011; Wagner & Torgesen, 1987). Different choices of method can also fit to explain why so divergent results have emerged in the mentioned studies.

Word Decoding Skills and Language Development

The results show a high correlation between the overall language competence and word decoding skills. This was expected, because phonemic awareness has been suggested as important for early word decoding skills (Lervåg et al., 2009; Muter et al., 2004; Schatschneider et al., 2004; Sprugevica & Høien, 2003). The fact that vocabulary growth influences reading skills (Garlock et al., 2001), and vice versa (Nation & Snowling, 1998), may also explain some of the correlations.

The association between these two factors supports the finding that problems with reading acquisition are related to difficulties in segmenting the stream of speech (Frith, 1999). For Norwegian children, the wordchain *ordpilvedhvem* probably gets easier to read if the child knows that the letter combination “hv” (from *hvem*) is more common in Norwegian than “dh”. This sensitivity to orthography has similarities with sensitivity to phonotactics. The phonotactics of a language determines which sound combinations are legal and illegal. Infants learn this when they gradually detect which sound combinations are the most frequent in their language. Sensitivity to phonotactics is crucial for discovering word boundaries (Karmiloff & Karmiloff-Smith, 2001, p. 50). TOLD-I measures phonology because it is integrated with semantic and grammatical skills (Hammill & Newcomer, 2008, p. 5). The correlations between word decoding skills and language competence may therefore be partly explained by the similarities between sensitivity to phonotactics and sensitivity to orthography. This is supported by the findings that orthographic and phonological processes seem to bootstrap each other (Talcott and Witton, 2002). The fact that many 6 to 7 year old children are unable to distinguish the separate sounds in spoken words, underpins the importance of phonics teaching (Bowey & Francis, 1991; Wimmer, Landerl, Linortner, & Hummer, 1991). If children had been taught letter-to-sound correspondences properly in Norwegian schools, they might have been better readers as well as better listeners (Macmillan, 1997, p. 31).

This may explain why some fourth-graders seem to have failed in acquiring the last of the three reading strategies (the orthographic) from Frith’s (1986) developmental framework for reading skills. These children may still use the alphabetic strategy, where they read one letter at a time, instead of perceiving the whole word sound with the orthographic strategy (Frith, 1986). When reading wordchains like “peghousefishone”, children who have mastered the orthographic strategy will discover word boundaries faster and make fewer mistakes than children who use the alphabetic strategy. A child who has not mastered the orthographic strategy has not achieved automatic decoding. She may therefore have to use more cognitive resources than normal to decode words, and will often compensate by pausing, looking back and rereading (Walczyk et al., 2007). A consequence may be fewer resources available for word recognition, as well as slower reading (Høien & Tønnesen, 1997).

As mentioned earlier, the high correlations between semantics and word decoding skills are consistent with the findings that vocabulary growth is important for early reading skills, and vice versa (Garlock et al., 2001; Nation & Snowling, 1998). They also give further support to the connectionist model which links orthography and phonology together via semantics (Harm & Seidenberg, 1999). In addition, word decoding skills influence comprehension skills (Muter et al., 2004), and children who are good readers are usually good at both word decoding and comprehending words (Curtis, 1980). Also, good comprehenders tend to have good semantic skills (Nation & Snowling, 1998). In other words, good decoding skills lead to good comprehension skills, which lead to good semantic skills. This may be causing the correlation between word decoding skills and semantic skills.

As for the subtests on semantics and grammar, the syntax tasks (Sentence Combining and Word Ordering) show the highest correlations with word decoding skills. This is consistent with what Bentin et al. (1989) discovered about a relationship between syntactic impairment and reading skills. The current findings also support Willows and Ryan's (1986) conclusion that grammatical sensitivity is related to reading skills.

