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Master's Thesis

The influence of orthography on Dutch children's past tense production

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Contents

Abstract

Background:

Dyslexia is a language-based disorder. It probably stems from an underlying phonological deficit, which results in problems with phonological tasks. Besides that, research has shown that dyslexics also have subtle language impairments. The present study looked into the morpho-phonological process of past tense inflection and the impact of orthography.

Aims:

The main purpose was to compare the results of 9-year-old normal and poor readers on a past tense experiment in which the children had to inflect verbs and pseudo-verbs. An additional comparison was made with 6-year-old children and adults. The second research question was whether 9-year-old poor readers perform better on the past-tense experiment in the orthographic modality, where the stimuli were presented both auditorily and visually.

Methods:

The past tense experiment of Vreugdenhil (2010) was used to elicit the past tense of verbs and pseudo-verbs with stem-final obstruents. The participants were either exposed to an auditory or an orthographic version of the experiment.

Results and outcomes:

The results demonstrated that 9-year-old poor readers do not differ from normal readers on the number of correctly inflected past tense forms for either verbs or pseudo-verbs. They were equally good at producing the past tense overall. However, the 9-year-old normal readers performed better when orthography was provided, whereas the poor readers did not benefit from the orthography.

Keywords: *past tense, voicing, morpho-phonology, orthography, reading disorder, dyslexia*

1. Introduction

In Dutch, the past tense is created by adding the suffix /–te/ ([tə]) or /–de/ ([də]) to the verb stem. The past tense inflection depends on the interaction between morphology and phonology, as the correct past tense suffix is determined by the phonological structure of the verb stem. In Dutch, a voiceless phoneme is followed by /-tə/, for example *ko<u>k</u>en* ("to cook") becomes *kook-te*, and a voiced phoneme is followed by /-də/, for example *ka<u>mm</u>en* ("to comb") becomes *kam-de*, as will be explained in more detail later. The present study builds on the research of Rispens & de Bree (2010) and of Vreugdenhil (2010), who both studied the past tense inflection in school-aged children. Rispens & de Bree (2010) investigated whether Dutch children with specific language impairment (SLI) were sensitive to phonological constraints of past tense morphology and compared the results with typically developing (TD) children. They used both verbs and pseudo-verbs as test stimuli with stems ending in voiceless obstruents ([k], [s] or [p]) or sonorants ([l], [r], [w], [m], or [n]). For these phonemes it is actually quite obvious to choose between the past tense suffix /–tə/ or /–də/ because the phonemes are either voiced or voiceless. The results demonstrated that children generally prefer voiceless obstruent clusters, i.e. /-tə/, despite the known fact that in Dutch the number of verbs inflected with the voiced suffix /-də/ is higher than the frequency of verbs inflected with a voiceless suffix[1]. Vreugdenhil (2010) conducted a similar experiment but looked at a more complicated pattern, namely the obstruents which can be both voiceless and voiced. In these cases it is absolutely necessary to make a distinction between voiced or voiceless stem-final obstruents to choose the correct past tense suffix. The main question of Vreugdenhil (2010) was whether children have a preference for /-tə/ or /-də/ in the past tense. Besides that, she also studied the influence of orthography, whether the orthography affects the preference for a voiceless or voiced past tense suffix. The results showed a clear preference for the voiced suffix /-də/ for the 9-year-old children against a preference for the voiceless suffix /-tə/ for the adults. Furthermore, the results showed that the orthography helps the participants (mainly the adults) with the inflection of pseudo-verbs, as there were generally fewer voice errors in the orthographical version compared to the auditory version. In the inflection of the neutral pseudo-verbs the orthography assists the adults in their choice on voicing, whereas the 9-year-old children did not rely on the orthographical cue when it comes to the consistent versus inconsistent pseudo-verbs.

[1] Rispens & de Bree (2010) also found a significant difference between the production of past tenses by typically developing children and SLI children.

Ernestus & Baayen (2001, 2003) have also examined the past tense production in Dutch adults. They asked Dutch participants to write down the regular past-tense forms of existing Dutch verbs and pseudo-verbs. For example, after hearing the pseudo-verb [Ik dAp], participants had to write down *ik dap<u>te</u>* or *ik dab<u>de</u>*. In some cases the participants wrote down illegal clusters , e.g. *[-bte] for pseudo-verbs. The results of Ernestus & Baayen (2001) demonstrated that the participants sometimes produced past tense forms for verbs violating the rule (i.e. /-tə/ is not always followed after a voiceless obstruent), where their decision is based on words that are phonologically similar to the given verb and take this suffix as well. This finding means that speakers tend to create past tense forms by analogy to existing words. In the study of Ernestus & Baayen (2003), they found the same results for pseudo-verbs, as Dutch speakers based again their interpretation of the final obstruent of pseudo-verbs on the phonologically similar existing words.

In the present study the inflection of past tense verbs and pseudo-verbs was examined in poorly reading children (including dyslexics) and also the effect of the orthography was investigated further. Before going into the past tense inflection in Dutch and the role of the orthography, information about reading problems is given.

1.1 Problems with reading

In the Netherlands around 9% of children in primary schools have problems with reading and around 4% of school-aged children are actually diagnosed with dyslexia (Blomert, 2002). Children with reading disorders have problems with reading and/or spelling, for instance they have problems with the accuracy and speed of reading. Dyslexia is the most well-known reading disorder. According to Lyon (1995), dyslexia is a specific language-based disorder characterized by persistent problems in reading and/or spelling that are unexpected in relation to cognitive abilities and age. Specifically, the reading problems encountered in dyslexia are problems in word-decoding and are most obvious when dyslexics are reading aloud. Some dyslexics have to spell out nearly every word, which results in a slow reading rate whereas others read inaccurately (e.g. omission of words, words read incorrectly) (Huizinga, 2000). To make a distinction between dyslexics and weak word-decoding readers (generally called poor readers) the word "persistent" is very important. Dyslexics have a persistent automatization deficit, which results in having problems with reading tasks. Besides that, dyslexics also have problems in other areas, for instance language skills and memory. Poor readers mostly only have problems with the onset of reading; they develop reading slower than typically developing readers (van der Leij, 2003).

1.1.1 Phonological deficit

What exactly cause(s) dyslexia is still a theoretical dispute. The most widely accepted explanation of dyslexia is that it stems from an underlying phonological deficit (Snowling, 2001). This hypothesis proposed that dyslexia is caused by poor phonological awareness, which refers to the ability to perceive and manipulate the sounds of spoken words (Castles et al., 2003). The brains of dyslexics code phonology less efficiently compared to normal reading children, leading to difficulties with encoding, maintaining and retrieving phonological representations (de Bree, 2007). It is assumed that phonological awareness is related to the success of learning to read because it indicates an awareness of the internal structure of words (Carlisle & Nomanbhoy, 1993). However, Castle et al. (2003) also described that there may be a danger of overstating the association between phonological awareness and reading because there should be more caution in the interpretation of phonological awareness test results.

Children with dyslexia have phonological difficulties and are therefore relatively insensitive to the internal structure of words for instance of regular past tense inflections. When children have problems with reading (e.g. because of dyslexia) it reduces the exposure to morphologically complex words in print, which in turn could affect the development of children's explicit knowledge of grammar (Egan & Pring, 2004). Studies have shown that dyslexic children are poorer on spoken tasks of inflectional morphology compared to peers, including the study of Egan & Pring (2004). They showed that dyslexic children do not have deficits in morphological processing in spoken language in relation to their reading ability, but they are slower at reading and less accurate at spelling regularly inflected verbs compared with normal reading children. A study by Joanisse et al. (2000) indicates that phoneme awareness and inflectional morphology are deficient in dyslexics. They assumed that morphological difficulties are likely to be a consequence of the phonological impairment. In English, the paste tense suffix /ed/ occurs in three forms ([-t], [-d] or [Id]). The correct variant is determined by the phonological structure of the verbs stem. Difficulty analyzing phonological structures could therefore affect the acquisition of the past tense.

Because of the subtle language problems which occur in dyslexics the assumption exists that there is an overlap with SLI (Bishop et al., 2009). Therefore, much research has been done on the distinction between SLI and dyslexia. Studies with children at family risk for dyslexia (which have at least one parent with dyslexia) and children with SLI show that both groups have lower scores on language tasks compared to typically developing children (Bishop & Snowling, 2004; de Bree, 2007; Rispens & Been, 2007; de Bree, Wijnen, Gerrits,

2010). However, the at-risk children generally score better than the SLI children. It can be concluded that children with dyslexia may have subtle language problems but they are not as severe as those found in the developmentally language impaired children (Joanisse et al., 2000).

1.1.2 Orthography

The kind of orthography, transparent or opaque, has an influence on the severity of reading and spelling problems. Dutch, for instance, has a relatively transparent orthography (Blomert & Willems, 2010), where graphemes generally represent only one phoneme. English and French in contrast, have an opaque orthography, where individual graphemes represent a number of different phonemes in different words (Spencer & Hanley, 2003). As noted in many studies (Blomert & Willems, 2010; Castles et al., 2003) it is easier to learn the associations between graphemes and phonemes in a language with a transparent orthography (e.g. Spanish, Italian) than in English (Spencer & Hanley, 2003).

In English children can choose between [-t], [-d] or [Id] in the orthography for the past tense phonemes /t/ and /d/. The study of Egan & Pring (2004) has shown that dyslexics have problems with written tasks of inflectional morphology, as there are different orthographic representations of the past tense phonemes. Dyslexic children have weak orthographic representation, due to problems with the acquisition of reading. Therefore, when they are faced with two spelling options they choose the most familiar one rather than the spelling pattern that should be chosen following the linguistic rules.

The study of Castles et al. (2003) showed that the written form of words positively influenced the performance on phonological awareness tasks. This only applies for participants (adults and 11-year-old children) with stronger orthographic skills. They concluded that a direct link exists between phonological awareness and orthographic ability. However, this link is weaker in poor readers than in normal readers. So, poor reading children make less use of the orthography and therefore have more problems with the representation of for instance past tense verbs.

