Variability in the acquisition of allomorphs

The Dutch diminutive and past tense

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Author contributions

Chapter 1: Introduction

Written by Tiffany Boersma. Boersma wrote the first version of the chapter and based on feedback from Rispens, Baker, and Weerman, she rewrote and revised the chapter into its final version as presented in this dissertation.

Chapter 2: Testing the diminutive and past tense

Written by Tiffany Boersma. Boersma wrote the first version of the chapter and based on feedback from Rispens, Baker, and Weerman, Boersma rewrote and revised the chapter into its final version as presented in this dissertation.

Chapter 3: The Dutch diminutive allomorph /-ətjə/: Description versus productivity

Boersma, T., Baker, A., Rispens, J., & Weerman, F. (submitted). The Dutch diminutive allomorph /-ətjə/: Description versus productivity. *Dutch Journal of Applied Linguistics*

The research question presented in this chapter on the productivity of the allomorph /-ətjə/, was posited by Boersma, Baker, Rispens, and Weerman. In order to obtain a better notion of the productivity of this allomorph, Boersma designed the stimuli for a Wug-type production and grammaticality judgement task. Based on feedback sessions on the stimuli and tasks with Rispens, Baker, and Weerman, Boersma revised the stimuli and tasks. An overview of the stimuli can be found in the Appendix. An explanation of the tasks and stimuli can be found in Chapter 2. Boersma applied for approval from the ethical committee and recruited the participants together with a student-assistant. Boersma and the student-assistant ran the experiment. Boersma statistically analysed the results. Boersma wrote the first version of the text. During several supervision sessions with Baker, Rispens, and

Weerman, but also with Baker alone, the text was discussed. On the basis of their feedback, Boersma rewrote and revised the paper into its final, submitted form.

Chapter 4: The effects of phonological skills and vocabulary on morphophonological processing

Boersma, T., Baker, A., Rispens, J., & Weerman, F. (2017). The effects of phonological skills and vocabulary on morphophonological processing. First Language, doi: 10.1177/0142723717725430

The research question presented in this chapter on the effects of children's phonological processing skills and vocabulary size on production and judgement accuracies of the Dutch past tense and diminutive was posited by Boersma, Rispens, Baker, and Weerman. Boersma designed the stimuli for a Wug-type production and grammaticality judgement task which were the same stimuli and tasks as presented in Chapter 3. The tasks testing IQ, receptive vocabulary, and phonological processing skills were standardised tasks taken from the Raven progressive matrices (Raven, Raven, & Court, 2003), the PPVT-III (Schlichting, 2005) and the CELF (Semel, Wiig, & Secord, 2010). The NWR task was the same as the one presented in Rispens and Baker (2012). Boersma applied for approval from the ethical committee and recruited the participants. Boersma and a student-assistant ran the experiment. Boersma statistically analysed the results. Boersma wrote the first version of the text. During several supervision sessions with Rispens, Weerman, and Baker, but also with Rispens alone, the text was discussed. On the basis of their feedback, Boersma rewrote and revised the paper into its final, submitted form.

Chapter 5: The acquisition of diminutive allomorphs: Taking item specific characteristics into account

Boersma, T., Rispens, J., Weerman, F., & Baker, A. (submitted). Acquiring diminutive allomorphs: Taking item specific characteristics into account. *Journal of Child Language*

The research question presented in this chapter on the effects of the phonological characteristics of stems, and type and phonotactic frequencies of the (stem+) allomorphs on production accuracies of the Dutch diminutive, was posited by Boersma, Rispens, Weerman, and Baker. Boersma designed the stimuli for a Wug-type production task which were the same stimuli as presented in Chapters 3 and 4. Boersma applied for approval from the ethical committee and recruited the participants. Boersma and a student-assistant ran the experiment. Boersma statistically analysed the results. Boersma wrote the first version of the text. During several supervision sessions with Rispens, Weerman, and Baker, but also with Rispens alone, the text was discussed. On the basis of their feedback, Boersma rewrote and revised the paper into its final, submitted form.

Chapter 6: Allomorphy in children with reading difficulties: Associations between morphophonology, phonology, and rapid automatized naming

Boersma, T., Rispens, J., Baker, A., & Weerman, F. (submitted). Allomorphy in children with reading difficulties: Associations between morphophonology, phonology, and rapid automatized naming. *Journal of psycholinguistic research*

The research question presented in this chapter on sensitivity to allomorphy in children with reading difficulties was posited by Boersma, Rispens, Baker,

and Weerman. Boersma designed the stimuli for a Wug-type production and grammaticality judgement task which were the same stimuli as presented in Chapters 3, 4, and 5. The tasks testing IQ, receptive vocabulary, and phonological processing skills were standardised tasks taken from the Raven progressive matrices (Raven et al., 2003), the PPVT-III (Schlichting, 2005), and the CELF (Semel et al., 2010). The NWR task was the same as the one presented in Rispens and Baker (2012). The real and pseudo word reading tasks were developed by respectively Brus and Voeten (1979) and Van den Bos, Spelberg, Scheepstra, and De Vries (1994). Boersma applied for approval from the ethical committee and recruited the participants. Boersma and a student-assistant ran the experiment. Boersma statistically analysed the results. Boersma wrote the first version of the text. During several supervision sessions with Rispens, Weerman, and Baker, but also with Rispens alone, the text was discussed. On the basis of their feedback, Boersma rewrote and revised the paper into its final, submitted form.