Word decoding skills are significantly correlated with all of the specific language competencies except for Morphological Comprehension, which is included in the subcategory grammar. This gives support to Bowey's (2005) findings. She used a test that resembles the subtest from TOLD-I (Hammill & Newcomer, 2008), in which the children were read short sentences that contained grammatical errors. Her results indicated that grammatical awareness has no substantial influence on the reading skills of beginning readers. She suspected that the results were different from other research findings because the sentences in her tests were only three to six words long. They may thus have demanded too little phonological processing to be linked to reading skills. In another study, Casalis and Louis-Alexandre (2000) found that morphological awareness had less influence on decoding than on reading comprehension. The current study's Morphological Comprehension included mostly short sentences, and the reading test assessed only word decoding. Thus, there may exist a relationship between grammar and reading skills in general, but it appears to be weaker between the more specific grammatical judgment of short sentences and word decoding. This is also supported by the fact that syllabic complexity, which is present in Norwegian, affects decoding more than it affects comprehension (Seymour et al., 2003).

This suggestion gets even more support from Fowler (1988). She tested second-graders in different tasks, including two oral syntactic tasks: In a judgment task, they were to tell if the sentences they heard were grammatical or ungrammatical (i.e., almost the same as in the current study), whereas in a correction task, they were to correct ungrammatical sentences. The correction task showed associations with decoding skills, whereas the judgment task did not. This lead Fowler to conclude that poor readers have knowledge about grammatical structures, but that they struggled in the correction task because it demanded more meta-linguistic knowledge and more use of short-term memory than the judgment task. It suits to explain the current study's results as well, although the current Morphological Comprehension included more judgment of morphology than did Fowler's task.

Language Competencies

Most of the language sub-categories show high correlations with each other. This was expected, and supports the lexicalist perspective that grammar and vocabulary are inseparable (Bates & Goodman, 1997, Dionne et al., 2003). Still, Morphological Comprehension shows no significant correlation with Sentence Combining. Both subtests measure grammar, but Morphological Comprehension measures morphological skills whereas Sentence Combining measures syntactic skills. According to research, morphology shows some dissociability to other aspects of language in older children and adults with language impairments (Bates & Goodman, 1997). Why does Morphological Comprehension show low correlations with Sentence Combining, but high correlations with the other syntax subtest, Word Ordering?

The creators of TOLD-I, Hammill and Newcomer (2008), also found this tendency when they tested the relationships among the subtests, although they did not find any non-significant correlations (pp. 59-61). In both their results and the current results, Morphological Comprehension showed lower correlations with Sentence Combining and Multiple Meanings than with the other subtests. Sentence Combining assesses discourse-oriented syntax competence. Morphological Comprehension, on the other hand, assesses meta-linguistic awareness (Lust, 2007, p. 129), and taps overall grammar competence, including word inflections of relevance to syntax. They thus assess two different aspects of language competence. Word Ordering taps building minimal phrase-structure (basic sentences), by using morphological information from the word inflections. This explains its correlation with Morphological Comprehension. In other words, the variation in correlations among the subcategories of language seems to be caused by the linguistic nature of the tasks.

An additional explanation may be that the scoring on both Sentence Combining and Morphological Comprehension was more problematic than the scoring on the other language subtests. In Sentence Combining, the children had to combine two or more short sentences in order to make one complex sentence. The freedom this task gave the children made it difficult for the experimenters to decide which answers were correct and which were wrong. Regarding Morphological Comprehension, the children were given 0 points if they judged more than one of the correct sentences to be wrong. They might have gotten a completely different score if that rule had not been there. Eight children got 0 points, and this may explain the high standard deviation in this subtest. The combination of the scoring problems on these subtests may have made their correlation lower than it otherwise would have been. The Norwegian TOLD-I is not yet standardized, and a standardization of it will hopefully clear out these problems.

Working Memory and Language Competence

Sentence Combining and Word Ordering, are suggested to measure WM functions alongside language competencies (Sabers, 1996), and they also show the highest correlations with STM among the TOLD-I subtests. In the two tests, the participating children had to both remember and reorganize the words they were read. In other words, the information was both stored and manipulated, and that requires use of

WM. The TOLD-I total score shows high correlations with Sentence Combining and Word Ordering. This lends support to the findings by Gathercole et al. (2005) that the WM function associated with the central executive is more important than PL for language acquisition on the whole. However, since the two subtests mainly measure language competencies, the high correlations are far from surprising. More complex analyses and more research are needed to determine the relationship between WM and language competence in Norwegian children.