In the previous paragraphs reading disorders, the phonological deficit and the connection to grammar, and the relation between orthography and reading has been described. In the following paragraph more information about Dutch grammar is provided, namely the past tense production in Dutch, including voicing and devoicing of obstruents and the interaction of voicing on vowel length in verbs.

1.2 Past tense in Dutch

In Dutch, the regular past tense is formed by adding the suffix –de ([də]) or –te ([tə]) to the verb stem. The selection of the regular past tense suffix is determined by the final phoneme of the verb stem. Verb stems ending in a voiceless consonant take /–tə(n)/, all other cases take /–də(n)/, i.e. after voiced obstruents, sonorants and vowels (Booij, 1995; de Jong, 1999). This is illustrated in (1)[2]. The obstruents include plosives ([p,b] an [t,d]) as well as fricatives ([s,z] and [f,v]); they can be both voiceless and voiced, except the voiceless velar plosive [k] which does not have a voiced counterpart in Dutch. Liquids ([l,r]), nasals ([m,n,ŋ]) and glides ([j,w]) belong to the sonorants and are nearly always voiced (Rietveld & van Heuven, 2001).

(1)	*Infinitive and stem of the verb*			*Singular past tense form*	
a.	*koken* [kokən]	*kook* [kok]	"cook"	*kookte* [koktə]	"cooked"
	schoppen [sxɔpən]	*schop* [sxɔp]	"kick"	*schopte* [sxɔptə]	"kicked"
	zagen [zaɣən]	*zaag* [zaɣ]	"saw"	*zaagde* [zaɣdə]	"sawed"
	kammen [kɑmən]	*kam* [kɑm]	"comb"	*kamde* [kɑmdə]	"combed"
b.	*leven* [levən]	*leef* [lef]	"live"	*leefde* [levdə]	"lived"
	grazen [xrazən]	*graas* [xras]	"graze"	*graasde* [xrasdə]	"grazed"
c.	*schudden* [sxYdən]	*schud* [sxYt]	"shake"	*schudde* [sxYdə]	"shaked"
	krabben [krɑbən]	*krab* [krɑp]	"scratch"	*krabde* [krɑbdə]	"scratched"

The examples given in (1b) illustrate that the suffix /-də/ is also added when the verb stem ends in an underlying voiced obstruent, whereas /-tə/ is added by underlying voiceless obstruents, as seen in (1a) for instance in *koken* which results in *kookte* [koktə]. The final obstruent of the verb stems in (1b and 1c) are all voiceless (*le<u>v</u>en* and *gra<u>z</u>en* vs. *lee<u>f</u>* and *graa<u>s</u>*) as a result of final devoicing. This process is typical of Dutch, which does not include any syllable-final voiced consonants (Booij, 1995). In Dutch, a morpho-phonological alternation occurs between voiced and voiceless obstruents in word-final position, for instance in *hoed* [hut] ("hat") and *hoeden* [hudən] ("hats") (Booij, 1995). The term alternation refers to the phenomenon that a phoneme and/or morpheme can be phonetically realized in different ways depending on the phonological or morphological context in which it appears (Kerkhoff, 2007).

The alternations that are made by the fricatives in (1b) also alternate in the orthographical representation. For instance, the singular present tense of the verb *le<u>v</u>en* "to live" is written with the letter [f] (i.e. *lee<u>f</u>* [lef]). Final devoicing is thus also represented in the orthography. The examples in (1b) illustrate that the fricatives not only change in their

[2] Some examples were taken from Vreugdenhil (2010) and Ernestus & Baayen (2001)

orthographical representation in the verb stem compared to the present tense, but also in the past tense (*le<u>v</u>en – leef – leef<u>d</u>e*). The plosives in (1c), on the other hand are not subject to orthographical changes, although final devoicing does occur in the pronunciation of the present tense (*kra<u>bb</u>en – kra<u>b</u> – kra<u>bd</u>e*).

In the present study the focus was on the alveolar and labiodental fricatives ([s], [z], [f] and [v]) and the bilabial plosives ([p] and [b]). These obstruents are most interesting because they have voiced and voiceless counterparts. It is especially important for speakers to determine if the final obstruent is underlyingly voiced or voiceless to make a decision between the suffix /-tə/ or /-də/ in the inflection of the verbs (Booij, 1995).

Besides final devoicing and phonological alternations there is another generalization in Dutch verbs related to voicing, namely vowel length. Voicing and vowel length are related for verb stems that end in an alveolar ([s], [z]) or labiodental ([f], [v]) fricative. Examples are illustrated in (2) and are taken from Vreugdenhil (2010). They illustrate that a short vowel (e.g. [ɑ] or [ɔ]) is typically followed by a voiceless obstruent, whereas a long vowel (e.g. [a] or [o]) is followed by a voiced obstruent (Vreugdenhil, 2010).

(2)	*wassen* [wɑsən]	"to wash"	*grazen* [xrazən]	"to graze"
	lossen [lɔsen]	"to unload"	*blozen* [blozən]	"to blush"
	blaffen [blɑfən]	"to bark"	*draven* [dravən]	"to trot"
	opdoffen [ɔpdɔfən]	"to dress up"	*doven* [dovən]	"to extinguish"

In the past tense experiment both verbs and pseudo-verbs are included. The pseudo-verbs vary in stem-final obstruent and vowel length resulting in legal forms, i.e. consistent with the Dutch phonotactic rules (e.g. spaven), and illegal forms, i.e. inconsistent with the Dutch phonotactic rules (e.g. drovven).

1.3 Research questions

The main question is whether 9-year-old normal readers perform better on the past tense production task of Vreugdenhil (2010) than 9-year-old poor readers. Based on what is known about the phonological and morphological skills of children with dyslexia it is expected that the poor readers will obtain a lower correct score on the experiment than normal readers. The results of the 9-year-old poor readers will also be compared with 6-year-old children and typically reading adults to see if there is a development in the acquisition of past tense inflection. At the same time the sensitivity to voicing patterns in Dutch will be established. Namely, if participants have a preference for the voiceless suffix /-tə/ or the voiced suffix /-də/ in the past tense.

The second research question is what the effect of the orthography is on correct past tense inflections. Do 9-year-old poor readers perform better in the auditory modality of the experiment than in the orthographic modality? It is expected that the poor readers will not benefit from the orthographic cue because of their reading problems. In both modalities (auditory and orthographic), the infinitive of the existing verb or pseudo-verb will be auditorily presented. In the orthographic modality the infinitive is auditorily presented and written down, so that the participants can read the verb or pseudo-verb. The written representation could help the participants in the phonological analysis of a verb or pseudo-verb and could also affect the choice of the past tense suffix /-tə/ of /-də/.

A third question is whether the consistency of the pseudo-verbs plays a role in the inflection of the pseudo-verbs. If inflection is based on analogy to existing verbs, the participants will inflect the consistent pseudo-verbs better than the inconsistent pseudo-verbs. They will have more problems with the inflection of the inconsistent pseudo-verbs, as these pseudo-verbs cannot occur in Dutch and will not have a comparative existing phonologically or semantically related word. However, if the inflection of the verbs and pseudo-verbs is relied on rules, consistency should not matter because it is just applying the past tense rule. If an effect of consistency is found it will probably be smaller for the poor readers because they have weaker phonological skills.

A separate question is whether verbs are inflected better than pseudo-verbs. The verbs could be stored in the mental lexicon and can be easily retrieved, unlike the pseudo-verbs. For the pseudo-verbs, the participants have to compute the past tense themselves and have to rely on their knowledge of Dutch past tense formation. Therefore, it is expected that all the participants will have more problems with the inflection of the pseudo-verbs than of the verbs. The poorly reading children are likely to have more problems with the inflection of the pseudo-verbs than the normally reading children because they are known to have difficulties with phonological processing tasks such as non-word repetition.

2. Methods

2.1 Participants

The present study included four different groups: 6-year-old children, 9-year-old normal readers, 9-year-old poor readers (including dyslexics) and typically reading adults. The characteristics of the participants are presented in table 1. The data of Vreugdenhil (2010)

were also added to this study. In appendix 1 an overview is given of the distribution of the participants of the present study and those of Vreugdenhil (2010).

The 6-year-old children were included in this experiment because they have barely had literacy instruction and are in the middle of the process of becoming literate. The adults were included because they have already learned how to inflect verbs and therefore should know the morphological rules. There were two different groups of 9-year-old children: the normal and the poor readers, who did not significantly differ in age $t(110) = -4.128$, $p = 0.342$. This age group was selected because 9-year-olds have not yet been explicitly educated with the morphological rule for inflecting verbs and the corresponding spelling rules. This is usually learned at age 10-12 years (fifth or sixth grade) in Dutch elementary schools. The group of 9-year-old normal readers included one child that was diagnosed with Autism Spectrum Disorder and two children that were raised bilingually, in Moroccan and Dutch. The group of 9-year-old poor readers included 16 children with a dyslexia certificate, one child that was diagnosed with dyslexia and ADHD and one child that was diagnosed with PDD-NOS and ADHD. This group also included 8 children with a suspicion of dyslexia but have not been diagnosed yet. All of the children were selected from primary schools that were located in the Middle and South-East of the Netherlands.

Table 1. Characteristics of the participants (pooled with Vreugdenhil, 2010)

	N	Males / females	Mean age in years	SD	Age-range in years
6-year-old	38	19 / 19	6;6	0.52	5;8 to 7;8
9-year-old normal readers	76	37 / 39	9;5	0.61	8;0 to 11;0
9-year-old poor readers	36	18 / 18	10;0	0.71	8;6 to 11;5
Adults	48	22 / 26	32;6	10.3	19;0 to 58;0

The scores of three different reading tasks were used to determine whether a 9-year-old child was a poor reader: 1) *Drie-Minuut-Test* (DMT; CITO, 2009) where the children had to read as many existing words correctly from three different cards in a time span of three minutes in total (one minute for each card), 2) *Een-Minuut-Test* (EMT[3]; Brus & Voeten, 1979) where the children had to read as many existing words correctly in a time span of one minute, and 3) the *Klepel*[3] (van den Bos, Spelberg, Scheepstra & De Vries, 1994) a non-word reading task with a time span of two minutes. The scores of the EMT and Klepel are presented in table 2. When a child had a D or E score on the DMT[4] (which is below the 25th

[3] The EMT and Klepel have an A and B version. In the present study only the A-version is used. Both reading tasks were recorded to guarantee the reliability of scoring.