Chapter 7: Discussion

Written by Tiffany Boersma. Boersma wrote the first version of the chapter and based on feedback from Rispens, Baker, and Weerman, Boersma rewrote and revised the chapter into its final version as presented in this dissertation.

1
Introduction

Becoming proficient in a language is a complex and multifactorial process. Nevertheless, the development of children's native language appears to proceed relatively quickly and easily. This development is characterized by a gradual acquisition of linguistic structures. The use of verbal inflections, for example, emerges during early childhood with the finiteness system gradually developing into a system in which inflections are nearly always used appropriately (Blom, 2003). There is a great deal of variation in how and when different linguistic milestones are acquired, not only within children but also within a linguistic system. This is evident in the case of morphological inflections as some inflections are acquired before others. For example in Dutch, person is acquired before tense (Van Kempen & Wijnen, 2000). But inflections with the same semantics, e.g., regular past tense, can also have different phonological forms with different developmental patterns.

The branch of linguistics that deals with the phonological representation of morphemes is called morphophonology. Within this area the acquisition of allomorphs is the main topic of this dissertation. The allomorphs dealt with in this dissertation are phonologically variant forms of morphemes. Consequently, the selection of the appropriate allomorph depends on the phonological characteristics of nouns or verbs in line with the phonotactic and/or phonological restrictions of a language, i.e., restrictions on the permitted combinations of phonemes (Buckler, 2014; Kerkhoff, 2007; Zamuner, Kerkhoff, & Fikkert, 2012). Earlier studies have found variability in the use and acquisition of allomorphs. For example, results from many previous studies have indicated that the three allomorphic forms of the English regular past tense, /-d/ as in *'lived'*, /-t/ as in *'helped'*, and /-Id/ as in *'waited'*, cause variability in production accuracies in children (Bybee, 1985;

Marshall & Van Der Lely, 2006; Matthews & Theakston, 2006; Oetting & Horohov, 1997). The syllabic /-Id/ allomorph is produced less accurately and is acquired later than the other two allomorphs. Other instances in which there is a protracted acquisition of some allomorphs compared to others are apparent not only in English, but also in other languages. In previous studies various explanations have been given for this protracted acquisition. However, a multifactorial approach that brings together and clarifies the relationships between these diverse explanations is missing. In this dissertation an attempt is made to not only re-examine previous results, but also to tie together the different factors that seem to be involved in the acquisition of allomorphs. By doing so a more univocal understanding of why some allomorphs take longer to acquire than others can be obtained.

1.1 Variability in the acquisition of allomorphs: potential factors

The phonological structure and characteristics of the stem that a suffix attaches to can define the phonological composition of the allomorph.[1] Consequently, phonology is an important component in the acquisition of some allomorphs. Several earlier studies have shown that coda complexity, articulatory difficulties, perceptual saliency, phonetic substance, local phonetic dependencies, stress, and syllabicity are related to allomorphic productivity and development (among others Baer-Henney & Van De Vijver, 2012; Jarmulowicz, 2006; Jarmulowicz & Hay, 2009; Mealings, Cox, & Demuth, 2013; Song, Sundara, & Demuth, 2009; Tomas, Demuth, Smith-Lock, & Petocz, 2015; Tomas, Van De Vijver, Demuth, & Petocz, 2017). The complexity of the phonological characteristics of a specific item has been shown to account for much of the variability in children's early productions of inflectional and

[1] Note that some allomorphs are lexically driven and are therefore not based on the phonological and/or phonotactic characteristics of the language.

derivational morphemes. Since morphological inflections and derivations can thus entail a phonological component, it might be argued that in such cases children's phonological skills will influence their awareness of the phonological characteristics and patterns involved in applying the appropriate allomorph. Weaknesses in children's phonological representations or competence might lead to a protracted acquisition of some allomorphs. Studies in which children with poor phonological skills participated, e.g., children with developmental dyslexia or specific language impairment, have indeed found a relation between children's phonological and morphological skills (Joanisse, Manis, Keating, & Seidenberg, 2000; Robertson, Joanisse, Desroches, & Terry, 2012; Tomas et al., 2015). It should, however, also be mentioned that several studies have found morphological and phonological skills to be independent from each other (Cantiani, Lorusso, Guasti, Sabisch, & Männel, 2013; Deacon & Kirby, 2004; Law, Wouters, & Ghesquière, 2015). An objective of this dissertation is to gain a better understanding of the associations between the complexity of the different phonological characteristics of stems, children's phonological processing skills, and children's acquisition of allomorphs. This is done in both typically developing (TD) children and children with reading difficulties who have poor decoding skills. The latter group of children have been reported to have impairments in their phonological processing skills (Gallagher, Frith, & Snowling, 2000; Hulme & Snowling, 2009; Ramus, Marshall, Rosen, & Van Der Lely, 2013; Snowling, 2013). A study including children with reading difficulties alongside TD children therefore provides additional insights into the learnability and processing of allomorphs and the relation between morphological and phonological skills in children.