Limitations in the Current Study

The results cannot be interpreted without bearing in mind that the Norwegian TOLD-I is not yet standardized. It was used for the first time in the current study, and will probably be revised later, when a sufficient number of Norwegian children in different age groups have been tested. The results might have turned out different with a standardized test. In addition, the choice of analysis constitutes a limitation in the current study, because a correlation analysis cannot determine the directions of causations among the factors.

Conclusions

Previous research shows mostly strong connections between language competence, word decoding skills and short-term memory (STM). A few examples are the findings that the phonological loop (PL), which is accessed by STM, has been found to support vocabulary development (Baddeley et al., 1998; Gathercole et al., 1992), and that phonological STM is connected to decoding skills (Brunswick et al., 2012). Studies also show a relation between syntactic impairment and reading skills (Bentin et al., 1989), and that grammar and vocabulary are strongly connected (Bates & Goodman, 1997). The current study set out to discover if the connections between the three factors, and internal connections for language competence, also could be found in Norwegian fourth-graders.

The expectations were almost, but not completely, fulfilled. Among the main three main factors, the highest correlations were found between overall language competence and STM. Thus, vocabulary and short-term memory seem to be strongly related in fourth-graders. STM tended to be more related to syntax than to morphology. This is consistent with the suggestion that the PL mediates syntactic learning (Baddeley et al., 1998), and indicates that the PL is somewhat less important for morphological learning. The fact that the standard deviation for morphological comprehension was higher than for the other language subtests may mean that fourth-graders are on quite different stages in the process of acquiring morphological awareness, which requires meta-linguistic skills.

The correlations between overall language competence and word decoding skills were a bit lower than between language competence and STM, but were still significant.

This supports the findings of a mutual influence between vocabulary development and reading skills (Garlock et al., 2001; Nation & Snowling, 1998). One may also speculate about a relationship between sensitivity to phonotactics and sensitivity to orthography. Thus, a broader introduction of phonics in Norwegian schools might lead Norwegian children to develop greater reading skills, as it has helped other children earlier (Ragnarsdóttir, 2007). This could probably be beneficial for their vocabulary development and other semantic skills as well (Nation & Snowling, 1998). No correlation could be found between Morphological Comprehension and word decoding skills. This is probably due to the nature of the tasks, and suggests that grammatical judgment of short sentences and word decoding are weakly related.

The correlations between word decoding skills and STM were not significant. This may also be due to the nature of the tasks, and indicates that being able to remember digits is less related to decoding skills than is being able to remember letters or words.

The high correlation between Morphological Comprehension and Word Ordering, and the absence of correlation between Morphological Comprehension and Sentence Combining, can be explained in terms of the specific aspects of grammar competence these tests tap.

According to the high correlations Sentence Combining and Word Ordering showed with the other factors, working memory (WM) is influential. However, these are only speculations. Therefore, the role of WM in the development of language and reading skills in Norwegian children would be interesting to investigate in future experiments. Also, phonics should be tried out in Norwegian schools, because of the possible connection between sensitivity to phonotactics and sensitivity to orthography, and because Norwegian children perform badly in reading compared to other OECD countries (Roe & Solheim, 2007).

In addition, the Norwegian version of TOLD-I will hopefully be standardized in the near future. When a larger number of Norwegian school children have been tested with it, more finite conclusions can be made about their language competence and its relationship with other skills.

References

Adams, A.-M , & Gathercole, S. E. (1995). Phonological working memory and speech production in preschool children. *Journal of Speech and Hearing Research, 38*(2), 403-414.

Adams, A.-M., & Gathercole, S. E. (2000). Limitations in working memory: Implications for language development. *International Journal of Language & Communication Disorders, 35*(1), 95-116.

Atkinson, R. C., & Shiffrin, R. M. (1968). Human Memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation: Advances in research and theory* (pp. 89–195). New York, NY: Academic Press.