[4] The results of the DMT were given by the school. The DMT results in a raw score and is then converted into an A-E score, where A is very good and E is insufficient. The primary schools tested the DMT in different steps (see Struiksma et al., 2004) making the raw scores difficult to compare. Therefore the DMT scores were not presented in table 2. Besides, the score on the DMT were not obtained of all the 9-year-old participants.

percentile) and a standard score below 7 on the EMT and/or Klepel, it was included as a poor reader. These reading tasks were not used for the 6-year-old children who were all in the middle of the process of becoming literate and not for the adults, who all reported normal literacy skills.

To obtain a general measure of the language skills of all the participants, including the adults, the *Peabody Picture Vocabulary Test lll-NL* (PPVT; Pearson, 2005) was used. The PPVT measures the receptive vocabulary. The scores of the PPVT are presented in table 2.

Table 2. Results on the standardized language and literacy tasks

		PPVT[a]	**EMT[b]**	**Klepel[b]**
6-year-old	M	68.9		
	SD	24.6		
	Range	12-97		
9-year-old normal readers	M	51.9	10.5[b]	11.2[b]
	SD	21.9	2.6	2.5
	Range	18-99	7-16	7-16
9-year-old poor readers	M	45.1	4.9[b]	5.6[b]
	SD	23.1	1.6	1.8
	Range	8-86	1-9	1-9
Adults	M	49.6		
	SD	24.3		
	Range	9-86		

[a] in percentiles; [b] results of the standard scores

An independent t-test showed that the difference between the 9-year-old normal readers and the 9-year-old poor readers on the reading tasks (EMT and Klepel) was significant, $t(110) = 11.737$, $p < 0.001$ and $t(110) = 12.037$, $p = 0.017$[5], as expected given the selection criteria. However, there was no significant difference on vocabulary, $t(110) = 1.488$, $p = 0.437$.

2.2 Experiment

The past tense production experiment of Vreugdenhil (2010) was used to elicit the past tense of verbs and pseudo-verbs from the participants. The experiment itself contained only obstruents (except two sonorant in the filler items), 40 items in total. Of these, 12 items were existing Dutch verbs and 28 were pseudo-verbs. The pseudo-verbs can be divided into three categories: neutral, consistent, and inconsistent pseudo-verbs. The neutral pseudo-verbs conformed to the Dutch phonotactic pattern and could either have a voiced or a voiceless obstruent at the end of the verb stem, which means that both suffixes are possible; examples are illustrated in table 3. The consistent pseudo-verbs were based on the Dutch phonotactic relation between voicing and vowel length (Vreugdenhil, 2010). In Dutch, a short vowel is

[5] A comparison between the 9-year-old normal and poor readers on the DMT was impossible because the DMT only gives an A-E score.

typically followed by a voiceless obstruent (e.g. *krassen* "to scratch") and a long vowel is followed by a voiced obstruent (e.g. *lezen* "to read"). The consistent pseudo-verbs conformed to these rules, whereas the inconsistent pseudo-verbs did not. They reversed the pattern of voicing, whereby a short vowel is followed by a voiced obstruent (see table 3 for examples). This leads to words which cannot occur in Dutch, except in loan words like *puzzel* [pyzəl] ("puzzle") (Booij, 1995).

Table 3. Categories of the stimuli (Vreugdenhil, 2010)

Category	**Number of items (voiceless-voiced)**		**Example (voiceless-voiced)**
	Adult version	**Child version**	
Verbs	8 (4 – 4)	8 (4 – 4)	eisen ("to claim") – reizen ("to travel")
Neutral pseudo-verbs	8 (5 – 3)	4 (2 – 2)	beisen – fleizen
Consistent pseudo-verbs	8 (4 – 4)	4 (2 – 2)	taffen – spaven
Inconsistent pseudo-verbs	8 (4 – 4)	4 (2 – 2)	trofen – drovven
Fillers	4 (2 – 2)	4 (2 – 2)	grijken – spennen
	4 irregular verbs	4 irregular verbs	eten – at ("to eat-ate")
Total	40	28	

The experiment also included eight fillers (examples are presented in table 3). Four fillers were Dutch irregular verbs, which were added to avoid the pattern of the addition of the past tense suffix /-tə/ or /-də/. The other four fillers were pseudo-verbs, included to mask the pattern of the test items which all included verbs stem ending in alveolar fricatives [s,z], labiodental fricatives [f,v] or bilabial plosives [p,b] (Vreugdenhil, 2010). The pseudo-verbs had verb stems ending in voiceless plosives and sonorants. For more information about the choices that have been made for selecting the stimuli, I refer to the study of Vreugdenhil (2010).

In the study of Vreugdenhil (2010) the adults and 9-year-old children were presented with an extended version of the experiment, including 12 existing verbs and 28 pseudo-verbs (as presented in table 3). She concluded that this version was too long for the 9-year-old children as they got bored and lost their concentration. Therefore, only the short version of the experiment was used for the different child groups (6-year-old children and the 9-year-old normal and poor readers) in the present study, referred as the child version. The child (short) version included the verbs and fillers from the adult (long) version and half of the pseudo-verb items (12 existing verbs and 16 pseudo-verbs), so that there were four items of each category. An overview of all the stimuli included in the adult and child version of the experiment is given in appendix 2.

The past tense experiment consisted of two different modalities: auditory and orthographic. In the first modality, the infinitive of the verb was presented auditorily and in the second modality the infinitive was presented both auditorily and orthographically. The

participants were only exposed to the infinitives of the verbs because it provided the participants with information of voicing of the obstruent in question and it avoided priming the participants with voiceless obstruents due to final devoicing. For instance, had the present tense of the verb *le<u>v</u>en* "to live" been given, which is *leef<u>t</u>*, the participant could prefer to form the past tense with the suffix /–tə/ (i.e. *leef<u>t</u>e*) instead of the suffix /–də/, which is correct (i.e. *leef<u>d</u>e*).

The participants were pseudo randomly assigned to one of the modalities (auditory or orthographic) so that the number of participants for each modality was equal (table 4). The 6-year-old children were not exposed to the orthographic condition because they are in the middle of the process of becoming literate. Therefore, they were only exposed to the auditory condition.

Furthermore, the experiment had two different orders to avoid order as experimental confound. This was also done pseudo randomly so that the number of participants in each order was equal (table 4). A one-way ANOVA with the number of correct responses (for both verbs and pseudo-verbs) as dependent variable and order as independent variable showed that order is not significant for both correct responses on the verbs $F(1,196) = 0.001$, $p = 0.971$, or pseudo-verbs $F(1,196) = 0.372$, $p = 0.543$.

Table 4. Division of the modality and order of the experiment among the participants

	Auditory	**Orthographic**	**Order 1**	**Order 2**
6-year-old children	38	-	19	19
9-year-old normal readers	38	38	38	38
9-year-old poor readers	18	18	18	18
Adults	24	24	24	24

2.3 Procedure

The past tense experiment was preceded by the background measures (i.e. two reading tasks and a language task) as described above. The set-up of the experiment corresponded to that of Vreugdenhil (2010). The past tense was elicited through a PowerPoint presentation of animated pictures (see appendix 3 for some examples). The pictures for existing verbs consisted of activities by animals or persons. For the pseudo-verbs animations of fantasy persons or monsters were used. Each picture was introduced with the sentence: "look, this animal/person is ……" After this sentence the participant had to click on the picture to hear the infinitive of the verb (e.g. running, washing, etc.) and was asked to finish the sentence: "Yesterday, he/she/it ……..."

For some children (especially the 6-year-old children) the past tense experiment was very difficult. They were barely able to make any past tense and therefore just repeated the infinitive that was auditorily presented, for example *gisteren *fietse(n)*, "yesterday cycling" or *gisteren *fietse(n) de kikker*, "yesterday cycling the frog". In some cases the children produced a past tense with an auxiliary verb *gisteren ging hij (ook) fietsen* "yesterday he went (too) cycling") or made a sentence with a past participle *gisteren is hij aan het fietsen geweest* "yesterday he was cycling" or *gisteren heeft hij ook gefietst* "yesterday he also cycled". In these cases the experimenter asked the child to make a shorter sentence and sometimes assisted the child by articulating the verb's first sound (e.g. experimenter: yesterday c…) (Vreugdenhil, 2010).

2.4 Scoring

A voice-recorder (Zoom Handy Recorder H1) was used to record the experiments. Scoring was done both on- and offline. During the online scoring (done by the author of this thesis) the given suffix was circled on the score list and the whole response was transcribed (if possible). The unclear responses were judged offline by both the author and the two supervisors of the present study. If there was still no consensus about the response of a participant, the responses were judged again by four experienced speech-language therapists. The two supervisors of the present study judged 191 responses. Of these, 28 responses were judged again by the four speech-language therapists.

Afterwards, the responses were transcribed and scored as correct or incorrect. Only the verb was judged, the remainder of the sentence that a participant might have uttered was ignored. A response was correct when it matched the voicing of the infinitive stimulus.

The total number of correct responses was counted. In addition to calculating the number of correct responses, the different types of errors of all the participants were analyzed. Four categories were created, based on the categories that Rispens & de Bree (2010) used in their study and the most frequently produced error types found in the data of Vreugdenhil (2010). Each error was assigned to a category. Examples of these errors are given with the pseudo-verb "beisen" (the correct past tense form is "beiste").