Frequency effects will also be studied in this dissertation. Earlier studies have repeatedly found that more frequent language structures are acquired before less frequent structures (Ambridge, Kidd, Rowland, & Theakston, 2015; Blom, Paradis, & Duncan, 2012; Bybee, 2001; Bybee, 2007; Kerkhoff, 2007; Marchman & Bates, 1994; Marchman, 1997; Paradis, Tremblay, & Crago, 2014; Zamuner et al., 2012). Variability in productivity across allomorphs could therefore be expected to be dependent on their relative frequency (Ambridge et al., 2015; Tomasello, 2003; Zamuner, Kerkhoff, & Fikkert, 2006). The influence of type frequencies of the allomorphs and phonotactic frequencies of the stem+allomorph combinations will be investigated. Phonotactic frequency is defined as the frequency or probability that adjacent phonemes appear together in a language. Several studies have found effects of phonotactic frequency in the development and acquisition of morphophonological patterns and allomorphs (De Bree & Kerkhoff, 2010; Rispens & De Bree, 2014; Zamuner et al., 2012). Type frequency takes into account the number of stems with which a certain allomorph is used (Ambridge et al., 2015; Blom et al., 2012; Bybee, 2007; Bybee, 2010; Matthews & Theakston, 2006). An allomorph that is encountered more often will become more deeply anchored in the lexicon and its lexical strength will increase (Blom et al., 2012). Related to this view are studies that have indicated that vocabulary development is a strong predictor of morphological development (Blom et al., 2012; Kerkhoff, 2007; Marchman & Bates, 1994). The learning of lexical items may trigger the organization of lexical information, optimally facilitating the abstraction of general patterns and subsequent productive usage (Marchman & Bates, 1994). Consequently, the larger the lexicon of the child, the more items (token frequency) or exemplars (type frequency) will exist in the lexicon, and the earlier the child might be able to abstract the different morphophonological patterns that give rise to the allomorphs. The

association between the size of the lexicon of a child and his/her sensitivity to allomorphy will also be assessed.

1.2 Research questions

The main issue addressed in this dissertation is the protracted acquisition of some allomorphs compared to others as reported in previous studies. Various mechanisms underlying this variability in acquisition have been identified in earlier work. Some studies posit that it is primarily the complexity of the phonological composition and characteristics of the stems that result in some allomorphs being produced more accurately than others (among others Jarmulowicz, 2006; Jarmulowicz & Hay, 2009; Mealings et al., 2013; Song et al., 2009; Tomas et al., 2017). Moreover, because of this phonological component, some of the variability in the acquisition of allomorphs might also be the result of weaknesses in children's phonological representations and competence (among others Joanisse et al., 2000; Robertson et al., 2012; Song et al., 2009). On the other hand, evidence from other studies suggests that it is mainly effects of frequency that cause the difficulties children have with some allomorphs, as well as the size of children's vocabulary (among others Blom et al., 2012; Bybee, 1985; Matthews & Theakston, 2006; Rispens & De Bree, 2014). A few studies have found both effects of frequency and of the phonological composition of the stem, but it is unclear how large these effects are and how these factors are related (for example Baer-Henney & Van De Vijver, 2012; Oetting & Horohov, 1997). In the studies presented in this dissertation an attempt is made to re-examine the findings of previous studies and consequently determine the factors that influence the acquisition of allomorphic patterns. Two types of factors are differentiated: 1) Child factors,

such as phonological skills and vocabulary size (linguistic skills), and 2) Item factors, such as the phonological characteristics of the stem and allomorph and their frequencies (item-specific characteristics). In addition, the relationship between these potential factors will be explored. The results will give a more inclusive picture that explains the variability in the use and acquisition of allomorphs. Finally, although the acquisition of allomorphs is the primary focus of this dissertation, it is important to be aware of what the outcome of this development will be, i.e., we need to know what the adult system looks like. Adult data is therefore also investigated. The Dutch diminutive is a complex morphophonological phenomenon with five allomorphs based on different phonological characteristics of the stem. The phonological characteristics of the stems that give rise to the allomorph /-ətjə/ appear to be particularly complex. Although relatively many theoretical papers exist on the formation of the Dutch diminutive, its actual productivity is unclear. It was therefore considered necessary to study the productivity of the Dutch diminutive system in adults.

In sum, the main question of this dissertation is whether and to what extent children's linguistic skills, and item specific characteristics influence the acquisition of allomorphs. Specifically, the Dutch past tense (two allomorphs) and the Dutch diminutive (five allomorphs) will be studied (see Sections 2.1 and 2.2). The sub-questions investigated in the different studies are:

- Is the Dutch diminutive system fully productive in adults? (Chapter 3)
- To what extent do children's phonological processing skills and vocabulary size influence their sensitivity to allomorphy? (linguistic skills; Chapter 4)
- What is the influence of item specific characteristics, such as phonological characteristics of stems and phonotactic and type

frequencies of (stem+) allomorphs, on the development of allomorphic patterns? (item specific characteristics; Chapter 5)

- Do children with reading difficulties exhibit problems in the allomorphic domain compared to their chronological age and reading age matched typically developing peers? (linguistic skills; Chapter 6)

1.3 Outline

The core of this dissertation consists of four empirical studies with the main conclusions of these studies discussed in the final chapter (Chapter 7). Chapter 2 provides an overview of the Dutch past tense and diminutive, the tasks, and the test items. The explanation of the formation of the Dutch past tense and diminutive is relevant for all four studies and is thus presented here and not repeated in the subsequent chapters. The empirical studies have considerable overlap in their methodology since the same judgement and production tasks with the same items are used in all studies. The description of the tasks and stimuli are therefore also presented in Chapter 2 and not repeated in the subsequent chapters.

