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The relationship between nonword repetition and word learning in children with SLI

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Contents

Abstract

Introduction: The aim of this study was to examine the relationship between a nonword repetition task and a word learning task in children with SLI. A positive correlation between nonword repetition and word learning was expected. Also, it was hypothesized that the relationship between the three syllable word set of the nonword repetition task and the total word learning task would be stronger than the relationship between the two tasks in general.
Method: Thirty-three 6-to-10 year old children with SLI participated. On the first day, the experiment commenced with a nonword repetition task and children had to learn 12 new words. On the second day the word learning task was continued and a vocabulary assessment was administered.
Results: The correlation between the nonword repetition task and the word learning task was weak and not significant (r = .106, p > .1). Also, no association between the ability to repeat three syllable nonwords and the ability to learn new words was detected.
Conclusion: The data are inconsistent with the general view that phonological short term memory and word form learning are related. This might be explained by the design of the experiment, the construction of the word learning task and the participant group.

1. Introduction

Children diagnosed with Specific Language Impairment (SLI) fail to develop language at normal rate in the absence of apparent sensory, neurological, cognitive, motor or emotional problems. Impairments can be manifest in language comprehension as well as language production and may involve grammatical, phonological, lexical and morphological abilities (van Weerdenburg, Verhoeven & van Balkom, 2006; Gillis & Schaerlaekens, 2000). It is generally assumed that SLI is caused by a combination of environmental and genetic risk factors, but the etiology of the disorder is still unclear (Bishop, 2006).

The group of children with SLI is heterogeneous (van Weerdenburg, Verhoeven & van Balkom, 2006; Gillis & Schaerlaekens, 2000). Van Weerdenburg et al. (2006) distinguished four subtypes of SLI, each with a specific linguistic profile. All children were significantly delayed on several language tests, including measures of lexical semantic abilities, compared with typically developing children. Other researchers point out that children with SLI have a delayed onset of first words, their vocabularies are less varied and they perform below typically developing children on norm-referenced vocabulary tests (Mainela-Arnold, Evans & Coady, 2010; Gray, 2004). Successful vocabulary acquisition is important for the development of oral language and has been found to predict literacy skills (Gray, 2004; Gray, 2003; van Weerdenburg, Verhoeven, Bosman & van Balkom, 2011).

Children with SLI have specifically problems with learning word forms (Coady & Evans, 2008; Gathercole, 2006). Storing a word form in short term memory is a necessary precondition for the construction of a word form representation in long term memory. In other words, it is the starting point of the acquisition of a new word (Gathercole, 2006). There is evidence that nonword repetition and word learning are related in typically developing children. For children with SLI, this relationship is not clear. Therefore, this study focuses on the relationship between temporary storage of new words in phonological short term memory and long term word learning. This relationship will be evaluated by examining the relationship between a nonword repetition task and a word learning task. Does performance on a phonological short term memory task predict the ability to learn new words? The outcomes of study will help to

develop insight in this topic in order to be able to create effective interventions and strategies to help children with SLI with vocabulary acquisition.

The present study takes the influence of word length on nonword repetition into account. Children with SLI have marked deficits in repeating nonwords of three and four syllables as compared to typical developing peers (Marton & Schwarz, 2003; Gathercole & Baddeley, 1990). Moreover, the number of presentations of the word learning task is high to avoid floor effects. Finally, the same set of nonwords is used in both the nonword repetition task and the word learning task, so as to control for the potential effects of lexical properties of the items on task performance (Gathercole, 2006).

Phonological short term memory and vocabulary

New word learning is supported by working memory and especially by phonological short term memory (pSTM) (Archibald & Gathercole, 2006; Baddeley, 2003). Working memory in general supports a wide range of cognitive activities by storing and manipulating incoming information. According to Baddeley (2003) working memory is a multidimensional system comprising three separate, yet interactive sub-systems (figure 1).

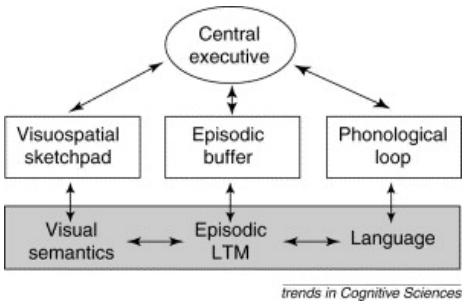

Figure 1: Model of working memory (Baddeley, 2000)

The three mechanisms of working memory are phonological short term memory for temporary retention of verbal material, the visuospatial sketchpad for visuospatial input and the central executive (coordinating and controlling activities in working memory). Recently, a fourth mechanism was added: the episodic buffer (Baddeley, 2000). The episodic buffer is thought to integrate input from pSTM and the visuospatial sketchpad into coherent episodes or representations (Montgomery, Magimairaj & Finney, 2010)[1]. PSTM is

[1] Language comprehension, e.g. processing verbal spatial information, is likely to be supported by the visuospatial sketchpad. The central executive reflects probably the individual differences in memory span

supporting word learning and language learning in general. To store representations of a new word form in long term memory, the word form must first be maintained in pSTM (Jarrold, Thorn & Stephens, 2009). While new word forms are temporarily stored in pSTM, robust representations in long term memory can be constructed (Graf-Estes et al., 2007; Gray, 2004). Thus, working memory and long term memory are interacting (Baddeley, 2003); temporary storage of a novel word form is a precondition for its long term storage. Repeated exposure to a new word will help create a stable phonological representation in long term memory (Gathercole, 2006). Verbal material that is kept passively in pSTM will decay quickly, but active rehearsal prevents this decay and helps memorizing the verbal material (Baddeley, 2003). Without a functioning pSTM, there can be no vocabulary growth (Gupta & Tisdale, 2009).

Several studies have found correlations between measures of pSTM and receptive vocabulary (Gathercole, 2006; Coady & Evans, 2008 Archibald & Gathercole, 2006). Individuals with strong pSTM skills tend to have a more extensive receptive vocabulary in their native language (Jarrold, Thorn & Stephens, 2009; Gathercole, 2006). This relationship becomes less strong in the course of language development, reflecting a change in vocabulary acquisition. As a consequence of learning more words, phonological knowledge expands and from the age of five this knowledge is used for vocabulary growth. Close neighbors (words that resemble phonologically to target words) in the mental lexicon facilitate word learning (Gathercole, 2006; Gupta & Tisdale, 2009). Although the relationship between vocabulary size and phonological working memory decreases with age, phonological working memory affects word learning until adolescence. Experimental research shows that if lexical knowledge cannot be used for new word learning, children with poor pSTM have problems with new word learning that persist into adulthood (Graf-Estes et al., 2007; Coady & Evans, 2008; Gathercole, 2006).