1. Voice errors (wrong suffix): beisde (i.o. beiste)
2. Zero marking / repetition (infinitive): beisen/ beise
3. Made irregular: bas
4. Other errors (e.g. verb stem: beis, present tense: beist, pronounced a totally different verb: danste)

"Voice errors" were responses where the participants chose the wrong suffix, for example the correct response of the infinitive [nɑvən] is [nɑvdə], when the participant said [nɑv̲tə] or [nɑf̲tə] it was scored as a "voice error". Voicing of the stem final sounds ([f] or [v]) was not relevant as it could not be transcribed reliably (due to assimilation). When the participants repeated the infinitive, the response was scored as "zero marking". In some cases the child seemed to use an inflected verb form with an ə-suffix and stressed the vowel suffix, for example *gisteren fietse* [fit'sə], "yesterday cycle". These responses were not pronounced as infinitives, but were difficult to interpret as a past tense. These responses were scored as incorrect and further analyzed as a "zero marking error". The category of "other errors" included several different responses, for instance some children gave a present tense response *gisteren fietst de kikker*, "yesterday + present tense cycles the frog".

2.5 Statistical analyses

An independent t-test was used to compare the 9-year-old normal and poor readers with each other on the results of the reading tasks and the vocabulary task. One-way analysis of variance or repeated measure analysis of variance (ANOVA) were used for overall comparisons of group means on the different variables (group, modality, consistency and suffix type). The proportions were based on the differences between the participants (i.e. subject analysis). No item analyses were conducted. When multiple comparisons were made, the significant difference test of Bonferroni was used. In general, a significance level of $p < 0.05$ was used.

Finally, Pearson's correlations were used to measure the correlation between language skills and reading ability and between language skills and correct past-tense inflection of the verbs and pseudo-verbs.

3. Results

In the analyses of the responses of the participants only the test items have been analyzed and the filler items were excluded. They were included in the experiment to avoid the pattern of adding the suffixes /-tə/ or /-də/ to the verbs stem and to mask the pattern of the stem-final obstruents [s,z] and [f,v] and [p,b]. These fillers were not of interest for the present study, therefore only the test items were analyzed. By excluding the filler items, the total number of test items for the children was 20 stimuli and for the adults was 32 stimuli.

3.1 Development in acquisition of past tense inflection (auditory condition)

The past tense experiment included four different groups: 6-year-old children, 9-year-old normal readers, 9-year-old poor readers and typically reading adults. The 6-year-old children were only exposed to the auditory condition of the experiment. Therefore, the following analyses are only from the auditory condition in order to compare the results of the four groups with each other.

A repeated measures ANOVA was carried out on the number of *correct responses in the auditory condition* with verb type (verb or pseudo-verb) as within-subject variable and group as between-subject variable. The results demonstrated a main effect of verb type $F(1,114) = 196.606$, $p < 0.001$, as more errors were made in the inflection of pseudo-verbs compared to the inflection of verbs (see figure 1). There was also a main effect of group $F(3,114) = 12.321$, $p < 0.001$. A Bonferroni post hoc analysis showed significantly lower correct scores for the 6-year-old children compared to all other groups ($p < 0.05$). Furthermore, there was a significant difference between the adults and the 9-year-old normal readers ($p = 0.028$) but not between the adults and the 9-year-old poor readers ($p = 0.261$). The two 9-year-old groups did not significantly differ from each other ($p = 1$). These results show that percentage correct increases with age, as is also illustrated in figure 1. There was no significant interaction between verb type and group $F(3,114) = 1.321$, $p = 0.271$.

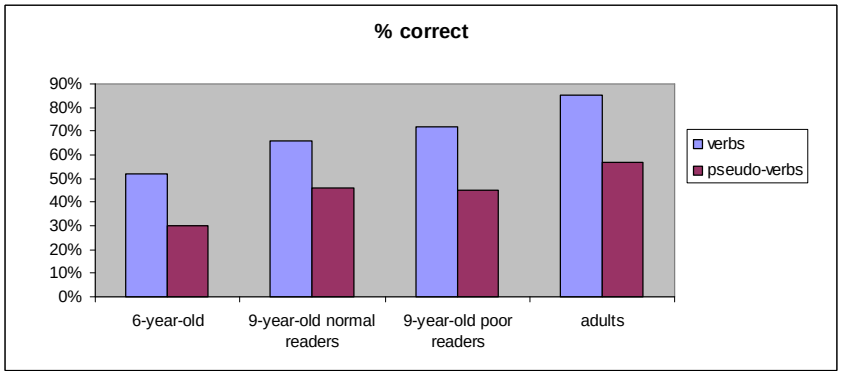

Figure 1. Percentage correct inflections of verbs and pseudo-verbs in the auditory condition for the different groups.

A qualitative error analysis was made to further investigate the types of errors that the participants made in the auditory condition of the past tense experiment. The incorrect responses were divided into four categories: "voice error", "zero marking", "irregular form" and "other errors" (see methods for a description of the error types). The percentage of the different types of errors are presented for verbs in figure 2 and for pseudo-verbs in figure 3.

The 6-year-old children inflected 39% (293/760) of the verbs and pseudo-verbs correctly[6]. The most common error for this group was "zero marking". It occurred in 30% (92/304) of the cases for the verbs and 41% (187/456) for the pseudo-verbs. In general, the type of errors of the 9-year-old normal and poor children correspond. They mostly made voice errors compared to the 6-year-old children and adults. Voice errors occurred in 23% (70/304) of the verbs and 38% (172/456) of the pseudo-verbs for the 9-year-old normal readers. The 9-year-old poor readers had nearly the same results, where voice errors occurred in 22% (31/144) of the verbs and 38% (82/216) of the pseudo-verbs. Besides voice errors and zero marking, verbs and pseudo-verbs were also made irregular in the 9-year-old group, for example [trɑp] as past tense of [trebən]. The 9-year-old normal readers made 3% (10/304) of the verbs and 1% (6/456) of the pseudo-verbs irregular, whereas the poor readers made only one verb and one pseudo-verb irregular. The adults made voice errors in 13% (24/192) of the cases for the verbs and 30% (170/576) for the pseudo-verbs. They also often made pseudo-verbs irregular, namely in 9% (54/576) of cases. Only 2% (2/192) of the verbs was made irregular. These results show that the adults made more pseudo-verbs irregular, whereas the 9-year-old normal readers made more verbs irregular. Furthermore, the adults often made errors that deal with vowel length changes (mostly changing a long vowel into a short vowel), e.g. [dɑptə] as past tense of [dapən]. These last responses were scored as "other" errors.

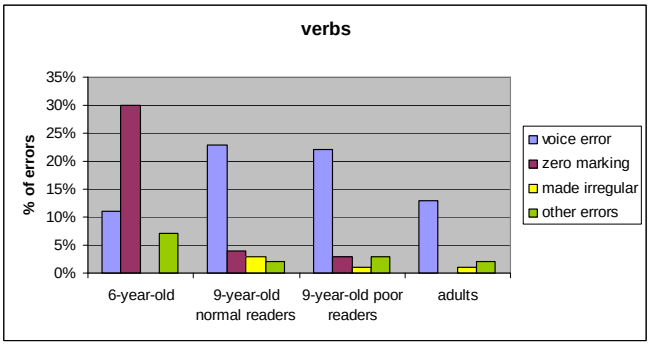

Figure 2. Percentage of the different errors for the verbs.

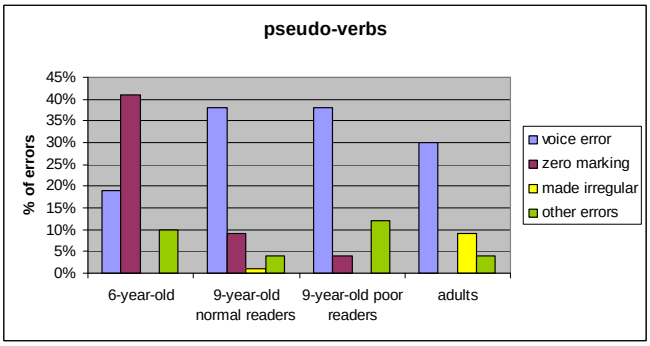

Figure 3. Percentage of the different errors for the pseudo-verbs.

[6] Fourteen 6-year-old children were in less than 50% of the 28 items able to make a past tense.

A repeated measures ANOVA was carried out on the *voice errors in the auditory condition* with verb type (verb or pseudo-verb) as within-subject variable and group as between-subject variable. The results demonstrated a main effect of verb type $F(1,114) = 74.467$, $p < 0.001$, as more voice errors were made in pseudo-verbs than in verbs. There was also a main effect of group $F(3,114) = 11.217$, $p < 0.001$. A Bonferroni post hoc analysis showed significant differences between the 6-year-old children and the 9-year-old normal ($p < 0.001$) and poor readers ($p = 0.001$) but not between the 6-year-old children and the adults ($p = 0.432$). Furthermore, there was a significant difference between the adults and the 9-year-old normal readers ($p = 0.032$). There were no differences between the adults and the 9-year-old poor readers ($p = 0.172$) and none between the 9-year-old normal readers and the 9-year-old poor readers ($p = 1$). There was no significant interaction between verb type and group ($p = 0.101$).

3.1.1 Consistency

The pseudo-verbs were divided into three categories: "neutral", "consistent" and "inconsistent" pseudo-verbs (see methods for a description of the different pseudo-verbs). First, only the consistent and inconsistent pseudo-verbs are compared because these are most interesting for answering the research question whether analogy plays a role in children's inflection of pseudo-verbs.