Chapter 3 describes the results of the first study testing production and judgement accuracies of the Dutch diminutive in adults. In Chapter 4 it is hypothesized that phonological processing skills and the size of the lexicon of Dutch TD primary school aged children (5;0 – 10;0) will be associated with their Dutch diminutive and past tense production and judgement accuracies. Here the focus lies on children's linguistic skills and to what extent these skills are associated with children's ability to accurately produce and judge allomorphs. In Chapter 5, item specific characteristics and their influence on children's production of the Dutch diminutive allomorphs are expanded on. It

is hypothesized that the complexity of the phonological characteristics of the noun stems and the type and phonotactic frequencies of the (stem+) allomorph will have an effect on children's diminutive production accuracies. In Chapter 6 the question is investigated whether children with reading difficulties exhibit problems in their understanding of which allomorphs are appropriate to use and whether these potential problems are associated with their phonological skills. They are compared to chronological age and reading age matched TD children. Finally, in the concluding chapter (Chapter 7) it becomes clear that the child's sensitivity to the phonological characteristics of the stems is an important factor in the protracted acquisition of some allomorphs.

2
Testing the diminutive and past tense

Since the studies presented in Chapters 3 to 6 have a comparable background and make use of similar methodologies, these aspects will be discussed here. In the first section of this chapter the formation of the Dutch past tense and diminutive will be described. The subsequent sections deal with the test materials used in the different studies presented in this dissertation. The studies used a wug-type production and grammaticality judgement task to test the Dutch past tense and diminutive in adults, typically developing children, and children with reading difficulties. Although all participants were assessed on the past tense and the diminutive using the production and the judgement tasks, not all the collected data is presented in each chapter. Only the data that were deemed relevant to answer the specific research questions in each study are presented. An overview of which data will be presented in which chapter is given in the final section.

2.1 The Dutch past tense

The Dutch simple past tense is used to refer to an action or event that took place in the past. It is most commonly used when referring to an event that took place in the past with no apparent connection to the present. It consists of two allomorphs that are attached to the stems based on place assimilation: The /-də/ allomorph is attached to stems ending in an underlyingly voiced consonant or vowel, e.g., *ren-de* (to run), *aai-de* (to pet), while the /-tə/ allomorph is attached to stems ending in an underlyingly voiceless consonant, e.g., *bak-te* (to bake), *knip-te* (to cut) (See also Booij, 1995; De Bree, Van Der Ven & Van Der Maas, 2017; De Haas & Trommelen, 1993; Ernestus & Baayen,

2006). Dutch is characterized by final devoicing which makes inflecting the past tense in an appropriate manner somewhat complex. Spoken word-final obstruents are always voiceless. For example, *bed* (bed) is pronounced with a /t/ and not with a /d/ (Booij, 1995; De Bree et al., 2017). Similarly, plosives and fricatives in stems of infinitival verbs are pronounced voiced (e.g., *tobben* (to worry)), but when these phonemes occur stem finally they are affected by final devoicing as in /tɔp/. However, because the plosive is underlyingly voiced, the past tense form is /tɔbdɔ/ (Booij, 1995; De Bree et al., 2017). Since we were not interested in testing children's awareness of final devoicing and the alternations consequently implied, we decided to not test items in which the stems end with plosives or fricatives.

2.2 The Dutch diminutive

In Dutch, diminutives seem to have been commonly used for a long time; they have been encountered in texts from the Middle-Dutch period, and are still a frequent phenomenon. The forms that we use nowadays are said to have been in use since the sixteenth and seventeenth century, also known as the 'Golden Age' in the Netherlands, although these forms might have been spreading through the Netherlands already in centuries before (Marynissen, 1998; Shetter, 1959). The most common way of forming a diminutive is by attaching the diminutive suffix to nouns (*hond-je,* dog-DIM). However, it can also be attached to other parts of speech forming a noun in each case: adjectives (*klein-tje,* little-DIM, little one), verbs (*speel-tje,* play-DIM, small toy) and a few prepositions (*uit-je,* out-DIM, outing). Semantically, the diminutive expresses smallness in that the referent is a smaller version of its sort but it can also express the fact that a referent is a great deal smaller than the speaker, i.e., a human being (Bakema, Defour, & Geeraerts, 1993; Peelaerts, 2008). As in many languages, the diminutive can also express an affective meaning. Moreover, some words with a diminutive suffix have been

lexicalized, e.g., *meis-je* (girl-DIM) and *ijs-je* (ice-cream-DIM). In these cases the resulting diminutives are not directly derived from the stem.

The Dutch diminutive consists of five allomorphs, /-jə/, /-tjə/, /-pjə/, /-kjə/, and /-ətjə/, which are attached to the noun stems based on the phonological characteristics of these stems. The final consonant of the stem determines the allomorph based on place assimilation between this consonant and the first consonant of the allomorph: stem ending in a labial *+pjə*, *raam-pje* (window), stem ending in an alveolar *+tjə*, *boon-tje* (bean), stem ending in an obstruent *+jə*, *huis-je* (house), and stem ending in a velar *+kjə*, *koning-kje* (king). For stems ending in a velar consonant, however, stress placement on the stem (ultimate vs penultimate), and therefore the number of syllables, is also relevant; compare *koning-kje* (king) versus *ring-etje* (ring). For stems ending in a labial or alveolar consonant, on the other hand, the length of the vowel is also relevant; compare *boom-pje* (tree) with a long vowel versus *bom-etje* (bomb) with a short vowel, similarly *zoon-tje* (son) versus *zonn-etje* (sun). A summary of the regularities of the context in which the different allomorphs can appear as provided by Booij (1995) is listed in (1) to (5).