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and will influence comprehension capacity, although semantical knowledge plays a major role in this process. The episodic buffer is proposed to be a storage system and integrates information from different sources. The tasks of the current study rely mainly on phonological short term memory, but also on the visuospatial sketchpad (recognizing pictures of new animals), the episodic buffer (integrating picture and word form) and more general the central executive to accomplish the task.

Phonological short term memory and vocabulary in children with SLI

Many children with SLI have poor working memory skills in comparison to their typically developing peers, especially pSTM. This deficit can be assumed to have implications for language learning (Montgomery et al., 2010; Gray, 2004). They have a reduced capacity of pSTM and the quality of the temporary representations of the verbal input is poor. Children with SLI need more exposures to a new word in order to create a stable phonological representation (Gathercole, 2006; Gray, 2004). Therefore, children with SLI have marked impairments in the acquisition of the phonological form of new words (Coady & Evans, 2008; Gathercole, 2006). However, Gathercole (2006) states that even children with poor pSTM, such as children with SLI, can acquire an age-appropriate vocabulary with enough time and exposure to new words. In studies that examined the relation between (receptive) vocabulary size (measured with norm-referenced vocabulary tests) and nonword repetition in children with SLI, no significant correlations were found when these children were aged five years and older (Coady & Evans, 2008).

In addition to problems with learning new word forms, children with SLI have semantic difficulties. They have problems with word recognition, picture naming, defining words and difficulties with linking the word form to word meaning (Mainela-Arnold, Evans & Coady, 2010). They need more exposures in order to learn a new word, and they have difficulties storing as well as retrieving words (Mainela-Arnold et al., 2010; Brackenbury & Pye, 2005).

Phonological short term memory can be assessed with tasks such as digit span, word span and nonword repetition (Montgomery et al., 2010). Children with SLI perform worse than typical developing peers on these tasks (Gray, 2004). In a digit span or word span task a child has to repeat a series of high frequent words or digits. In a nonword repetition task children are asked to repeat pseudowords (words following the phonotactic restrictions of a language, such as ‘jiefoot’ for Dutch) (Gerrits, 2005). The items of a nonword repetition task are unfamiliar, in contrast with the items of digit or word span, therefore nonword repetition is thought to be closer to language learning. It relies heavily on pSTM function, because the opportunity to rely on lexical knowledge is reduced (Baddeley, 2003; Baddeley & Gathercole, 1998).

There is consistent evidence in the literature that the ability to repeat nonwords in children with SLI is less accurate than their typically developing

peers, although the magnitude of this deficit varies across studies (on average -1.27 SD below typical developing peers). Researchers used tasks that differed with regard to item construction: variables as word length, word likeness and articulatory complexity differed and explained the differences in accurateness (Graf-Estes et al., 2007).

Nonword repetition has been adopted as a marker to identify SLI and poor nonword repetition is probably the strongest predictor of language learning ability (Gathercole, 2006; Coady & Evans, 2008; Bishop, 2006). The task taps multiple processes: speech perception (hearing), phonological decoding (segmenting the phonological string into smaller units), phonological memory, speech motor planning (assembling a motor plan that contains the relevant phonemes) and articulation (Graf-Estes et al., 2007; Coady & Evans, 2008). Thus, it taps many abilities that children with SLI exhibit problems with. Interpreting nonword repetition deficits is therefore problematic (Coady & Evans, 2008). Gathercole (2006) suggests that problems with nonword repetition are due to limited phonological storage capacity combined with problems with phonological processing. Measures of pSTM, such as digit span, correlate significantly with nonword repetition (Coady & Evans, 2008). Other researchers state that nonword repetition is mainly supported by the ability to process and manipulate phonological information (Jarrold et al., 2009). Which deficit is primary for children with SLI, limited storage capacity or problems with phonological processing, remains unsolved (Coady & Evans, 2008).

It is clear, though, that constraints in storage capacity play a key role in new word learning. The word learning capacities of children with SLI are constrained by their deficits in pSTM (Gathercole, 2006).

Relation between nonword repetition and word learning

In a nonword repetition task a child hears a nonword once and has to memorize the new phonological string long enough to be able to repeat it immediately. In vocabulary acquisition, a child has several encounters with a new word and has to store the phonological information in long term memory. The present study focuses on the relationship between those two tasks. Several studies have found correlations between the ability to repeat nonwords and long term new word learning in typically developing children and adults, although designs differ (Gathercole, 2006). Gathercole and Baddeley (1990) studied new

word learning in typically developing children aged 5 to 6 years. The children had to learn four new words with a maximum of 15 trials. After 24 hours the children were tested with a picture naming task. A negative correlation was found between nonword repetition and the number of trials needed to learn the words (r = -.455). Michas and Henry (1994) presented three new words with definitions to typically developing children (mean age 5;06 years). They found a correlation of r = .303 between nonword repetition and new word learning measured with a production task. Horohov and Oetting (2004) studied new word learning in a story-viewing task in two groups of children (normal language and SLI) aged 5 to 7 years. The children had to learn 32 words in a story-learning paradigm (new words were presented in a narration) and were assessed with a picture pointing task and a real word synonym task. The words were presented three times. They found moderate correlation between nonword repetition and new word comprehension in the total group (r = .51). Nonword repetition explained 23% of the variance in children's picture pointing score. Gray (2004) found that nonword repetition predicted 31% of the variance of the total amount of trials needed to produce new words. Children with SLI and normal language aged 4-5;11 years participated in this study. They had to learn four new words with two syllables in four sessions assessed with both a production and comprehension task. The amount of exposures was high (96x). Children with SLI needed significantly more trials to learn the words. Gupta (2010) found that the relationship between word learning and nonword repetition also exists in adults (r = .357). Concluding, mostly moderate correlation is found between nonword repetition and new word form learning, despite of the theoretical strong link.

Factors influencing nonword repetition and word learning

The present study uses the same vocabulary for both nonword repetition and word learning, because both tasks are influenced by the lexical construction of the target words. Factors as word likeness, phonotactic frequency and articulatory complexity have an effect on performance on these tasks. Higher degrees of lexical familiarity, for instance nonwords containing lexical units, and articulatorily simple nonwords facilitate both nonword repetition and word learning. Familiar words are thought to be easier to perceive and process because language knowledge in long term memory influences both processes.

Another explanation is that lexical knowledge is used to reconstruct incomplete phonological representations at point of retrieval. Concluding, lexical knowledge supports phonological learning. New word learning is more challenging when the items have low phonotactic frequency or the items are phonological similar (Gathercole, 2006). Consequently, the reliability of an experiment using these two tasks will increase when these factors are held constant.

A factor that influences the ability to repeat nonwords is word length. The ability to repeat nonwords decreases with increasing word length in typically developing children, adults and specifically in children with SLI (Gathercole, 2006). Both Marton and Schwarz (2003) and Gathercole and Baddeley (1990) found marked impairments in repeating three and four syllable nonwords in SLI groups compared to language age and nonverbal chronological age-matched controls, but small effect sizes for one and two syllable words. Longer nonwords are more difficult to process and rely heavily on the capacity of pSTM (Coady & Evans, 2008). The effect of word length on new word learning has not been studied yet.