Aukrust, V. G. (2007). Young children acquiring second language vocabulary in preschool group-time: Does amount, diversity, and discourse complexity of teacher talk matter? *Journal of Research in Childhood Education, 22*(1), 17-37.

Baddeley, A. D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences, 4*(11), 417–422.

Baddeley, A. D. (2003). Working memory: Looking back and looking forward. *Nature Reviews Neuroscience, 4*(10), 829-839.

Baddeley, A. D., Gathercole, S. E., & Papagno, C. (1998). The phonological loop as a language learning device. *Psychological Review, 105*(1), 158–173.

Baddeley, A. D., & Hitch, G. J. (1974). Working memory. In G. A. Bower (Ed.), *Recent advances in learning and motivation* (pp. 47–90). New York, NY: Academic Press.

Bates, E., Bretherton, I., & Snyder, L. (1988). *From first words to grammar: Individual differences and dissociable mechanisms.* Cambridge, England: Cambridge University Press.

Bates, E., & Goodman, J. C. (1997). On the inseparability of grammar and the lexicon: Evidence from acquisition, aphasia and real-time processing. *Language and cognitive Processes, 12*(5-6), 507-584.

Bentin, S., Deutsch, A., & Liberman, I. Y. (1989). Syntactic competence and reading ability in children. *Journal of Experimental Child Psychology, 49*(1), 147-172.

Bowey, J. A. (2005). Grammatical sensitivity: Its origins and potential contribution to early word reading skill. *Journal of Experimental Child Psychology, 90*(4), 318-343.

Bowey, J. A., & Francis, J. (1991). Phonological analysis as a function of age and exposure to reading instruction. *Applied Psycholinguistics, 12*(1), 91-121.

Brunswick, N., Neil Martin, G., & Rippon, G. (2012). Early cognitive profiles of emergent readers: A longitudinal study. *Journal of experimental child psychology, 111*(2), 268-285.

Caravolas, M., Lervåg, A., Mousikou, P., Efrim, C., Litavský, M., Onochie-Quintanilla, E., ... & Hulme, C. (2012). Common patterns of prediction of literacy development in different alphabetic orthographies. *Psychological science, 23*(6), 678-686.

Casalis, S., & Louis-Alexandre, M. F. (2000). Morphological analysis, phonological analysis and learning to read French: A longitudinal study. *Reading and Writing, 12*(3), 303-335.

Chomsky, N. (1986). *Knowledge of Language. Its nature, origin and use.* New York, NY: Praeger.

Coltheart, M., Curtis, B., Atkins, P., & Haller, M. (1993). Models of reading aloud: Dual-route and parallel-distributed-processing approaches. *Psychological Review, 100*(4), 589-608.

Curtis, M. E. (1980). Development of components of reading skill. *Journal of Educational Psychology, 72*(5), 656-669.

Denckla, M. B., & Rudel, R. G. (1976). Rapid ‘automatized’ naming (R.A.N.): Dyslexia differentiated from other learning disabilities. *Neuropsychologia, 14*(4), 471-479.

Dionne, G., Dale, P. S., Boivin, M., & Plomin, R. (2003). Genetic evidence for bidirectional effects of early lexical and grammatical development. *Child Development, 74*(2), 394-412.

Fowler, A. E. (1988). Grammaticality judgments and reading skill in grade 2. *Annals of Dyslexia*, *38*(1), 73-94.

Frith, U. (1986). A developmental framework for developmental dyslexia. *Annals of Dyslexia, 36*(1), 69-81.

Frith, U. (1999). Paradoxes in the Definition of Dyslexia. *Dyslexia, 5*, 192-214.

Gathercole, S. E., Alloway, T. P., Willis, C., & Adams, A. M. (2006). Working memory in children with reading disabilities. *Journal of Experimental Child Psychology*, *93*(3), 265-281.