A repeated measures ANOVA was carried out on the number of *correct responses in the auditory condition* of the experiment for the subset of pseudo-verbs (consistent and inconsistent) with consistency as within-subject variable and group as between-subject variable. The results demonstrated a main effect of consistency $F(1,114) = 29.180$, $p < 0.001$, as there were more correct responses on the consistent pseudo-verbs compared to the inconsistent pseudo-verbs (see figure 4). There was also a main effect of group $(F3,114) = 7.233$, $p < 0.001$. A Bonferroni post hoc analysis showed only significant differences for correct responses between the 6-year-old children and the 9-year-old normal readers ($p = 0.003$) and adults ($p < 0.001$). There was a marginally significant difference between the 6-year-old children and the 9-year-old poor readers ($p = 0.053$). The other groups, including the two 9-year-old groups, did not significantly differ from each other ($p = 1$). There was a significant interaction between consistency and group $F(3,114) = 4.453$, $p = 0.005$. A follow-up repeated measures ANOVA demonstrated that the adults $F(1,23) = 23.991$, $p < 0.001$, and 9-year-old poor readers $F(1,17) = 5.276$, $p = 0.035$ show a significant effect of consistency, as there were more errors in the inflection of the inconsistent pseudo-verbs compared to

consistent pseudo-verbs (see figure 4). There was no significant effect of consistency for the 6-year-old children ($p = 0.324$) and 9-year-old normal readers ($p = 0.067$).

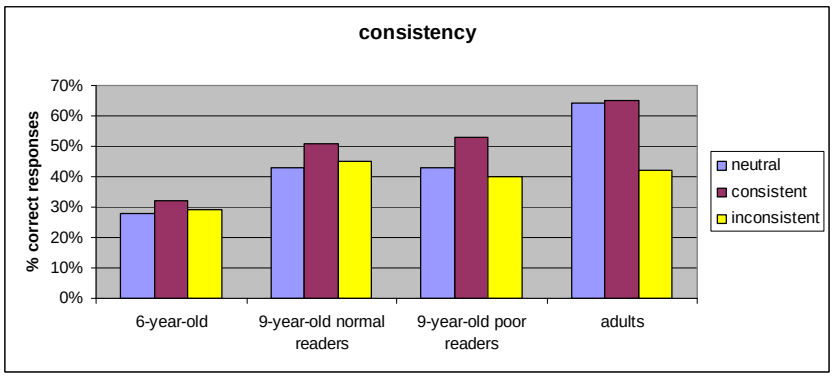

Figure 4. Percentage correct inflections of neutral, consistent and inconsistent pseudo-verbs in the auditory condition for the different groups.

In a subsequent repeated measures ANOVA the neutral pseudo-verbs were also analyzed and compared to the consistent and inconsistent pseudo-verbs. The results demonstrated again a main effect of consistency $F(1,114) = 6.124$, $p = 0.015$, as there were more correct responses on the consistent pseudo-verbs compared to the neutral ($p = 0.026$) and inconsistent pseudo-verbs ($p < 0.001$). Furthermore, the neutral pseudo-verbs were inflected correctly more often than the inconsistent pseudo-verbs ($p = 0.015$). There was also a main effect of group $F(3,114) = 9.820$, $p < 0.001$. A Bonferroni post hoc analysis showed only significant differences for correct responses between the 6-year-old children and all other groups ($p < 0.05$). There was a significant interaction between consistency and group $F(3,114) = 6.216$, $p = 0.001$. A follow-up repeated measures ANOVA demonstrated that only the adults show a significant effect of consistency $F(1,23) = 25.329$, $p < 0.001$, as there were more errors in the inflection of the inconsistent pseudo-verbs compared to the neutral and consistent pseudo-verbs (see figure 4). The 6-year-old children $F(1,37) = 0.028$, $p = 0.868$, 9-year-old normal readers $F(1,37) = 0.327$, $p = 0.571$, and the 9-year-old poor readers $F(1,17) = 0.173$, $p = 0.682$, did not show a significant effect of consistency. However, in the previous analysis (excluding the neutral pseudo-words), the poor readers did show a significant effect of consistency. This analysis have showed that the children, especially the two 9-year-old groups, have more problems with the inflection of the neutral pseudo-verbs compared to the adults, who performed equally well on the consistent and neutral pseudo-verbs.

3.1.2 Suffix selection

For the inflection of verbs and pseudo-verbs the participants had to choose between the voiceless suffix /-tə/ or the voiced suffix /-də/. Figure 5 shows the percentage of voiceless and voiced suffixes (both correct and incorrect) for verbs and pseudo-verbs separately that were produced by the participants in the auditory condition of the experiment. Here, all responses in which a suffix was used were analysed, irrespective of whether it was the correct suffix (e.g. including both *beiste* and **beisde*), to determine whether the groups differed in their overall use of the suffix. For this analysis, only the stimuli from the short version of the experiment were included, to make sure that any differences between the adults and children were not due to the additional stimuli that adults received[7]. A repeated measures ANOVA was carried out on the *overall use of the suffixes /-tə/ and /-də/ in the auditory condition* with suffix (/-tə/ and /-də/) and verb type (verbs and pseudo-verbs) as within-subject variables and group as between-subject variable. The results demonstrated a main effect of suffix $F(1,114) = 5.956$, $p = 0.016$, as there was a greater preference for the voiced suffix /-də/ than the voiceless suffix /-tə/ (see figure 5). There was a main effect of verb type $F(1,114) = 51.475$, $p < 0.001$, as verbs were more often inflected than pseudo-verbs. There was also an interaction between suffix and verb type $F(1,114) = 14.459$, $p < 0.001$, as a preference for /-tə/ was found for verbs. There was also a main effect of group $F(3,114) = 13.526$, $p < 0.001$. A Bonferroni post hoc analysis showed only significantly differences for the 6-year-old children compared to all other groups ($p < 0.001$). The other groups, including the two 9-year-old groups, did not significantly differ from each other ($p = 1$). Finally, there was a significant interaction between suffix and group $F(3,114) = 4.475$, $p = 0.005$. A marginal significant interaction was found between verb type and group $F(3,114) = 2.548$, $p = 0.059$. There was no significant interaction between suffix, verb type and group $F(3,114) = 1.376$, $p = 0.254$.

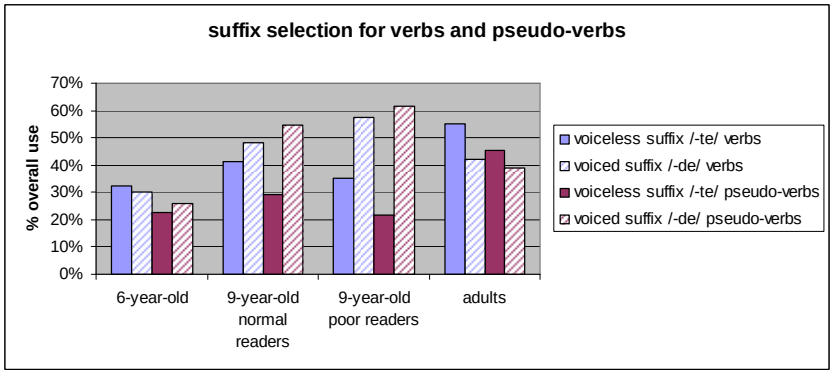

Figure 5. The percentage of voiceless and voiced suffixes for both verbs and pseudo-verbs.

[7] All other analyses include both the long (adult) and short (children) version of the experiment, as leaving out the additional items for the adult group made no difference to any of the analyses.

Different follow-up repeated measures ANOVA were carried out for each group on verbs and pseudo-verbs with suffix as within-subject variable. The results demonstrated that the 6-year-old children have no preference for the voiceless or voiced suffix in either verbs $F(1,37) = 0.232$, $p = 0.633$, or pseudo-verbs $F(1,37) = 0.420$, $p = 0.521$. The results of the 9-year-old normal readers showed a greater preference for the voiced suffix /-də/ compared to the voiceless suffix /-tə/. However, this was only significant for the pseudo-verbs $F(1,37) = 7.819$, $p = 0.008$, and not for the verbs $F(1,37) = 0.850$, $p = 0.363$ (see figure 5). The results of the 9-year-old poor readers showed that they also have a greater preference for the voiced suffix /-də/ compared to the voiceless suffix /-tə/. This was significant for the pseudo-verbs $F(1,17) = 9.178$, $p = 0.008$, and marginally significant for the verbs $F(1,17) = 4.258$, $p = 0.055$ (see figure 5). The last group were the adults, who showed a significant preference for the voiceless suffix /-tə/ compared to the voiced suffix /-də/. However, this was only significant for the verbs $F(1,23) = 6.053$, $p = 0.022$, and not for the pseudo-verbs $F(1,23) = 0.412$, $p = 0.527$) (see figure 5). In general, the 6-year-old children did not show a preference for either suffix, the 9-year-old normal and poor readers have a greater preference for voiced suffixes (particularly when inflecting pseudo-verbs), whereas the adults have a preference for voiceless suffixes (particularly when inflecting verbs).

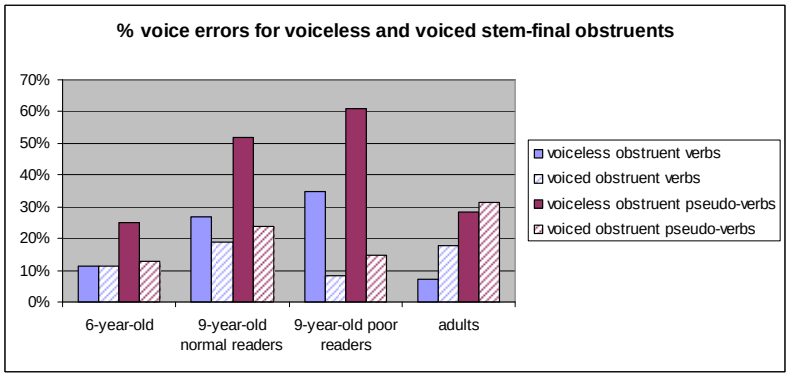

Figure 6. Percentage voice errors for voiceless and voiced medial obstruents for both verbs and pseudo-verbs.