Word learning tasks

Several different paradigms are used in experimental studies of word learning. In fast mapping and quick incidental learning the child is exposed one or two times to a target word and immediate recall is asked; thus short term learning is assessed (Gray 2003). For fast mapping tasks a meta-analysis showed that children with SLI performed significantly poorer than children with normal language development (Kan & Windsor, 2010). Other studies used direct teaching or a supported learning context in which children had to process and store new words in long term memory. The studies differed in the number of exposures over sessions and days, the context provided with the target words, the feedback that was given about the accuracy of responses, and the amount of interaction between child and experimenter (Gray, 2003). There was a large variability in the outcomes of studies that addressed the word learning abilities of children (participants with SLI and typically developing children). Some studies found large differences, while other studies did not find group differences. The different outcomes may be due to differences in sample and experimental design (Kan & Windsor, 2010; Gray, 2004).

Horohov and Oetting (2004) argue that the number of presentations in a new word learning task has the highest influence on new word learning, while lexical factors had less influence (Horohov & Oetting, 2004). Coady and Evans (2008) state that children with SLI can succeed in new word learning tasks assessed with a comprehension task, but they need more exposures over sessions to the words. Their production of new words is less accurate. In long term word learning tasks children with SLI learned fewer words than their typically developing peers (Gray, 2003; Gray, 2004; Horohov & Oetting, 2004). In fast mapping studies, the numbers of presentations differed from 'low' (1-6 presentations), to 'medium' (12-14 presentations) and to 'high' (20 or more presentations) (Kan & Windsor, 2010).

Thus, for the present study the number of exposures to the new words is high and word learning is assessed with a comprehension task. This will make the task feasible and create sufficient variability. As children with SLI need two to three times more exposures to new words in order to learn an equal amount of words compared to their typical developing peers (Mainela-Arnold et al., 2010) this study presents the target words 48 times.

Present study

The correlations between the nonword repetition task and word learning performance in typically developing children reported in the literature are moderate at best (Gathercole & Baddeley, 1990; Michas & Henry, 1994; Horohov & Oetting, 2004; Gray, 2004). One would expect a higher correlation, because of the theoretical link between pSTM and long term word learning. Children with SLI have problems with vocabulary acquisition and show deficits on both tasks. The underlying cause of these problems could be their poor pSTM (Montgomery et al., 2010). As vocabulary expansion is an important goal in the education to children with SLI, the present study will help gain insight in the most efficient way to teach children with SLI new words. It is expected that children with poor pSTM will have more problems with new word learning. If this hypothesis is correct, this implies adjustments in education. The outcomes of this study will make professionals able to differentiate their teaching methods according to the specific problems of the children and it will help them to gain insight in factual expectations to have of children with SLI and pSTM deficits.

Depending on the severity of pSTM deficits, children could learn strategies, for instance the use of visual cues, to compensate for their deficits.

Children with SLI learn fewer words in word learning tasks. To make the present experiment feasible, the number of exposures to the words that have to be learned is high. Another factor that could influence the correlation between nonword repetition and word learning is word length. Word length has, especially in children with SLI, a large effect on the ability to repeat nonwords. Children with SLI exhibit larger deficits on repeating three and four syllable words than one and two syllable words compared with typically developing peers (Gathercole, 2006; Marton & Schwarz, 2003; Gathercole & Baddeley, 1990). It is hypothesized that the ability to repeat three syllable words will correlate more strongly with new word learning than the overall performance on the nonword repetition task. Probably, there will be more variability on this particularly difficult part of this task and it is expected that this difficult subtask is a better predictor of word learning. Previous studies did not take this variable into account while analyzing their results. The present study will further explore this relationship.

Concluding, the present study examines the relation between immediate nonword repetition and new word learning in an experiment in a group of children with SLI. Research questions are: (1) What is the correlation between non word repetition and a word learning task in a group of children with SLI? and (2) Is the ability to repeat three syllable words a better predictor of new word learning than the nonword repetition task in general? It is expected that a positive correlation will be found for both questions and that the correlation will be higher for the second research question.

2. Method

Participants

Complete data of 33 children diagnosed with SLI were collected, 25 boys and 8 girls. Three of these children had a bilingual background and the other children were monolingual Dutch. The children were attending three special schools for children with SLI in the Netherlands. Results of language tests were not available, but children were placed in the schools in accordance with the

four formal placement criteria: (1) Severe (SD > -1.5) speech- and/ or language disorders on two or more aspects of language (speech production, speech perception, syntactic knowledge and lexical-semantical knowledge) and average nonverbal cognitive abilities; (2) extremely poor communication skills; (3) at least six months speech and language therapy without making progress and (4) impairment in participating in regular education and not benefiting from help and guidance on a regular school.

In September 2009 Schools were asked to select children from their population for this study on basis of their own records. They were asked to exclude children who had: (1) hearing problems; (2) a non verbal IQ ≤ 85; and (3) additional known handicaps such as autism spectrum disorder.

Forty-eight children were selected and parents gave permission for their children to participate in this study. Preliminary to this experiment, another exclusion criterion was added: phonological problems in speech production. From the selected group of 48 children, seven children did not participate because they left their school during the time that passed between selection and actual participation, five children were excluded because of phonological problems in speech production and three children were excluded because their data were incomplete. The remaining 33 children were tested in April 2012. While the study was running one boy was diagnosed with ADHD; he was not excluded from the sample. The average age of the children was 96.58 months (SD = 17.07).

Design

This experiment was part of a larger study looking into the effect of gestures on word learning[2]. All children participated in a control condition in which no gestures were presented. The children were divided over two groups: one group actively repeated the gestures and a second group did not repeat gestures. The data obtained in the control condition are used in this study. In

[2] This wider experiment aimed to study whether there is evidence for the effectiveness of the use of signs/ gestures in vocabulary training. Macedonia and Knösche (2011) found that words from a foreign language that were encoded with gestures were better memorized by adults. Gestures/ signs are widely used in special schools for language and hearing impaired children in the Netherlands, while there is no convincing evidence that this approach has a positive effect on the language learning of children with SLI (Kouwenberg, Slofstra-Bremer & van Weerdenburg, 2008). But see, Weismer and Hesketh (1993).

this condition the children took part in three tasks: (1) a nonword repetition task, (2) a word learning task and (3) an assessment of vocabulary size.

This method section describes the entire experiment, but data for this study were taken from the control condition only.

Materials

Nonword repetition task. The nonword repetition task comprised 29 nonwords divided in five sets of words that ranged from one to five syllables (Gerrits, 2005) (appendix A). All sets contained six words, except the five syllable set, which contained five items[3]. Nonwords were digitally recorded and the clips were inserted in a PowerPoint presentation. The clips showed a women articulating the target words.