Gathercole, S. E., & Alloway, T. P. (in press). Working memory and classroom learning. In K. Thurman and K. Fiorello (Eds), *Cognitive Development in K-3 Classroom Learning: Research Applications.*

Gathercole, S. E., Hitch, G. J., Service, E., & Martin, A. J. (1997). Phonological short-term memory and new word learning in children. *Developmental Psychology, 33*(6), 966-979.

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*(6), 598-611.

Garlock, V. M., Walley, A. C., & Metsala, J. L. (2001). Age-of-acquisition, word frequency, and neighborhood density effects on spoken word recognition by children and adults. *Journal of Memory and Language, 45*(3), 468–492.

Gathercole, S. E., Willis, C., Emslie, H., & Baddeley, A. D. (1992). Phonological memory and vocabulary development during the early school years: A longitudinal study. *Developmental Psychology, 28*(5), 887-898.

Goswami, U. (2008). The development of reading across languages. *Annals of the New York Academy of Sciences, 1145*(1), 1-12.

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

Hammill, D. D., & Newcomer, P. L. (2008). *Test of language development: Intermediate. Examiner's manual.* Austin, TX: PRO-ED.

Harm, M. W., & Seidenberg, M. S. (1999). Phonology, reading acquisition, and dyslexia: Insights from connectionist models. *Psychological Review, 106*(3), 491-528.

Hauser, M. D., Chomsky, N., & Fitch, W. T. (2002). The faculty of language: What is it, who has it, and how did it evolve? *Science, 298*(5598), 1569-1570.

Ho, C. S.-H., & Bryant, P. (1997). Phonological skills are important in learning to read Chinese. *Developmental Psychology, 33*(6), 946–951.

Hoff-Ginsberg, E. (1991). Mother-child conversation in different social classes and communicative settings. *First Language, 12*(4), 233-244.

Howard, D., & Best, W. (1996). Developmental phonological dyslexia: Real word reading can be completely normal. *Cognitive Neuropsychology, 13*(6), 887-934.

Hurford, J. R. (1991). The evolution of the critical period for language acquisition. *Cognition, 40*(3), 159-201.

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

Høien, T., & Tønnesen, G. (1997). *Håndbok til ordkjedetesten*. Stavanger, Norway: Stiftelsen Dysleksiforsking.

Jacobsen, C. (1993). *Ordkjedjor (Wordchains).* Sweden: Psykologiförlaget.

Jackendoff, R. (2002). What's in the lexicon? In Noteboom, S., Weerman, F., & Wijnen (Eds.), *Storage and Computation in the Language Faculty*, (pp. 23-58). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Johnston, R. S., & Watson, J. (2003). *Insight 4: Accelerating reading and spelling with synthetic phonics: A five-year follow up*. Edinburgh, Scotland: Scottish Executive Education Department.

Juel, C., Griffith, P. L., & Gough, P. B. (1986). Acquisition of literacy: A longitudinal study of children in first and second grade. *Journal of Educational Psychology, 78*(4), 243-255.

Karmiloff, K., & Karmiloff-Smith, A. (2001). *Pathways to language: From fetus to adolescent.* Cambridge, MA, and London, England: Harvard University Press.

Lervåg, A, & Bråten, I. (2002). Effects of memory load on word recognition: Are there dual-routers in Norway? *Reading and Writing: An interdisciplinary Journal, 15*(3-4), 233-259.

Lervåg, A., Bråten, I., & Hulme C. (2009). The cognitive and linguistic foundations of early reading development: A Norwegian latent variable longitudinal study. *Developmental Psychology, 45*(3), 764-781.

Lust, B. (2007). *Child language*. Cambridge, England: Cambridge University Press.

Lyons, J. (1968). *Introduction to theoretical linguistics*. Cambridge, England: Cambridge University Press.

Macmillan, B. (1997). *Why schoolchildren can't read* (No. 2). London, England: Coronet Books Inc.

Macmillan, B. (2004). Illiterate boys: The new international phenomenon. *Reading Reform Foundation, 51*, 27–33.