Figure 6 shows the percentage voice errors for voiceless and voiced stem-final obstruents. For instance, in the verb *blaffen*, the medial [f] is a voiceless obstruent and therefore the correct suffix should be /-tə/ which results in *blafte*. When the response of a participant was *blafde* it was scored as a voice error. A repeated measures ANOVA was carried out on the *voice errors for voiced and voiceless medial obstruents in the auditory condition* of the experiment with verb type and voicing (voiced and voiceless) as within-subject variables and group as between-subject variable. The results demonstrated a main

effect of verb type $F(1,114) = 71.813$, $p < 0.001$, as more voice errors were made in pseudo-verbs than in verbs (see figure 6). There was a main effect of voicing $F(1,114) = 12.615$, $p = 0.001$, as there were more voice errors for voiceless stem-final obstruents compared to the voiced obstruents (i.e. of the type **beisde*), reflecting the /-de/ preference found earlier. There was also a main effect of group $F(3,114) = 10.846$, $p < 0.001$. A Bonferroni post hoc analysis showed significant differences for the 6-year-old children compared to the 9-year-old normal readers ($p < 0.001$) and 9-year-old poor readers ($p = 0.001$), but not between the adults ($p = 0.409$). Furthermore, there was a significant difference between the 9-year-old normal readers and adults ($p = 0.042$), but not between the 9-year-old poor readers ($p = 1$). There was no significant difference between the adults and the 9-year-old poor readers ($p = 0.207$). A significant interaction was found between voicing and group $F(3,114) = 4.697$, $p = 0.004$, and verb type and voicing $F(1,114) = 19.653$, $p < 0.001$.

Different follow-up repeated measures ANOVA were carried out for each group on verbs and pseudo-verbs with voicing as within-subject variable. The results demonstrated that for the 6-year-old children there were more voice errors for the voiceless obstruents compared to the voiced obstruents. However, this was only significant for the pseudo-verbs $F(1,37) = 4.851$, $p = 0.034$, and not for the verbs $F(1,37) = 0.000$, $p < 0.001$. This means that the 6-year-old children often made errors such as *blafde* instead of *blafte*. The two 9-year-old groups also made more voice errors in the voiceless obstruents compared to the voiced obstruents. However, for the 9-year-old normal readers this was only significant for the pseudo-verbs $F(1,37) = 9.227$, $p = 0.004$, and not for the verbs $F(1,37) = 1.186$, $p = 0.283$. The results of the 9-year-old poor readers were significant for both verbs $F(1,17) = 6.692$, $p = 0.019$, and pseudo-verbs $F(1,17) = 13.639$, $p = 0.002$. This indicates a preference for the voiced suffix /-də/, as there were more voice errors in the voiceless infinitives than in the voiced infinitives. Furthermore, it seems that the poor readers have a greater preference for the voiced suffix /-də/, overusing it in both verbs and pseudo-verbs compared to the 9-year-old normal readers (see figure 6). Alternatively, the distinction between verbs and pseudo-verbs might be smaller for the poor readers. The normal readers mostly made voice errors in pseudo-verbs with medial voiceless obstruents (e.g. *beisen*). The adults showed the opposite pattern, as they mostly made errors for the voiced infinitives (e.g. *spaafte* instead of *spaafde*). However, this difference was marginally significant for the verbs $F(1,23) = 4.021$, $p = 0.057$, and not significant for the pseudo-verbs $F(1,23) = 0.070$, $p = 0.794$.

3.2 Past tense inflection: Influence of modality

The past tense experiment was performed in two modalities: auditory and orthographic. The orthographic modality was not presented to the 6-year-old children as mentioned before. Therefore, only the 9-year-old normal readers, 9-year-old poor readers and adults were included in the analysis of the effect of modality.

A repeated measures ANOVA was carried out on the number of *correct responses* with verb type as within-subject variable and group (9-year-old normal readers, 9-year-old poor readers and adults) and modality (auditory or orthographic) as between-subject variables. The results demonstrated a main effect of verb type $F(1,154) = 278.453$, $p < 0.001$, as more errors were made in the inflection of pseudo-verbs compared to the inflection of verbs (see figure 7). There were no significant interactions between verb type and group ($p = 0.195$), verb type and modality ($p = 0.714$) and verb type, group and modality ($p = 0.095$). There was a main effect of group $F(2,154) = 16.419$, $p < 0.001$, with the adults inflecting the verbs and pseudo-verbs better than the 9-year-old normal and poor readers ($p < 0.01$). The 9-year-old normal and poor readers did not significantly differ from each other ($p = 1$). Furthermore, there was no significant effect of modality ($p = 0.343$) and no significant interaction between group and modality ($p = 0.789$).

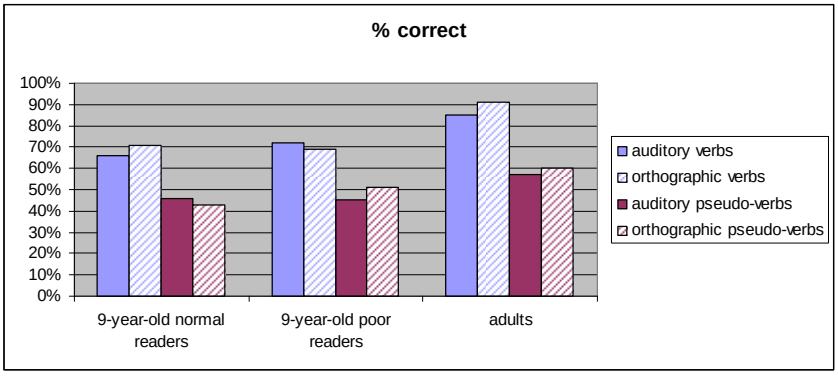

Figure 7. Percentage correct inflections of verbs and pseudo-verbs in the auditory and orthographic condition.

In a follow-up analysis the 9-year-old normal and poor readers were compared with each other (referred as literacy) on the number of correct responses. A repeated measures ANOVA with verb type as within-subject variable and literacy (9-year-old normal and 9-year-old poor readers) and modality as between-subject variables demonstrated nearly the same results as in the previous analyses. However, in this analysis there was a significant interaction between verb type, literacy and modality $F(1,108) = 4.376$, $p = 0.039$. A follow-up repeated measures ANOVA for the 9-year-old normal readers with verb type as within-

subject variable and modality as between-subject variable showed a significant interaction between verb type and modality $F(1,74) = 4.220$, $p = 0.043$, as the orthographic modality increases performance on verbs but not pseudo-verbs. The same repeated measures ANOVA for the 9-year-old poor readers did not show a significant interaction between verb type and modality $F(1,34) = 1.206$, $p = 0.280$.

A qualitative error analysis of the types of errors for both modalities (auditory and orthographic) demonstrated that the 9-year-old normal readers, 9-year-old poor readers and adults again made mostly voice errors in both verbs and pseudo-verbs. The results resemble those of the error types on the auditory condition only. Figure 8 only presents the percentage voice errors of the three groups.

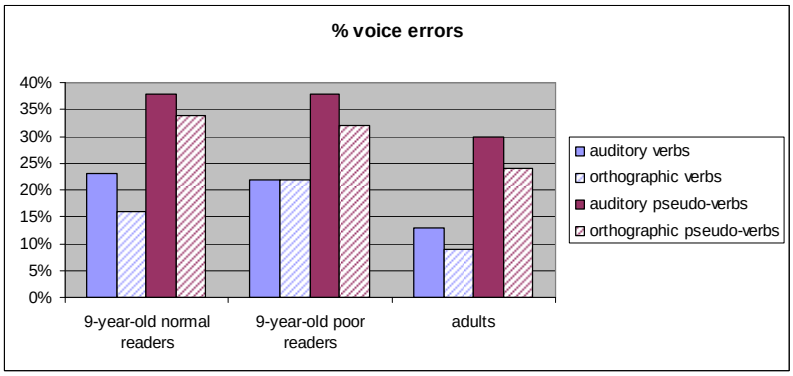

Figure 8. Percentage voice errors of verbs and pseudo-verbs in the auditory and orthographic condition.

A repeated measures ANOVA was carried out on the *voice errors* with verb type as within-subject variable and group and modality as between-subject variables. The results demonstrated a main effect of verb type $F(1,154) = 126.168$, $p < 0.001$, as more voice errors were made in pseudo-verbs than in verbs. There were no significant interactions between verb type and group ($p = 0.605$), verb type and modality ($p = 0.6190$, group and modality ($p = 0.834$) and verb type, group and modality ($p = 0.310$). There was a main effect of group $F(2,154) = 9.755$, $p < 0.001$, with the adults making less voice errors compared to the 9-year-old normal readers ($p < 0.001$) and 9-year-old poor readers ($p = 0.001$). The 9-year-old normal and poor readers did not significantly differ from each other ($p=1$). Furthermore, there was a main effect of modality $F(1,154) = 4.160$, $p = 0.043$, as there were more voice errors in the auditory condition than in the orthographic condition (see figure 8).

In a follow-up analysis the 9-year-old normal and poor readers were again compared with each other on the voice errors. A repeated measures ANOVA with verb type as within-subject variable and literacy and modality as between subject variables showed nearly the

same results as above. However, in this analysis there was no significant main effect of modality ($p = 0.142$), which means that for the 9-year-old normal and poor readers there is no significant difference in voice errors between the auditory and orthographic condition of the experiment. To further investigate this, a separate one-way ANOVA was carried out for the 9-year-old normal readers with percentage voice errors for verbs as dependent variable and modality as independent variable. The results showed that there was an effect of modality on voice errors in verbs $F(1,75) = 5.860$, $p = 0.018$, as there were more voice errors in the auditory modality for verbs compared to the orthographic modality (see figure 8). The same analysis was done again for the 9-year-old poor readers, where the results did not show a significant effect of modality $F(1,35) = 0.013$, $p = 0.909$[8].