The nonwords were composed in accordance with Dollaghan and Campbell's (1998) guidelines: (1) None of the nonword's syllables corresponded to a lexical item in Dutch; (2) the articulatory complexity of the nonwords was low (e.g., no complex, late-acquired sounds such as /r/; no consonant clusters); (3) no lax vowels were included, because speech perception problems were more likely to occur with syllables comprising lax vowels and (4) every phoneme occurred at most once per nonword.

Word learning task. A word learning paradigm was designed based on tasks used by Gupta (2010). Twelve rare animals were given a new nonword name and children had to learn the (new) names of these animals (appendix B). Lexical factors influencing word learning and nonword repetition were held constant by using the same items as in the nonword repetition task for this word learning task. The words of the nonword repetition task were randomly divided into two sets (set A and set B; see appendix B). Three filler words were added to each set of words to in order to reduce the chance that correct answers were guessed in the test phase. In all, 18 words were presented: 12 target words and 6 filler words. Each set of target words was split up in three groups of one to three syllable words: two words in each group.

The total experiment had three conditions. The conditions and their differences are presented in table 1. All children participated in condition 1, the

3 It was planned that this set of words would contain six words. During data collection, it was noticed that one of the words of the five syllable word set missed in the PowerPoint presentation.

control condition. Half of the children participated in condition 1 and 2 and the other half in condition 1 and 3.

Table 1: conditions of the experiment

Condition	Stimuli	Response
1: control	nonword	nonword
2: passive gesture	nonword + gesture	nonword
3: enactment gesture	nonword + gesture	nonword + gesture

Each target word was presented on six trials on day 1 and on six trials on day 2. A trial consisted of four steps: (1) Presentation of a picture of an animal for three seconds (the picture was visible during the entire length of the trial); (2) two presentations of the associated target word with a one second break in between; (3) a reproduction phase: the child was shown a Powerpoint slide with a question mark which indicated that the child was to reproduce the target word; and (4) repetition of the second and third step. A trial took about 17-20 seconds for the spoken Dutch condition and about 20-25 seconds for the condition with gestures. Trial durationd varied in correspondence to the participants' latencies on step three.

Each trial comprised four presentations of a new word. The total number of exposures to a word was 48 (= (2x6) x4). No feedback was given about the correctness of children's responses. The filler words were presented in a similar way but only in two trials per session (total amount of exposures was 16 (= (2x2) x4). The filler words were excluded from data analysis.

The order of the words was different for each group of children in each session to avoid order effects. All words and gestures were articulated or signed by a woman and recorded on digital film. The clips were inserted in PowerPoint presentations.

Tests of word learning. After the teaching session a test was administered to determine the number of target words the children retained. Children looked en listened to a PowerPoint presentation and had to point at the correct picture on a sheet displaying all nine animals. Halfway, the answering sheet was changed, presenting a new order. After the second test a final test was administered. This test contained all 18 words from both sets of learned words.

All words were articulated by a woman and recorded on digital film. The clips were inserted in the PowerPoint presentation.

Vocabulary assessment. Participant's vocabulary size was assessed with two subtests of a screening instrument for language and reading problems (Verhoeven, 2004). The passive vocabulary test consisted of 72 items and was administered with a laptop computer. Words were presented as sound clips and children had to choose the correct picture from four simultaneously displayed options.

The active vocabulary test consisted of 65 items and was administered live with a book. Both subtests were composed of black-and-white pictures.

Procedure

The experiment took place in a quiet room in the school of the children. The experiment was conducted in two sessions, divided over two days. On the first day the nonword repetition task and session 1 and 2 of the word learning task were administered. After a session, a test was administered to evaluate the knowledge of the target words and filler words. After the second test, a final test was administered. In this test all 18 words were tested. Between all tasks children were given a short break.

On day two, the procedure for the word learning task was similar to that in the first session. Subsequently, the passive and active vocabulary tests were administered. The order of all tasks and tests of the two days of the experiment is shown in table 2.

Table 2: order of all tasks and tests over the two days

day 1:	NWRT	WLT-1	test 1	WLT-2	test 2	final test	
day 2:	WLT-1	test 1	WLT-2	test 2	final test	PV	AV

NWRT = nonword repetition task, WLT = word learning task, PV = passive vocabulary, AV = active vocabulary

The total duration of the experiment was about 120 minutes (spread over two days). There was one day between the two days for most children. Five children had two days in between and for three children session 2 took place the following day.

Nonword repetition task. The nonword repetition task contained three practice items followed by 29 test items. The nonword was first played over the headphones and children were instructed to repeat the nonword. The

experimenter repeated the practice items if the child did not react correctly. The test procedure was aborted when four or more words in the sets with three to five syllable words were incorrectly repeated so as to prevent that children would get frustrated by the procedure. The total number of correct responses was scored.

Word learning task. Children were told that they were going to see and hear names of rare animals. They were instructed to learn the names of these animals. The children wore headphones during the learning sessions. For each condition, children were instructed they had to repeat the name (i.e., the non-word). In the imitation condition they also had to reproduce the gesture that accompanied the animal's name. For the total experiment, children had to learn 12 animal names divided over two sets. Three filler words were added per set. Nine new animal names were presented with gestures and nine animal names were presented in spoken Dutch. In the condition with gestures, half of the children were asked to imitate the gesture (passive gesture). The other half of the children only looked at the gestures (enactment gesture). In total there were four different orders of presentation for both conditions (see table 3). Conditions and sets were counterbalanced to avoid order or set effects.

Table 3: Order of all conditions of the word learning task presented in both the enactment and passive gestures condition. Data for this experiment were taken from the marked cells.

	Session 1	Test 1	Session 2	Test 2	Final test
1	D-A-1/2	A1/A2	G-B-1/2	B1/B2	AB1/ AB 2
2	G-B-1/2	B1/B2	D-A-1/2	A1/A2	AB1/ AB 2
3	D-B-1/2	B1/B2	G-A-1/2	A1/A2	AB1/ AB 2
4	G-A-1/2	A1/A2	D-B-1/2	B1/B2	AB1/ AB 2

D-A-1/2 = Spoken Dutch set A day 1 and 2 (control set)
D-B-1/2 = Spoken Dutch set B day 1 and 2 (control set)
G-A-1/2 = Gestures set A day 1 and 2 (passive gestures or enacted)
G-B-1/2 = Gestures set B day 1 and 2 (passive gestures or enacted)

Tests of word learning. Before this test started, children were asked some distracter questions about their age, school group and home language so as to erase all information of the word learning task from immediate memory. Also for this purpose, each session in the teaching phase ended with a filler word.

In the test phase children heard each word twice through headphones after which they had to point at the correct picture on a sheet displaying all nine animals. When all animals were checked once, another answering sheet was

presented and all words were presented a second time following the same procedure.