Majerus, S., & Lorent, J. (2009). Is phonological short-term memory related to phonological analysis stages in auditory sentence processing? *European Journal of Cognitive Psychology, 21*(8), 1200-1225

Marchman, V., Miller, R., & Bates, E. (1991). Babble and first words in children with focal brain injury. *Applied Psycholinguistics, 12*(1), 1-22.

Masoura, E. V., & Gathercole, S. E. (1999). Phonological short-term memory and foreign language learning. *International Journal of Psychology, 34*(5-6), 383-388.

McBride-Chang, C., Wagner, R. K., Muse, A., Chow, B. W.-Y., & Shu, H. (2005). The role of morphological awareness in children's vocabulary acquisition in English. *Applied Psycholinguistics, 26*, 415-435.

McGuinness, D. (1981). Auditory and motor aspects of language development in males and females. In A. Ansara, N. Geshwind, A. Galaburda, A. Marilyn, & N. Gartrell (Eds.), *Sex differences in dyslexia* (pp. 55-72). Towson, MD: Orton Dyslexia Society.

Melby-Lervåg, M., Lervåg, A., Lyster, S.-A. H., Klem, M., Hagtvet, B., & Hulme, C. (2012). Nonword-repetition ability does not appear to be a causal influence on children's vocabulary development. *Psychological Science, 23*(10), 1092-1098.

Miller-Guron, L. (1999). *Wordchains: Word reading test. Teacher's guide.* Windsor, England: NFER-NELSON.

Miller-Guron, L., & Lundberg, I. (2000). Dyslexia and second language reading: A second bite at the apple. *Reading and Writing: An interdisciplinary Journal, 12*(1-2), 41–61.

Morra, S. (1994). Issues in working memory development: Testing for M-capacity. *International Journal of Behavioral Development*, *Special Issue, 17*(1), 143–159.

Muter, V., Hulme, C., Snowling, M., & Stevenson, J. (2004). Phonemes, rimes, vocabulary, and grammatical skills as foundations of early reading development: Evidence from a longitudinal study. *Developmental Psychology, 40*(5), 665–681.

Nation, K. (1999). Reading skills in hyperlexia: A developmental perspective. *Psychological Bulletin, 125*(3), 338-355.

Nation, K. (2005). Picture naming and developmental reading disorders. *Journal of Research in Reading, 28*(1), 28-38.

Nation, K., & Snowling, M. J. (1998). Semantic processing and the development of word-recognition skills: Evidence from children with reading comprehension difficulties. *Journal of Memory and Language, 39*(1), 85-101.

Nithart, C., Demont, E., Metz-Lutz, M.-N., Majerus, S., Poncelet, M., & Leybaert, J. (2011). Early contribution of phonological awareness and later influence of phonological memory throughout reading acquisition. *Journal of Research in Reading, 34*(3), 346-363.

Papagno, C., Cecchetto, C., Reati, F., & Bello, L. (2007). Processing of syntactically complex sentences relies on verbal short-term memory: Evidence from a short-term memory patient. *Cognitive neuropsychology, 24*(3), 292-311.

Pennington, B. F., & Bishop, D. V. (2009). Relations among speech, language, and reading disorders. *Annual Review of Psychology*, *60*, 283-306.

Pickering, S. J., & Gathercole, S. E. (2001). *Working memory test battery for children.* London, England: Psychological Corporation UK.

Pugh, K. R., Shaywitz, B. A., Shaywitz, S. E., Constable, R. T., Skudlarski, P., Fulbright, R. K., ... & Gore, J. C. (1996). Cerebral organization of component processes in reading. *Brain, 119*(4), 1221-1238.

Ragnarsdóttir, G. A. (2007). Teaching an Icelandic student with autism to read by combining direct instruction and precision teaching. *European Journal of Behavior Analysis, 8*(2), 289-304.

Roe, A., & Solheim, R. G. (2007, December). *PISA og PIRLS. Om norske elevers leseresultater.* Oslo, Norway: Utdanningsdirektoratet.

Sabers, D. L. (1996). By their tests we will know them. *Language, Speech, and Hearing Services in Schools, 27*(2), 102-108.