(1) /-jə/ appears after stem-final obstruents

Hof (yard)	*hofje*
Baas (owner)	*baasje*
Huis (house)	*huisje*
Kat (cat)	*katje*

(2) /-pjə/ appears after /m/ except if preceded by a short vowel

Boom (tree)	*boompje*
Duim (thumb)	*duimpje*
Raam (window)	*raampje*
Zalm (salmon)	*zalmpje*

(3) /-kjə/ appears after /ŋ/ except when there is no stress on the penultimate syllable

Woning (home)	*woninkje*
Koning (king)	*koninkje*

Botsing (crash)	*botsinkje*
Ontploffing (explosion)	*ontploffinkje*

(4) /-tjə/ appears after /n/, /r/ or /l/ except if preceded by a short vowel

Laan (lawn)	*laantje*
Veer (feather)	*veertje*
Schoen (shoe)	*schoentje*
Boon (bean)	*boontje*

(5) /-ətjə/ appears after sonorant consonants if preceded by a short vowel with primary or secondary stress

Bal (ball)	*balletje*
Bom (bomb)	*bommetje*
Tekening (drawing)	*tekeningetje*
Ring (ring)	*ringetje*

The above examples (1-5) show that the diminutive allomorphs are derived in an 'item-and-arrangement' manner in which the different allomorphs are selected in the appropriate phonological environment (Peelaerts, 2008; Trommelen, 1984; Van der Hulst, 2008). The allomorphs /-jə/, /-tjə/, /-pjə/, and /-kjə/ are selected based on the manner of articulation of the final stem phoneme (obstruent/sonorant), and, in the case of stems ending with a sonorant, on the place of articulation of the final stem phoneme. In contrast, /-ətjə/ does not follow from a place assimilation process; factors like vowel length, number of syllables, and stress placement have to be taken into account. In addition, this allomorph adds two syllables to the original noun (for example *ring – ringetje* (ring)), instead of one (compare *boom-boompje* (tree)). In sum, the four short forms without a schwa follow from regular phonotactic nasal-obstruent cluster generalizations in Dutch (Booij, 1995). This makes these four allomorphs fairly transparent and relatively easy to apply. In contrast, /-ətjə/ is more complex and less transparent in its use.

2.3 The participants

Adults (Chapter 3), five to ten year old typically developing children (Chapters 4 and 5), and eight to ten year old children identified as children with reading difficulties (Chapter 6) were tested. Although at this age children are presumed to understand and be able to produce inflections and derivations, variabilities in production accuracies between allomorphs are thus still apparent. The groups of participants used in each study varied. The details of the groups will therefore be presented in the respective chapters separately.

2.4 Test materials

Differences between children in terms of their Dutch past tense and diminutive production and judgement accuracies, phonological processing skills, and vocabulary size are assessed. Additionally, effects of frequency and complexity of the phonological characteristics of the stems that give rise to the allomorphs are evaluated. Both real and nonce verbs and nouns were tested. Generalizations of both the past tense and diminutive to nonce verbs and nouns give extra information as to whether the participants actually use a morphophonological pattern. Nonce forms typically follow the same patterns as the real (regular) verbs and nouns but by definition have no lexical representation stored in long-term memory that can be drawn upon. The children and adults tested in this dissertation are thus required to analyze the stem and make use of their knowledge of the morphophonological patterns to apply the appropriate allomorph. Using nonce nouns and verbs as well as real nouns and verbs thus gives more insight into the actual patterns the participants are applying.

As mentioned above, both production (wug-type) and perception (grammaticality judgement) skills are tested. Production data indicate whether the participants are able to use their knowledge actively, while perception data are more indicative of passive knowledge. Moreover, in the

case of children, production difficulties could stem from articulatory difficulties so that they might seem to know less than is actually the case. Finally, in order to compare the production and perception skills with other variables, data were collected on children's phonological processing skills, vocabulary size, nonverbal intelligence, and reading skills (see Chapters 4 and 6). The tasks testing these skills are also described below.

2.4.1 Test items

The same items were used in the judgement and production tasks (see the Appendix for an overview of the items). To make sure the real lexical items were as similar as possible and known to the children, they were selected from a list of words which had previously been established as known to children aged 4 – 6 years (Damhuis, 1992). The lexical frequencies of the nouns lay between 3 - 15 instances per million (taken from the SUBTLEX-NL database (Keuleers, Brysbaert, & New, 2010)). The verbs were divided into items with high (45 – 960 instances per million) and low (1 – 40 instances per million) lexical frequencies. In addition, the items were controlled for their phonotactic frequencies (range real items -0.87 — -1.55), which were calculated based on the Dutch phonotactic frequency database (Adriaans, 2006) derived from the corpus of spoken Dutch (Oostdijk, 2000). The nonce nouns were constructed with a nonce word generator (Wuggy: Keuleers & Brysbaert, 2010). Wuggy constructs nonce words based on given input by the researcher, which for this study were the real words. However, the items were adapted so that they consisted of one or two syllables and did not contain any consonant clusters to make sure that even the youngest children could produce them. They also had to conform to the phonological and phonotactic rules of Dutch. The nonce nouns and verbs were tested with a wordlikeness task to make sure the items were considered by adult speakers as possible in the Dutch language. Again, as with the real nouns and verbs, they were controlled for

their phonotactic frequencies (range nonce items -0.97 — -1.55). The diminutive and past tense stimuli were presented in the same task semi-randomly to ensure the children and adults did not focus too much on either the past tense or the diminutive.