After test 2 a final test was administered in which all 18 words were tested. The procedure was almost the same: children heard the word twice and had to point at the correct picture. All animals were checked a second time, but the answering sheet stayed the same the total test. The order of presentation of the words varied in all tests, as did the presentation of the pictures on the answering sheets.

No feedback was given about the children's responses. A word was scored correct when a child provided the correct answer both times and the total number of words retained was computed.

Vocabulary tests. The passive vocabulary test was administered with a laptop computer. Children heard a target word and had to choose the correct picture by using a computer mouse. There were 3 practice items; these items were repeated until children chose the correct drawing. The test was aborted when four consecutive items were wrong. The active vocabulary test was administered live and was aborted when five consecutive answers were wrong. Children had to answer questions or had to complete a sentence spoken out by the experimenter. If children interpreted the drawings wrong it was allowed to repeat test items once. This test had two practice items.

3. Results

The total score on the nonword repetition task was computed as a proportion, i.e. the quotient of number of correctly repeated words and the maximum number of correct responses. The same procedure was repeated for each of the subsets of words with different lengths (1 - 3 syllables). Raw scores of the vocabulary assessment were used for data analysis. Table 4 shows the scores for the nonword repetition task and the vocabulary tests.

Table 4: Results of the nonword repetition task and the vocabulary tests. The outcomes of the nonword repetition task are given as the proportion of correct answers.

Task	Mean	SD
Nonword repetition	0.42	0.12
Nonword repetition one syllable items	0.78	0.18
Nonword repetition two syllable items	0.8	0.19
Nonword repetition three syllable items	0.41	0.25
Passive vocabulary	32.09	10.43
Active vocabulary	20.73	6.44

For the word learning task, target words that were correctly produced twice on each test were counted as correct and a total score was calculated as the proportion of correct answers. Next, scores for the separate word length sets were computed. Table 5 shows the outcomes of the word learning task for the two days separately as well as for the total experiment.

Table 5: Average proportions of words correctly remembered of the word learning task (standard deviations in parentheses). The outcomes are given as the proportion of correct answers.

Task	Day 1	Day 2	Total
Word learning task	0.32 (0.22)	0.51 (0.28)	0.42 (0.23)
Word learning task one syllable items	0.42 (0.37)	0.61 (0.39)	0.52 (0.36)
Word learning task two syllable items	0.27 (0.29)	0.47 (0.32)	0.37 (0.28)
Word learning task three syllable items	0.27 (0.34)	0.45 (0.43)	0.36 (0.36)

On average, a proportion of 0.42 of the nonwords on the nonword repetition task was repeated correctly. A repeated measures analysis of variance was conducted to compare the three word length sets with each other. The results of this statistical test revealed that the three word length sets differed significantly from each other: $F\ (_{2,64}) = 59.298$, $p < .01$. Post hoc testing with Bonferroni correction showed a significant difference between the one and three syllable words and the two and three syllable words (p's < .01). Thus, the three syllable words were more often repeated incorrectly than the one and two syllable words.

The four and five syllable words from the nonword repetition task were excluded from further analysis, because too few children completed the sets of this task (four syllable words: n = 8 children; five syllable words: n = 2 children).

The average proportion of retained words was 0.42 (sd = 0.23). A paired t-test revealed that the number or words retained, increased over the two days: $t\ (_{32}) = -6{,}045$, $p < .01$. For the separate word length sets similar effects were

found; one syllable words: $t\ (_{32}) = -4.18$, $p < .01$; two syllable words: $t\ (_{32}) = -4.782$, $p < .01$; three syllable words: $t\ (_{32}) = -3.91$, $p < .01$.

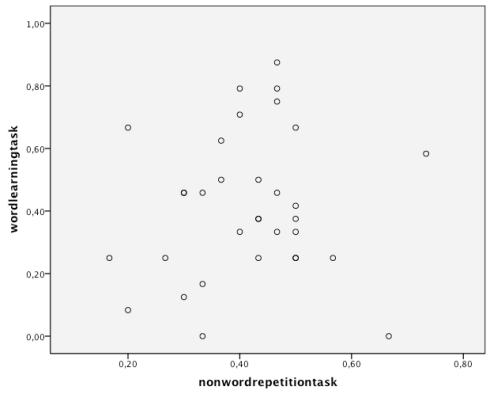
A repeated measures analysis of variance was conducted to compare the results of the three word length sets of the word learning task. Although visual inspection of the data suggested that the one syllable words were retained better than the two and three syllable words, this difference did not reach significance ($F(_{2,64}) = 2.826$, $p > .05$).

Next, a two-way repeated measures ANOVA was conducted with the two days and the separate word length sets of the word learning task as within-subjects variables and the number of learned words as dependent variable. The findings of this ANOVA were consistent with the findings reported above. Across word length sets, the children had retained more words on the second day than on the first day. The difference between the two days was significant: $F\ (_{1,32}) = 36.542$, $p < .01$. The main effect for word length set was not significant ($F\ (_{1,32}) = 3.498$, $p > .05$). The children learned an equal amount of words in all word length sets over the two days. There was no interaction between the two days and the word length sets: these variables were not dependent on each other.

Correlational analyses

Nonword repetition and word learning. A scatterplot of the independent variable nonword repetition and the dependent variable word learning is shown in figure 2. The scatterplot does not suggest a correlation between the two variables. This was confirmed by calculating the correlation coefficient. The correlation between nonword repetition and new word learning in these data was weak and not statistically reliable ($r = .106$, $p > .1$).

Figure 2: Scatterplot of the nonword repetition task with the word learning task



Nonword repetition, word learning and vocabulary. Next, the correlation coefficients between vocabulary, nonword repetition and word learning were calculated (see table 6). None of the experimental measures under study correlated; there was no significant association between vocabulary, word learning and nonword repetition.

Table 6: Correlations between the nonword repetition task, word learning task and the vocabulary assessment.

task	PV	AV	NWRT	WLT
PV	1			
AV	.599*	1		
NWRT	-.113	-.80	1	
WLT	.063	.192	.106	1

NWRT = nonword repetition task, WLT = word learning task, PV = passive vocabulary test and AV = active vocabulary test
* p< .01

The passive and active vocabulary tests did correlate with each other. Children with high scores on the passive vocabulary test also gained high scores on the active vocabulary test.

Word length, nonword repetition and word learning. The second, exploratory question of this study concerned the effect of word length. Because not all variables were distributed normally, Spearman's rank correlation coefficient was used for all calculations. The correlation coefficients are presented in table 7.