Saldaña, D., Carreiras, M., & Frith, U. (2009). Orthographic and phonological pathways in hyperlexic readers with autism spectrum disorders. *Developmental Neuropsychology, 34*(3), 240-253.

Scarborough, H. S. (1998). Early identification of children at risk for reading disabilities: Phonological awareness and some other promising predictors. In B. K. Shapiro, P. J. Accardo, & A. J. Capute (Eds.), *Specific reading disability: A view of the spectrum* (pp. 75-119). Timonium, MD: York Press.

Schatschneider, C., Fletcher, J. M., Francis, D. J., Carlson, C. D., & Foorman, B. R. (2004). Kindergarten prediction of reading skills: A longitudinal comparative analysis. *Journal of Educational Psychology, 96*(2)*,* 265–282.

Seymour, P. H. K., Aro, M., & Erskine, J. M. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology, 94*(2)*,* 143–174.

Seymour, P. H. K., & Evans, H. M. (1999). Foundation-level dyslexias: Assessment and treatment. *Journal of Learning Disabilities*, *32*(5)*,* 394–405.

Snowling, M., Goulandris, N., Bowlby, M. & Howell, P. (1986). Segmentation and speech perception in relation to reading skill: A developmental analysis. *Journal of Experimental Child Psychology, 41*, 489–507.

Sprugevica, I., & Høien, T. (2003). Enabling skills in early reading acquisition: A study of children in Latvian kindergartens. *Reading and Writing, 16*(3), 159-177.

Sprugevica, I., & Høien, T. (2004). Relations between enabling skills and reading comprehension: A follow-up study of Latvian students from first to second grade. *Scandinavian Journal of Psychology, 45*(2), 115-122.

Talcott, J. B., & Witton, C. (2002). A sensory-linguistic approach to normal and impaired reading development. In E. Witruk, A. D. Friederici, & T. Lachmann (Eds.), *Basic functions of language, reading and reading disability* (pp. 213-240). Dordrecht, The Netherlands: Springer.

Tomasello, M. (2000). Do young children have adult syntactic competence? *Cognition, 74*(3), 209-253.

Tulving, E. (1985). How many memory systems are there? *American Psychologist, 40*(4), 385-398.

Tunmer, W. E. (1989). The role of language related factors in reading disability. In D. Shankweiler, & I. Y. Liberman (Eds.), *Phonology and reading disability: Solving the reading puzzle* (pp. 91–131). Ann Arbor, MI: University of Michigan Press.

UNESCO, & OECD. (2003). *Literacy skills for the world of tomorrow – further results from Pisa 2000*. Paris, France: UNESCO.

Wagner, R. K., & Torgesen, J. K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin, 101*(2), 1–21.

Walczyk, J. J., Wei, M., Griffith-Ross, D. A., Goubert, S. E., Cooper, A. L., Zha, P. (2007). Development of the interplay between automatic processes and cognitive resources in reading. *Journal of Educational Psychology, 99*(4), 867-887.

Walczyk, J. J., Wei, M., Zha, P., & Griffith-Ross, D. A. (2006). The interaction of automatic processes and cognitive resources in reading: A compensatory framework. In A. V. Mittel (Ed.), *Focus on educational Psychology* (pp. 195–216). New York: Nova Science.

Weizman, Z. O., & Snow, C. E. (2001). Lexical input as related to children's vocabulary acquisition: Effects of sophisticated exposure and support for meaning. *Developmental Psychology, 37*(2), 265-279.

Willows, D. M., & Ryan, E. B. (1986). The development of grammatical sensitivity and its relationship to early reading achievement. *Reading Research Quarterly, 21*(3), 253-266.

Wimmer, H., Landerl, K., Linortner, R., & Hummer, P. (1991). The relationship of phonemic awareness to reading acquisition: More consequence than precondition but still important. *Cognition, 40*(3), 219-249.

Wimmer, H., Landerl, K., & Schneider, W. (1994). The role of rhyme awareness in learning to read a regular orthography. *British Journal of Developmental Psychology, 12*(4), 469-484.