From the phonological characteristics of the stems that give rise to the five diminutive allomorphs, four phonological conditions were created: 1) Obstruent, stems ending in an obstruent taking /-jə/; 2) Sonorant type, stems ending in a labial taking /-pjə/; 3) Vowel length, stems ending in an alveolar with a long vowel taking /-tjə/ and stems ending in an alveolar or labial with a short vowel taking /-ətjə/; 4) Stress, stems ending in a velar with either stress on the penultimate syllable taking /-kjə/ or stress on the ultimate syllable taking /-ətjə/. There were ten items per phonological condition for both the real and nonce nouns. There were also ten items per condition, voiced and voiceless stem endings, for the real and nonce past tense forms.

Due to restrictions in time, the stimulus set was divided in two. The stimuli were semi-randomly assigned to one of the two sets. Each child or adult was randomly assigned to one of the two sets. No significant differences between the two sets were found for either the production or the judgement task so that analysis of the data was done on the two sets taken together. Each child or adult was assigned to the same set of stimuli in the production and judgement task.

2.4.2 Production task

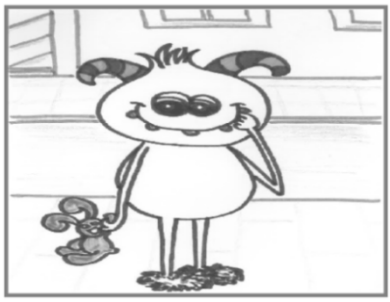
A wug type task (Berko, 1958) was used in which the participants had to provide the diminutive form of a noun and the past tense form of a verb. The stimuli were presented auditorily: first via the computer and a second time by the experimenter. Figure 2.1 shows a test item to elicit the diminutive (using a real item). To elicit the past tense, the verb was introduced by a sentence in which the infinitive form of the verb was presented to the participants twice.

The participant was then asked to tell the experimenter what happened yesterday by giving the past tense form of the verb. Figure 2.2 shows a test item used to elicit the past tense (using a nonce item). The answer was scored as correct if the target (correct/appropriate) stem+allomorph combination was produced. A total of 80 nouns (40 real and 40 nonce) and 20 verbs (10 real and 10 nonce) were tested[1].

Dit is een vlag This is a flag	Dit is een … (target answer: vlaggetje) This is a… (target answer: flag-DIM)

Figure 2.1 Example diminutive production task. The example is with a real noun.

[1] For the nonce past tense, one of the forms, *luunen*, was unfortunately not tested and instead *lummen* was tested in both sets.



De alien is aan het ronen. De alien is elke dag aan het ronen. Gisteren ook. Gisteren… (Target answer: roonde)
The alien ronen-INF. The alien ronen-INF every day. Yesterday too. Yesterday… (Target answer: roonde)

Figure 2.2 Example past tense production task. The example is with a nonce verb.

2.4.3 Judgement task

A grammaticality judgement task was used in which the participants had to judge a diminutive or past tense form presented auditorily via the computer. The items were embedded in a sentence and accompanied by pictures to facilitate comprehension of the nonce nouns and verbs. Figure 2.3 shows a diminutive test item (using a nonce item) and Figure 2.4 a past tense test item (using a real item).

All nouns and verbs were presented twice: once with the target allomorph (expected according to the linguistic descriptions of the Dutch diminutive and past tense) and once with the non-target allomorph (unexpected according to the linguistic description). The non-target allomorphs violated one morphophonological pattern. To illustrate this for the diminutive: in the case of the noun *koek* ('cookie') the target allomorph is /-jə/ due to the final consonant being an obstruent. The non-target allomorph chosen was /-tjə/, **koektje*, which violates the obstruent pattern, but not for example the vowel length pattern. Other non-target stem+allomorph

combinations could be **koeketje*, and **koekpje* but these violate two patterns or are phonotactically unlikely in Dutch.

The Dutch past tense has only two allomorphs and for the non-target stem+allomorph combinations they were interchanged with each other. For example, the stem of the verb *pakken* ('to grab') is *pak* which ends with a voiceless consonant and therefore receives the allomorph /-tə/. The non-target form is then formed by attaching the voiced allomorph /-də/ which makes **pakde*.

If the participants decided the diminutive or past tense form was incorrect, they were asked to give their version of the correct answer. Each response was scored as correct (appropriate) or incorrect (inappropriate) according to the existing linguistic descriptive rules. The stimuli set consisted of N = 160 nouns, 80 real and 80 nonce, and N = 40 verbs, 20 real and 20 nonce, and contained the target and non-target stem+allomorph combinations.

Figure 2.3 Example diminutive judgement task. Example is with a nonce noun.

Ik aai de kat. Gisteren aaide/*aaite de vrouw de kat
I pet the cat. Yesterday the women petted/*petted the cat

Figure 2.4 Example past tense judgement task. Example is with a real verb.

2.4.4 Tasks for background measures

Table 2.1 presents the tasks used to measure nonverbal intelligence, receptive vocabulary, phonological processing, and reading skills of the children.