Table 7: Correlations between the scores on the nonword repetition task, the word learning task and the separate word length setss of these two tasks.

task	NWRT	WLT	NWRT 1	NWRT 2	NWRT 3	WLT 1	WLT 2	WLT 3
NWRT	1							
WLT	.095	1						
NWRT 1	.501**	.071	1					
NWRT 2	.762**	.143	.381*	1				
NWRT 3	.834**	.056	.166	.425*	1			
WLT 1	.083	.708**	.107	.116	.048	1		
WLT 2	-.173	.605**	-.112	-0.13	-.191	.238	1	
WLT 3	.169	.704**	.060	.038	.220	.132	.290	1

NWRT = nonword repetition task, WLT = word learning task, NWRT 1-3 = separate word length setss of nonword repetition task and WLT 1-3 = separate word length setss of word learning task
* p< .05, ** p<.01

There was a weak correlation between the three syllable words on the nonword repetition task and the total word learning task (*r* = .056). No

association between the ability to repeat longer nonwords and the ability to learn new words was detected.

Moderate to strong correlations between the partial and total nonword repetition task subsets were found. Children who did well on, for instance, the one syllable words on the nonword repetition task also did well on the total nonword repetition task. There was a correlation between the one and two syllable words and two and three syllable words, but the one and three syllable words were not associated. Nor were the word length sets of the word learning task.

4. Discussion

Summary and main findings

In one experiment, the strength of the relationship between nonword repetition and performance on a word learning task was studied in a group of children with SLI. According to current theorizing, short term storage capacity, as indicated by nonword repetition performance, is a critical factor in word learning. Previous studies on typically developing children have reported moderate correlations between nonword repetition performance and word learning. Because performance on both tasks is influenced by lexical factors and the phonological construction of the items, this study used the same nonword items for both tasks. It was hypothesized that the relationship between the three syllable words of the nonword repetition task and the total word learning task would be stronger than the relationship between the two tasks in general. Thus, an at least moderate correlation between the two tasks in general and a strong correlation coefficient between the three syllable words of the nonword repetition task and the total word learning task was predicted.

However, the predicted relationship between nonword repetition and word learning was not observed: the correlation between the two tasks was weak and not statistically reliable. When the data were explored per word length set, the expected stronger relationship between the ability to repeat three syllable nonwords and new word learning was not found: similar weak correlation was revealed. The data are not consistent with the general

hypothesis that phonological short term memory capacity constrains the learning of new word forms.

Discussion of main findings

This study found no association between nonword repetition and word learning in children with SLI, while other studies found moderate correlations for typically developing children (Gathercole & Baddeley, 1990; Michas & Henry, 1994; Horohov & Oetting, 2004; Gray, 2004, Gupta, 2010). The absence of a correlation is surprising, because the use of the same vocabulary for both the nonword repetition task and the word learning task was expected to increase the strength of the correlation. The findings of this experiment indicate that this relationship, that was observed in children with normal language, might not exist in children with SLI or, at least, was not detected in this experiment. Because this study was part of a wider study that primarily aimed to study the effectiveness of the use of signs/ gestures for vocabulary training, several factors in the design of this study may have had an impact on the outcomes. These factors will be discussed first in this section.

The two conditions with gestures that were not relevant to this study may have caused unwanted variability. The gesture conditions forced the study to use two sets of words for the word learning task. For this purpose, the words of the nonword repetition task were randomly split into two sets. Post hoc analysis, however, revealed that children performed better on the words of set B in comparison to the words of set A of the word learning task (set A: M = .31; set B: M = .54; $t\ (_{31}) = -3.182$, $p < .01$). Apparently, items in set B were easier to learn than items in set A. Approximately half of the participants received more difficult items. The specific features of the items of the word learning task seemed to differ between the two sets of words.

Another possibility that could explain the results of this study is that the number of items per word length set was too small. Support for this suggestion was found in the correlational data of this study. The one, two and three syllable words of the nonword repetition task were moderately correlated. The one, two and three syllable word sets of the word learning task were not correlated at all. Children who performed best on the one syllable words of the word learning

task, would also have been expected to perform best at the two and three syllable words. This pattern did not occur and could have been more easily detected if there were more items in each set of words. More items would have increased the distribution of the word length sets to normality.

The nonword repetition task did reveal the difficulties that children with SLI have with repeating nonwords longer than two syllables. As expected, the one and two syllable words of the nonword repetition task were better repeated than the three syllables words. Marton and Schwarz (2003) and Gathercole and Baddeley (1990) also found that children with SLI had marked impairments in the repetition of three- and four syllable nonwords. In the current study most children (n = 25) made so many mistakes on the three syllable words of the nonword repetition task that the test was aborted after this part of the task.

It was hypothesized that the relationship between a more difficult task, repeating three syllable words, and word learning would be stronger than the relationship between the two tasks in general. A more difficult task will produce more varying results, thus more variance in the three syllable word group was expected. This was confirmed by the data. The ANOVA that compared the means of the word length sets of the nonword repetition task was significant: $F_{(2,64)} = 59.298$, $p < .01$. Nevertheless, the hypothesis that the relationship between repeating three syllable words and word learning in general would be stronger than the relationship on both tasks in general, was rejected: the correlation between the three syllable word set of the nonword repetition task and word learning in general was just as weak as the correlation between the total nonword repetition task and word learning. The question remains whether a stronger relationship between the three syllable words of the nonword repetition task and word learning in general could have been yielded with a larger number of items per word length set. Another explanation could be that repeating three syllable words is so difficult for children with SLI that this is a marker for their language deficits like nonword repetition in general has been stated as a marker for SLI by Coady & Evans (2008), Gathercole (2006) and Bishop (2006).

Consequently, this study would have been stronger if all children had learned the same words and if each word length set would have contained more

items. The latter would have increased the stability of the tasks and the distributions per word length set would have increased to normality. In this particular scenario, a significant correlation might have been observed.

The data of this experiment show the effectiveness of the word learning task. On the second day of the experiment on average 51 percent of all words were learned: the task was feasible for children with SLI. The high number of exposures to words and an assessment based on new word comprehension might have been factors that did contribute to this, as stated by Coady & Evans (2008). There was also a significant increase in performance on the word learning task over the two days. On the first day 32 percent of the words was learned and on the second day 52 percent of the words was learned.

Children seemed to have performed best on the one syllable words of the word learning task (one syllable M = 0.52, two syllable M = 0.37, three syllable M = 0.36). These differences did not reach significance; maybe the number of items per group was too small for this variable too for this difference to be detected.

Another factor contributing to variability in the data was the participant group. During data analysis, it became clear that the participant group contained two age groups: a younger group (YC) with an average age of seven (n = 21, M = 84.48) and an older group (OC) with an average age of almost ten (n = 12, M = 117.75). The effect of developmental changes over the time span of three years between the two groups is conceivable. Van Weerdenburg et. al (2006) state that areas of linguistic difficulty change over time in children with SLI. Also, the ability to repeat nonwords changes with age, as it is influenced by nonverbal abilities, phonological abilities and semantic knowledge (Chiat, 2006). The older children had a larger vocabulary: passive vocabulary OC: M = 39.50; YC: M = 27.86; $t\ (_{31}) = 3.621$, $p < .01$ and active vocabulary OC: M = 24.42; YC: M = 18.62; $t\ (_{31}) = 2.725$, $p = .01$. Therefore, the older children could have had an advantage on the nonword repetition task. Surprisingly, both groups performed almost equally on this task (YC: M = 0.41; OC: M = 0.42, Mann-Whitney U: $p > .1$). Maybe the performance of the older children on the nonword repetition task was affected by ceiling effects: the older children did not do better because repetition skills do not grow from a certain age.