3.2.1 Consistency and the effect of modality

A repeated measures ANOVA was carried out on the number of *correct response* of the pseudo-verbs with consistency as within-subject variable and group and modality as between-subject variable. The results demonstrated a main effect of consistency $F(1,154) = 29.463$, $p < 0.001$, as there were more correct responses on the consistent pseudo-verbs compared to the neutral (0.009) and inconsistent pseudo-verbs ($p < 0.001$). Furthermore, the neutral pseudo-verbs were better inflected than the inconsistent pseudo-verbs ($p < 0.001$). There was also a main effect of group $F(2,154) = 9.037$, $p < 0.001$, with the adults performing better than the 9-year-old normal readers ($p < 0.001$) and the 9-year-old poor readers ($p = 0.036$). There was no significant effect of modality $F(1,154) = 0.431$, $p = 0.513$. A significant interaction was found between consistency and group $F(2,154) = 13.980$, $p < 0.001$. A follow-up repeated measures ANOVA demonstrated that only the adults show a significant effect of consistency $F(1,46) = 61.578$, $p < 0.001$, as there were more errors in the inflection of the inconsistent pseudo-verbs compared to the neutral and consistent pseudo-verbs (see figure 9). The 9-year-old normal readers $F(1,74) = 1.293$, $p = 0.259$, and 9-year-old poor readers $F(1,34) = 0.832$, $p = 0.368$, did not show a significant effect of consistency. There were no significant interactions between consistency and modality $F(1,154) = 2.980$, $p = 0.086$, group and modality ($p = 0.334$), and consistency, group and modality ($p = 0.749$).

[8] Other separate one-way ANOVAs with the 9-year-old normal and poor readers on percentage voice errors for pseudo-verbs did not show any significant effects ($p > 0.3$).

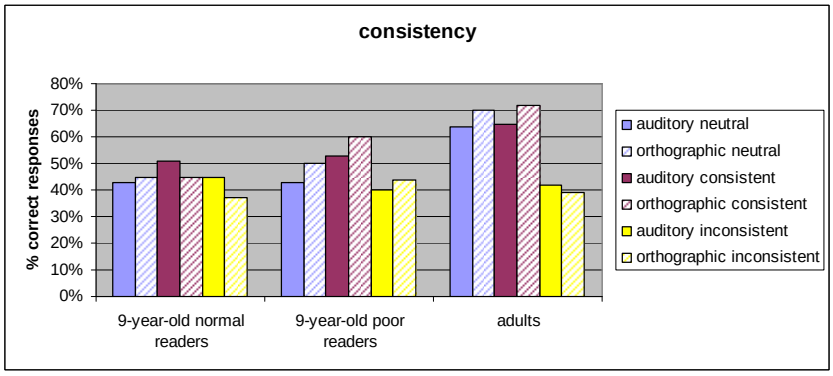

Figure 9. Percentage correct inflections of neutral, consistent and inconsistent pseudo-verbs in the auditory and orthographic condition for the different groups.

Figure 9 shows the percentage correct inflected neutral, consistent and inconsistent pseudo-verbs. It looks like the participants have inflected more pseudo-verbs correctly in the orthographic condition. However, this was not significant. Furthermore, it seems that the 9-year-old normal readers and the adults were confused when they had to inflect inconsistent pseudo-verbs in the orthographic condition of the experiment because they made more errors in the orthographic condition than in the auditory condition. However, this was not statistically tested.

3.3 Influence of vocabulary and literacy on the past tense inflection

Several studies have shown that children with a greater vocabulary will inflect verbs more easily than those with more limited vocabularies (e.g. Edwards, Beckman & Munson, 2004). In contrast to these findings, Vreugdenhil (2010) did not find correlations between the PPVT and the correct inflections.

The results of the present study showed that there is a weak significant correlation between the raw score of the PPVT and the correct inflection of verbs (Pearson's $r = 0.459$, $p < 0.001$) and pseudo-verbs (Pearson's $r = 0.391$, $p < 0.001$). Furthermore, a weak negative significant correlation was found between the raw score of the PPVT and the voice errors of verbs (Pearson's $r = -0.154$, $p = 0.043$) but not of pseudo-verbs (Pearson's $r = 0.11$, $p = 0.885$).

The correlation of the different groups demonstrated that there were only weak significant correlations for the 6-year-old children between the raw score of the PPVT and the correctly inflected verbs (Pearson's $r = 0.512$, $p = 0.001$) and pseudo-verbs (Pearson's $r = 0.442$, $p = 0.005$) and voice errors of verbs (Pearson's $r = 0.367$, $p = 0.023$). A weak marginal significant correlation was found between the raw scores of the PPVT and the voice errors of pseudo-verbs (Pearson's $r = 0.312$, $p = 0.056$). The correlations for the other three groups

were all $p > 0.05$. It seems that there is some evidence for the 6-year-old children that a greater vocabulary leads to a better score of the inflection of verbs, based on the raw score.

Furthermore, the results of the literacy tasks were compared with the number of correctly inflected verbs and pseudo-verbs. The results showed no significant correlations ($p > 0.05$). There were also no correlations between the literacy tasks and the number of voice errors in both verbs and pseudo-verbs ($p > 0.05$).

4. Discussion

The main question of the present study was whether there is a difference between the results of 9-year-old normal and poor readers on a past tense production experiment, in which children had to inflect verbs and pseudo-verbs. In addition, a comparison with 6-year-old children and adults was made to investigate the acquisition of the past tense inflection and the sensitivity to voicing (voiceless of voiced suffix) in Dutch. Furthermore, the effect of orthography and the effect of phonotactic consistency of the pseudo-verbs was evaluated.

The results of the past tense experiment demonstrated that the 9-year-old normal and poor readers did not differ from each other on the number of correctly inflected past tense forms for either verbs and pseudo-verbs. They were equally good at producing the past tense overall. This is consistent with the findings of Egan & Pring (2004), who also did not find a difference between dyslexic children and children of the same reading and spelling age in a spoken language task. However, the 9-year-old normal readers performed better when orthography was provided in the inflection of verbs but not of pseudo-verbs, whereas the poor readers did not benefit from the orthography.

For the different groups percentage correct inflected verbs and pseudo-verbs increases with age, as the two 9-year-old groups and adults performed better on the past tense experiment task than the 6-year-old children. In all groups and for both modalities (auditory and orthographic), the existing verbs were better inflected than the pseudo-verbs. The participants also made less voice errors in the verbs compared to the pseudo-verbs. These findings correspond with Ernestus & Baayen (2001, 2003) and indicate that the pseudo-verbs were inflected in analogy to phonologically or semantically related existing verbs.

4.1 Type of errors (voice errors)

The voice errors made in the experiment were the most interesting error type because the participants had to make an underlying distinction between voiced and voiceless

obstruents in order to add the correct past tense suffix. Only the voice errors were analyzed, as the general focus was on the 9-year-old normal and poor readers and they mostly made voice errors. The 9-year-old normal readers made less voice errors in the inflection of verbs in the orthographic modality of the experiment unlike the 9-year-old poor readers, which indicates that the visual presentation of verbs helps the 9-year-old normal readers with the past tense inflection. Another difference between the two 9-year-old groups was found in the qualitative type of error analysis, where the 9-year-old normal readers irregularized a verb and pseudo-verb more often compared to the 9-year-old poor readers, who made only one verb and one pseudo-verb irregular. The type of error: "made irregular" has not been further elaborated as it was beyond the scope of the present study. However, it would be very interesting to further investigate this and to compare it with the adults who also often made pseudo-verbs irregular.

The percentage of voice errors for the 6-year-old children was much lower compared to the two 9-year-old groups and the adults, due to less inflected verbs and pseudo-verbs at all. Fourteen children (37%) where barely able to inflect verbs and pseudo-verbs and often just repeated the infinitive (zero marking). The adults made less voice errors compared to the two 9-year-old groups. Furthermore, they benefit from the orthographic modality in the inflection of both verbs and pseudo-verbs, as they made less voice errors in the orthographic modality of the experiment compared to the auditory modality.

4.2 Consistency

The factor consistency affected the number of correct responses of the adults and the 9-year-old poor readers, as they had more correct inflections on consistent pseudo-verbs compared to the inconsistent pseudo-verbs. The inconsistent verbs were sometimes made consistent by adjusting the vowel length, so that the inconsistent pseudo-verbs conformed to the Dutch phonotactic rules of voicing and vowel length and show analogy to Dutch existing past tenses. This mostly occurred in the adults realizations. The analysis, including the neutral pseudo-verbs showed that the two 9-year-old groups, have more problems with the inflection of the neutral pseudo-verbs compared to the adults, who actually performed equally well on the consistent and neutral pseudo-verbs.

The adults and two 9-year-old groups did not benefit from the orthographic modality in the inflection of the inconsistent pseudo-verbs. In some cases, it seemed that the orthographical representation of an inconsistent pseudo-verb leads to distraction as the verb looks so unfamiliar because it does not correspond to the Dutch phonotactic rules. Besides that, for the inconsistent pseudo-verbs the participant cannot rely on analogy to existing verbs

because these verbs cannot occur in Dutch and will not have a comparative existing phonologically or semantically related word. Due to this the adults inflect the verb as an irregular verb or change the vowel length to make it consistent. The 9-year-old normal readers also did not benefit from the orthographical cue in the inflection of the inconsistent pseudo-verbs. This might be because these children have not been explicitly educated in the correct spelling rules of past tense inflection.

4.3 Suffix selection

The present study also looked at suffix selection of the participants whether the different groups have a preference for the voiced (/-də/) or voiceless (/-tə/) past tense suffix. The results showed that the 6-year-old children do not have a preference for either suffix. Based on the number of voiceless and voiced suffixes, the 6-year-old children might have a preference for the voiced clusters, which would be reject the finding of Vreugdenhil (2010). She found that the 6-year-old children had a preference for the voiceless suffix /-tə/. However, Vreugdenhill (2010) already mentioned in her study that this conclusion could not be drawn based on the number of obtained data for this group, therefore the number of her data were expanded in the present study.