Table 2.1
Measures of nonverbal intelligence, receptive vocabulary, phonological processing, and reading skills

RAVEN (Standard Progressive Matrices) (Raven, Raven, & Court, 2003)	Measure of non-verbal IQ Children were asked to complete visual patterns by selecting the correct missing piece from an array of six or eight possible pieces. The test consists of five sets of 12 items that increase in difficulty. A single raw score is calculated, which is then converted to a percentile score based on provided norms.
PPVT (Schlichting, 2005)	Measure of receptive vocabulary Children were presented with four pictures and were asked to point at the picture that matched the word spoken to them by the experimenter. The test consists of 17 sets with 12 items each. On the basis of a child's age the starting set is chosen and the test is discontinued after a child makes 9 or more mistakes. A single raw scores is

	calculated and is then converted into a normally distributed standardized score with a mean of 100 based on provided norms.
RAN, CELF-IV (Semel, Wiig, & Secord, 2010)	Measure of visual processing and storing of repeated shapes, colours, and shape-colour combinations in working memory. Children were asked to recite as fast as possible colours, shapes, or shape-colour combinations presented to them visually. The test was timed and based on this raw score in seconds a standardized scores was derived based on the provided norms. A standard score of 10 corresponds to a percentile score of 50.
Phonological awareness, CELF-IV (Semel et al., 2010)	Measure of phonological awareness Children were asked to rhyme and manipulate sounds and syllables. The tests contained 9 subtests of each five items that assessed children's ability with phoneme blending, final phoneme identification, medial phoneme identification, syllable recognition, final syllable deletion, syllable deletion, and phoneme substitution. A single raw score is calculated and is then converted into a standardized score based on the provided norms. A standard score of 10 corresponds to a percentile score of 50.
Digit span, CELF-IV (Semel et al., 2010)	Measure of phonological working memory Children were asked to repeat a series of numbers forwards and backwards. A composite score of the forward and backward task was used in this dissertation. The raw score was calculated as the total number of correctly recalled lists. This raw score is then converted into a standardized score based on the provided norms. A standard score of 10 corresponds to a percentile score of 50.
NWR (Rispens & Baker, 2012)	Measure of phonological processing skills Children had to repeat nonce words with varying difficulties (two to five syllables and phonotactic frequent and infrequent). The raw score was calculated as a percentile score based on the correctly recalled phonemes of all nonce words together.

Real word reading test (RWT) (Brus & Voeten, 1979)	Measure of real word reading Children were asked to read as many real words as they could in one minute. The raw score was the total number of words read in one minute. A standardized score was derived from the raw score based on the provided norms. A standard score of 10 corresponds to a percentile score of 50.
Nonce word reading test (NWT) (Van Den Bos, Spelberg, Scheepstra, & De Vries, 1994)	Measure of nonce word reading Children were asked to read as many nonce words as they could in two minutes. The raw score was the total number of nonce words read in two minutes. A standardized score was derived from the raw score based on the provided norms. A standard score of 10 corresponds to a percentile score of 50.

2.5 Overview of the data presented in the individual chapters

Although all participants were assessed on the production and judgement task testing the past tense and diminutive, not all data are presented in each chapter. The adult study was conducted to obtain insight into adult-like performance. Because, as expected, the adults performed at ceiling level on the past tense, these data are not presented in this dissertation; only the diminutive data are presented (Chapter 3). The main goal of this dissertation is to investigate children's linguistic skills and item specific characteristics in relation to children's allomorphic skills. Chapters 4 and 6 focus on children's linguistic skills and present the data from both the production and grammaticality judgement tasks with the past tense and diminutive. Chapter 5 focusses on the item specific characteristics and only the data from the diminutive and the production task are presented. Table 2.2 gives an overview of which data were collected and in which chapter they are discussed.

Table 2.2
Overview of the data presented in the chapters

	Production diminutive	**Production past tense**	**Judgement diminutive**	**Judgement past tense**
Adults	Chapter 3[2]		Chapter 3	
Typically developing children	Chapter 4[3]	Chapter 4	Chapter 4	Chapter 4
	Chapter 5[4]			
	Chapter 6	Chapter 6	Chapter 6	Chapter 6
Children with reading difficulties	Chapter 6[5]	Chapter 6	Chapter 6	Chapter 6

[2] A slightly modified version of Chapter 3 has been submitted as: Boersma, T., Baker, A., Rispens, J., & Weerman, F. (submitted). The Dutch diminutive allomorph /-ətjə/: Description versus productivity. *Dutch Journal of Applied Linguistics*

[3] A slightly modified version of Chapter 4 appeared as: Boersma, T., Baker, A., Rispens, J., & Weerman, F. (2017). The effects of phonological skills and vocabulary on morphophonological processing. *First Language*, 1-28. doi: 10.1177/0142723717725430

[4] A slightly modified version of Chapter 5 has been submitted as: Boersma, T., Rispens, J., Weerman, F., & Baker, A. (submitted). Acquiring diminutive allomorphs: Taking item specific characteristics into account. *Journal of Child Language*

[5] A slightly modified version of Chapter 6 has been submitted as: Boersma, T., Rispens, J., Baker, A., & Weerman, F. (submitted). Allomorphy in children with reading difficulties: Associations between morphophonology, phonology, and rapid automatized naming. *Journal of psycholinguistic research*

3
The Dutch diminutive allomorph /-ətjə/*

Description versus productivity

Abstract

This chapter presents the results of a study in which the production and judgement of the Dutch diminutive allomorph /-ətjə/ were investigated. It was evaluated whether its greater complexity and/or its more variable use compared to the other allomorphs influences production and judgement accuracies. Dutch university students were tested on all five diminutive allomorphs (real and nonce). Performance on the production and judgement tasks was lower for /-ətjə/ compared to the other allomorphs, but this difference was significant for the nonce nouns only. Allomorphs were chosen instead of /-ətjə/ based on place assimilation between the final consonant of the stem and the first consonant of the allomorph. The results show that /-ətjə/ is less productive than would be expected based on the existing linguistic grammatical descriptions. The findings of this study demonstrate that linguistic grammatical descriptions do not necessarily correspond to the productivity patterns in a language.