Although the data seemed to show that the older children learned more words than the younger children (YC: M = 0.38; OC: M = 0.47), this difference was not significant ($t_{(31)} = 1.072$, $p > .1$), which may be due to a lack of statistical power because of the small sample size.

A feature of this experiment that might have contributed to the weak correlation coefficients is the fact that children with SLI are a heterogeneous group. Many, but not all, have difficulties with lexical semantic abilities (van Weerdenburg, Verhoeven & van Balkom, 2006; Gillis & Schaerlaekens, 2000). The underlying problems for SLI might be different for specific subgroups of children (Ellis Weismer & Edwards, 2006). The heterogeneity of a sample will have its effect on each study with children with SLI as predicting other abilities from a heterogeneous group will be difficult. Furthermore, many children with SLI have problems with several components of attention that play a role in language processing (Finneran, Francis & Leonard, 2009; Ebert & Kohnert, 2011). Since this experiment took 60 minutes per day and the learning sessions of the word learning task lasted 15-20 minutes, this experiment appealed to the abilities of the children. This might have been a confounding variable in accordance with other studies in which fewer words were learned and participants were typically developing children or adults whose attention skills will exceed the sample of this study.

As mentioned above, the data yielded with the vocabulary assessment showed that the older children had a larger vocabulary than the younger children. There was no association between the nonword repetition task and the vocabulary assessment. This finding is consistent with other research, because for children with SLI the association between vocabulary and nonword repetition is not as clear as for children with normal language (Graf-Estes, Evans & Else-Quest, 2007; Gupta & Tisdale, 2009). In the group of children with SLI, several studies on this topic have different outcomes (Coady & Evans, 2008). A factor that seems to play a role in these outcomes is age. From the age of five the relationship between nonword repetition and vocabulary changes in directionality. The increase of vocabulary changes the manner in which new words are phonologically processed. From this age children use their vocabulary knowledge to repeat nonwords. Studies with children with SLI aged

more than five did not find a relation between vocabulary and nonword repetition (Coady & Evans, 2008). From that, the findings of this study, whose participants were all older than five, are consistent with other research.

Implications and recommendations

Theoretically, temporary phonological short term memory has a role in word form learning (Coady & Evans, 2008; Gathercole, 2006). A new word form must be maintained in pSTM, before a long term equivalent can be stored. Unfortunately, experimental conditions are not comparable to normal word learning. Not only is natural word learning more than learning a word form (word form must be paired with word meaning), but also, most words are learned incidentally, without direct teaching (Brackenbury & Pye, 2005). However, new word form learning and phonological short term memory have a shared basis and are important for the development of oral language and literacy (Gray, 2004; van Weerdenburg, Verhoeven, Bosman & van Balkom, 2011).

Since the outcomes of this experiment may have been biased by several factors, recommendations for future research on this topic are that as much variability as possible should be reduced by selecting more participants from one age group. The effects of age on nonword repetition and word learning should be considered. Since the older children did not perform better on the nonword repetition task than the younger children, the influence of age on nonword repetition could be examined in more detail. The stimuli of the tasks should be selected with care and more stimuli per word length set should be added. Variables that will add no appropriate information could be excluded. It is recommended to use the same vocabulary in both tasks as this study did. Also, feasibility of the task is important: children with SLI need a high number of exposures to the words to be able to learn them. Future research has the difficult task to balance between adding more words per word length set and the needed amount of exposures in order to avoid too long sessions. The minimal number of exposures for a word learning task needed to avoid floor effects is not clear and could be examined in future studies.

It is an empirical finding that nonwords longer than two syllables are more difficult to repeat. It is worth considering the effect of this finding on new word learning as this study tried. Additionally, nonword repetition is considered

a marker of language deficits by several authors (Coady & Evans, 2008; Gathercole, 2006; Bishop, 2006). It would be interesting to study whether the ability to repeat nonwords of three syllables (and longer) will be a better marker for language deficits than performance on a nonword repetition task in general.

Children with SLI have problems with lexical semantic abilities and their vocabularies are less varied (Mainela-Arnold, Evans & Coady, 2010; Gray, 2004). Their acquisition of new word forms is impaired (Coady & Evans, 2008; Gathercole & Baddeley, 1990) and one hypothesis on the underlying cause of these problems is that new word form learning is constrained by the deficits these children have in phonological working memory (Montgomery et al., 2010; Gray, 2004). This experiment increased the knowledge on new word form learning and phonological short term memory in a group of children with SLI. The strength of the relationship between the two measures is not clear yet, but the present study added knowledge on the best methodology to study these phenomena. This type of research forms the base for the development of the most effective intervention or strategy to help children with SLI gain an age appropriate vocabulary. And more specific, the best way to teach children with SLI new word forms.

Conclusions

The data reflected an inconsistent pattern in comparison with the general hypothesis that phonological short term memory capacity constrains the learning of new word forms in experimental conditions and is, dependent on age, associated with measures of vocabulary. Several possible explanations for these findings are provided, including the design of the study, the participant group, the construction of the word learning task and the ability to generalize findings to normal word learning. There was no relationship between nonword repetition and new word learning for this group of children with SLI. Does this relationship not exist, because children with SLI develop language differently from children with normal language or does the relationship exist and is the extent not clear yet?

References

Archibald, L.M.D. & Gathercole, S.E. (2006). Short-term and working memory in specific language impairment. International Journal of Language & Communication Disorders, 41, 1-40.

Baddeley, A. (2000). The episodic buffer: a new component of working memory? Trends in Cognitive Sciences, 4, 417-423.

Baddeley, A. (2003). Working memory and language: an overview. Journal of Communication Disorders, 36, 189-208.

Baddeley, A. & Gathercole, S. (1998). The phonological loop as a language learning device. *Psychological review, 105,* 158-173.

Bishop, D.V.M. (2006). What causes specific language impairment in children? *Current directions in psychological science, 15,* 217-221.

Brackenbury, T. & Pye, C. (2005). Semantic deficits in children with language impairments: issues for clinical assessment. *Speech and Hearing Services in Schools, 36*, 5-16.

Chiat, S. (2006). Commentaries: Growing contributions of vocabulary. *Applied psycholinguistics 27,* 545-598.