Both 9-year-old groups had a preference for voiced clusters (particularly when inflection pseudo-verbs), whereas the 9-year-old poor readers often overused the voiced suffix /-də/ in both verbs and pseudo-verbs. The results showed a stronger effect of voiced suffixes for the poor readers compared to the normal readers even though they show the same suffix pattern. The pattern of voice errors also showed the preference for voiced clusters for the two 9-year-old groups as there were much more voice errors on voiceless infinitives than on voiced infinitives. These results correspond to the expectations of Rispens & de Bree (2010), who indeed expected that children would have a preference for voiced suffixes given that the frequency of verbs taken /-də/ is much higher than verbs taken /-te/. However, their results showed the opposite. Therefore, they concluded that the phonotactic probability of the suffix and the environment in which it occurs better explains the fact that their participants had a preference for /-tə/. The present study used different consonants, namely only obstruents and did not look at frequency and phonotactic probability because it was beyond its scope. It would be interesting to take these two aspects into account in a follow-up study, to see what influence these aspects have on poor readers and if it helps them in past tense inflection. Another explanation for /-tə/ preference could be found in the procedure of the experiment. In the study of Rispens & de Bree (2010) the participants were namely exposed to the present

tense form of the verb within a sentence, e.g. "she bakes", and also with the infinitive of the verb. This way the participants were mostly primed with voiceless obstruents and therefore maybe made more voiceless inflections, as they already heard the [t].

Unlike the 6-year-old children, 9-year-old normal and poor readers the adults showed a preference for voiceless clusters, particularly when inflecting verbs. The pattern of voice errors demonstrated that more voice errors were made on voiced infinitives compared to voiceless infinitives, which also indicates a preference for /-tə/. The fact that the adults have a preference for voiceless suffixes could be due to the general effect of devoicing in Dutch. In Dutch, in recent years more and more voiced fricatives are realized as voiceless in (fast) speech, which is becoming the current way of speaking.

4.4 Recommendations further analyses and research

Some recommendations for further analyses of the data or further research have already been given in the previous paragraphs, namely to investigate the verbs that were made irregular and to study the frequency and phonotactic probability of the past tense suffixes /-tə/ and /-də/ and their influence on the preference of voiceless or voiced suffixes. Here, some additional recommendations are given regarding filler items and gender. As mentioned before, the filler items were excluded from the analysis as it was beyond the scope of the present study. It would be interesting to further investigate how the participants inflect the irregular verbs. "Are 9-year-old children already able to inflected irregular verbs?" How will 9-year-old poor readers inflect irregular verbs? Will they regularize the items?

Furthermore, the literature describes that in poor reading children there are differences in gender. Blomert (2002) mentioned that there are more boys with reading problems compared to girls. Given time constraints it was not possible to investigate whether there is a difference in the correct inflection of verbs and pseudo-verbs for gender. A follow-up analysis could investigate if boys indeed make more errors than girls in past tense inflection.

Finally, in the present study the participants were asked to finish a sentence and to fill in the correct past tense. The participants did not have to write the verbs and pseudo-verbs, they only have to say them aloud. As Egan & Pring (2004) state in their study dyslexics might be only impaired in morphology in written but not spoken language. So, what would happen with the inflection of the verbs and pseudo-verbs when the participants have to write down the past tense forms? Will they make more errors? Do they also write down illegal clusters, just like the participants in the study of Ernestus and Baayen (2003)? To answer these

questions it would be very interesting to do the same experiment again, only this time the participants have to write down their responses.

4.5 Summary

In sum, this study has shown that it is important to take the role of development into consideration when assessing past tense verb inflection because the participants showed a shifting from a /-də/ preference for children to a /-tə/ preference for adults. Furthermore, it has demonstrated that the 9-year-old normal readers and poor readers did not differ on several measures: correctly inflected verbs and pseudo-verbs, number of voice errors, inflection of pseudo-verbs and preference for a suffix. However, the normal readers use of the orthographical cue in the inflection of verbs, whereas the 9-year-old poor readers did not pay any attention to this. Furthermore, the consistent pseudo-verbs were better inflected compared to the inconsistent pseudo-verbs for the adults and 9-year-old poor readers. The orthography did not help the participants in the inflection of the pseudo-verbs.

In general, the influence of the orthography on poor reading children should be further investigated in order to learn more about the influence of the orthography on poor phonological representation, and in turn, its relation to morphological inflection.

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Appendix 1: Total number of participants

In table 5 an overview is given of the total number of participants. Where a distinction is made between de selected participants of the present study and those of Vreugdenhil (2010).

Table 5. Overview participants

	Vreugdenhil (2010)	**Hoeben (2011)**	**Total**
Control group			
6-year-old children	17	21	38
9-year-old children	51	25	76
Adults	25[1]	23	48
Experimental group			
Children with reading disorders: *- dyslexics* *- weak word-decoding readers*	5[2] *2* *3*	31 *17* *14*	36 *19* *17*
Total	98	100	198

[1] *Four adults out of the data of Vreugdenhil (2010) were excluded because of literacy difficulties and one participant was excluded as he was too young (17 years instead of 18).*
2 Five children were excluded from the control group and were selected for the experimental group because of dyslexia or low timed (pseudo)word reading scores.

Appendix 2: Overview of the stimuli

The complete list of the stimuli, that were used in the experiment, are shown in table 6. The stimuli are listed per category (verbs: fillers and pseudo-verbs: neutral, consistent, inconsistent). All these items were included in the long version of the experiment for the adults. The verbs marked with an asterisk belonged to the short version for the children.

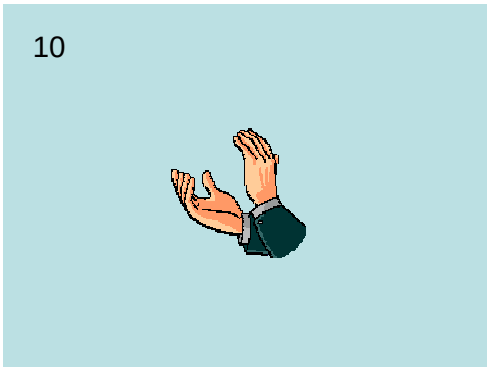
Table 6. Overview of the stimuli

Verb / pseudo-verb	Category	Voicing[9]	Obstruent[10]	Infinitive
a .verb	Example	-	-	*rennen
b. verb	Example	-	-	*fietsen
1. verb	-	vl	S	*eisen
2. verb	-	vd	S	*reizen
3. verb	-	vl	F	*blaffen
4. verb	-	vd	F	*draven
5. verb	-	vl	P	*klappen
6. verb	-	vd	P	*krabben
7. verb	-	vl	T	*praten
8. verb	-	vd	T	*schudden
9. pseudo-verb	Neutral	vl	S	*beisen
10. pseudo-verb	Neutral	vd	S	*fleizen
11. pseudo-verb	Neutral	vl	S	tonsen
12. pseudo-verb	Neutral	vd	S	kronzen
13. pseudo-verb	Neutral	vl	S	*kelsen
14. pseudo-verb	Neutral	vd	S	*brelzen
15. pseudo-verb	Neutral	vl	P	bloppen
16. pseudo-verb	Neutral	vl	P	dapen
17. pseudo-verb	Consistent	vl	F	*taffen
18. pseudo-verb	Consistent	vd	F	*spaven
19. pseudo-verb	Consistent	vl	F	kreffen
20. pseudo-verb	Consistent	vd	F	breven
21. pseudo-verb	Consistent	vd	P	dabben
22. pseudo-verb	Consistent	vd	P	*trobben
23. pseudo-verb	Consistent	vl	S	nossen
24. pseudo-verb	Consistent	vl	S	*gressen
25. pseudo-verb	Inconsistent	vl	F	*trofen
26. pseudo-verb	Inconsistent	vd	F	*drovven
27. pseudo-verb	Inconsistent	vl	F	krafen
28. pseudo-verb	Inconsistent	vd	F	navven
29. pseudo-verb	Inconsistent	vd	P	*treben
30. pseudo-verb	Inconsistent	vd	P	froben
31. pseudo-verb	Inconsistent	vl	S	drosen
32. pseudo-verb	Inconsistent	vl	S	*knasen
33. verb	Filler	-	-	*kopen
34. verb	Filler	-	-	*slapen
35. verb	Filler	-	-	*eten
36. verb	Filler	-	-	*lezen
37. pseudo-verb	Filler	vd	-	*spennen
38. pseudo-verb	Filler	vd	-	*binkelen
39. pseudo-verb	Filler	vl	-	*kloepen
40. pseudo-verb	Filler	vl	-	*grijken

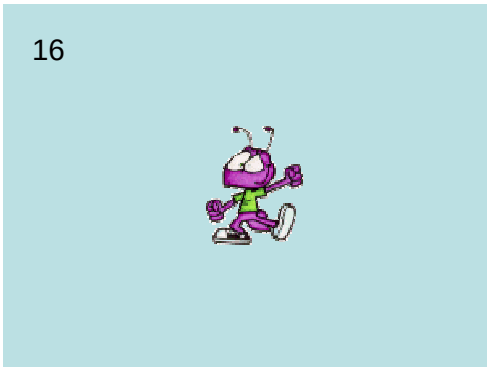
[9] Voiceless is abbreviated as "vl" and voiced as "vd".
[10] The obstruent is the last phoneme of the first person singular.

Appendix 3: Examples of the past tense production experiment

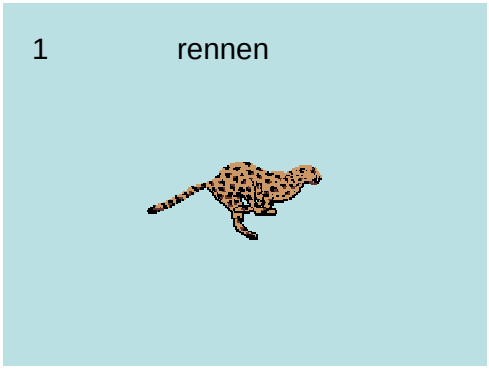
1) Auditory condition existing verb *klappen* [klɑpən] ("to clap")



2) Auditory condition pseudo-verb *greiken* [GrEikən]



3) Orthographically condition existing verb *rennen* [rɛnən] ("to run")



4) Orthographically condition pseudo-verb *drovven* [drɔvən]