Coady, J.A. & Evans, J.L. (2008). Uses and interpretations of non-word repetition tasks in children with and without specific language impairment (SLI). *International Journal of Language & Communication Disorders, 43,* 1-40.

Dollaghan, C. & Campbell, T.F. (1998). Nonword repetition and child language impairment. *Journal of Speech, Language, and Hearing Research, 41,* 1136-1147.

Ebert, K.D. & Kohnert, K. (2011). Sustained Attention in Children With Primary Language Impairment: A Meta-Analysis. *Journal of Speech, Language, and Hearing Research, 54,* 1372-1384.

Finneran, D.A., Francis, A.L. & Leonard, L.B. (2009). Sustained attention in children with Specific Language Impairment (SLI). *Journal of Speech, Language, and Hearing Research, 52,* 915-929.

Gathercole, S.E. (1990). The role of phonological memory in vocabulary acquisition: a study of young children learning new names. *British Journal of Psychology, 81,* 439-454.

Gathercole, S.E. (2006). Nonword repetition and word learning: the nature of the relationship. *Applied psycholinguistics, 27,* 513-543.

Gathercole, S.E. & Baddeley, A.D. (1990a). The role of phonological memory in vocabulary acquisition: a study of young children learning new names. *British Journal of Psychology, 81,* 439-454.

Gathercole S.E. & Baddeley, A.D. (1990b). Phonological memory deficits in language disordered children: is there a causal connection? *Journal of Memory and Language, 29,* 336-360.

Gerrits, E. (2005). Taaldiagnostiek bij meertalige kinderen: problemen en oplossingen. *Toegepaste Taalwetenschap in Artikelen, 74,* 169-177.

Gillis, S. & Schaerlaekens (Ed.) (2000). *Kindertaalverwerving een handboek voor het Nederlands.* Groningen, The Netherlands: Martinus Nijhoff uitgevers.

Graf Estes, K., Evans, J.L. & Else-Quest, N.M. (2007). Differences in the nonword repetition performance of children with and without specific language impairment: a meta-analysis. *Journal of Speech, Language, and Hearing Research, 50,* 177–195.

Gray, S. (2003). Word-learning by preschoolers with specific language impairment: what predicts success? *Journal of Speech, Language, and Hearing Research, 46,* 56-67.

Gray, S. (2004). Word learning by preschoolers with specific language impairment: predictors and poor learners. *Journal of Speech, Language, and Hearing Research 47: 1117–1132.*

Gupta, P. (2010). Examining the relationship between word learning, nonword repetition, and immediate serial recall in adults. *The Quarterly Journal of Experimental Psychology, 56,* 1213-1236.

Gupta, P. & Tisdale, J. (2009). Does phonological short-term memory causally determine vocabulary learning? Toward a computational resolution of the debate. *Journal of Memory and Language, 61,* 481-502.

Horohov, J.E. & Oetting, J.B. (2004). Effects of manipulations on the word learning-abilities of children with and without language impairment. *Applied psycholinguistics, 25,* 43-65.

Jarrold, C., Thorn, A.S.C. & Stephens, E. (2009). The relationships among verbal short-term memory, phonological awareness, and new word learning: evidence from typical development and Down syndrome. *Journal of Experimental Child Psychology, 102,* 196-218.

Kan, P.F. & Windsor, J. (2011). Word learning in children with primary language impairment: a meta-analysis. *Journal of Speech, Language, and Hearing Research, 53,* 739-756.

Kouwenberg, M., Slofstra-Bremer, C. & van Weerdenburg, M. (2008). Gestures en gebaren bij specifieke taalontwikkelingsstoornissen: een overzicht van literatuur. *Stem-, Spraak- en Taalpathologie, 16,* 69-87.

Macedonia, M. & Knösche, T.R. (2011). Body in mind: how gestures empower foreign language learning*. Mind, Brain and Education, 5,* 196-211.

Marton, K. & Schwarz, R.G. (2003). Working memory capacity and language processes in children with specific language impairment. *Journal of Speech, Language, and Hearing Research, 46,* 1138-1153.

Mainela-Arnold, E., Evans, J.L. & Coady, J.A. (2010). Explaining lexical-semantic deficits in specific language impairment: the role of phonological similarity, phonological working memory, and lexical competition. *Journal of Speech, Language, and Hearing Research, 53,* 1742-1756.

Michas, I.C. & Henry, L.A. (1994). The link between phonological memory and vocabulary acquisition. *British Journal of Developmental Psychology, 12,* 147-163.

Montgomery, J.W., Magimairaj, B.M. & Finney, M.C. (2010). Working memory and specific language impairment: an update on the relation and perspectives on assessment and treatment. *American Journal of Speech-Language Pathology, 19,* 78-94.

Van Weerdenburg, M., Verhoeven, L. & van Balkom, H. (2006). Towards a typology of specific language impairment. *Journal of Child Psychology and Psychiatry, 47,* 176-189.

Van Weerdenburg, M., Verhoeven, L., Bosman, A. & van Balkom, H. (2011). Predicting word decoding and word spelling development in children with Specific Language Impairment. *Journal of Communication Disorders, 44,* 392-411.

Verhoeven, L. (2004). *Screeningtest voor Taal- en Leesproblemen.* Arnhem, NL: CITO.

Weismer, S.E. & Hesketh, L.J. (1993). The influence of prosodic and gestural cues on novel word acquisition by children with specific language impairment. *Journal of Speech, Language, and Hearing Research, 36,* 1013-1025.

Appendix A

Nonword repetition task[4]

a. toes
b. peef
c. mie-FAAP

1. jiek
2. mieg
3. neek
4. paaf
5. soel
6. teip

7. fie-PAAS
8. jie-FOOT
9. kee-FUUS
10. pee-LOEM
11. soe-FEEP
12. woo-KAAN

13. doo-FIE-neep
14. joe-SEE-waun
15. kie-LOE-meef
16. noe-PIE-faat
17. suu-TIE-moof
18. waa-FEI-lien

19. bee-PUU-taa-soef
20. kaa-JEE-muu-teip
21. lee-TOO-mie-foes
22. puu-SOE-daa-jien
23. sie-BAA-too-neek
24. tie-KEE-poo-faam

25. baa-woo-VUU-lie-zeen
26. kee-pie-SOE-fuu-taus
27. lee-daa-NOO-kie-moef
28. pee-taa-SEI-koo-nief
29. tie-waa-KEE-soe-faup

4 Stressed syllables are printed in capitals

Appendix B

Words of word learning task[5]

Set A	Set B
Target words:	Target words:
neek	teip
mieg	soel
wo-KAAN	pee-LOEM
kee-FUUS	jie-FOOT
suu-TIE-moof	waa-FEI-lien
noe-PIE-faat	joe-SEE-waun
Filler words:	Filler words:
paaf	jiek
fie-PAAS	soe-FEEP
doo-FIE-neep	kie-LOE-meef

5 Stressed syllables are printed in capitals