*A slightly modified version of this chapter has been submitted as: Boersma, T., Baker, A., Rispens, J., & Weerman, F. (submitted). The Dutch diminutive allomorph /-ətjə/: Description versus productivity. *Dutch Journal of Applied Linguistics*

3.1 Introduction

How well the linguistic rules as set out in grammatical descriptions of languages correspond to reality is a delicate matter. Often very little is known about the status of the linguistic descriptions as recent empirical research has not been conducted despite the fact that linguistic forms can change over the years. For a better understanding of not only productivity in the adult language, but also for the study of child language, knowledge about the status of these rules or patterns is important. If a linguistic phenomenon is not fully productive in the adult language, it remains unclear to what extent it is, and whether it can become, fully productive in the child's grammar. Knowledge of productivity in the adult language thus needs to be in place before investigating child language.

This paper will focus on the productivity of the allomorph /-ətjə/, one of the five allomorphic forms of the Dutch diminutive, and the status of its linguistic description. The diminutive is often used in child-directed speech. However, very little is known about its actual productivity. In addition, forming the diminutive is a complex morphophonological phenomenon involving five allomorphs. It is thus an interesting case study for the acquisition of morphophonology in children. As was described in Chapter 2, one of these five allomorphs, /-ətjə/, appears to be more complex than the other allomorphs. Dahl (2004) describes complexity as a measure of the amount of information needed to describe or reconstruct a particular process or linguistic phenomenon. In other words, the length of the shortest description of the phenomenon describes its complexity.[1] Following this definition, the more complex a phenomenon, the more features/patterns/rules need to be taken into account (which is the case for

[1] Note that this is not the same as difficulty but an objective property of the system (Dahl, 2004)

/-ətjə/), and the greater the cost to the user. This can possibly affect the direction of language change such that processes or phenomena with the greater cost are the first to disappear (Aalberse, 2009). This study will investigate the production and judgement of /-ətjə/ to see whether speakers adhere to the linguistic patterns as formulated in previous literature and whether a reduction of complexity is taking place.

3.1.1 The Dutch Diminutive

Chapter 2 presented a linguistic description of how to form the Dutch diminutive. This description is a relatively short summary but many more detailed linguistic descriptions have been proposed over the years (see for example Cohen (1958) and Trommelen (1984)). In particular, the distinction between the short forms without a schwa, /-tjə/, /-jə/, /-pjə/, and /-kjə/ and the long form with a schwa /-ətjə/, has been a matter of debate. The main concern has been the motivation of the choice between the form containing a schwa versus the four forms without a schwa (Trommelen, 1984; Van Der Hulst, 2008). Although different analyses and motivations have been proposed, they all have in common the idea that the allomorph /-ətjə/ is different from the others (Ewen, 1978; Haverkamp-Lubers & Kooij, 1971; Huber, 2005; Trommelen, 1984; Van Der Hulst, 2008; Van Voorst, 1983). The four short forms without a schwa follow from regular phonotactic nasal-obstruent cluster generalizations in Dutch (Booij, 1995). Only one constraint, place of articulation of the final sonorant of the stem, has to be taken into account in order to apply /-tjə/, /-pjə/, /-kjə/ correctly and stems ending in an obstruent always take /-jə/. This makes these four allomorphs fairly transparent and relatively easy to apply. In contrast, the allomorph /-ətjə/ is more complex as two constraints are involved in the correct use of /-ətje/;

disregard place assimilation when the stem has 1) a short vowel or 2) no stress on the penultimate syllable.

Another characteristic of /-ətjə/ is that it appears with some nouns in spite of the phonological characteristics of those noun stems. Thus some words have, in addition to their regular diminutive, a variant form with /-ətjə/, e.g., *kip-kipje-kippetje* (chicken), *bloem-bloempje-bloemetje* (flower), *wiel-wieltje-wieletje* (wheel). This never happens with the other allomorphs (**boomtje* never appears). In the case of *bloem*, there is also a semantic difference: *bloempje* is a little flower, while *bloemetje* refers to both a small flower and a (small) bouquet of flowers. Note that the more complex allomorph is added instead of the simpler forms. In most cases, speakers have a preference for one of the forms, although the other form is often judged as acceptable as well. By no means, however, can all nouns be used in this way. For example, although comparable to *wiel*, *schoen* (shoe) will never take /-ətjə/, i.e., **schoenetje* will not be accepted by speakers. According to Van der Hulst (2008) the usual explanation is that the long vowels in the stems that also take /-ətjə/ are fairly short. However, this phenomenon has not been studied very thoroughly and, except for this rather simple explanation, it is not clear why this variability in the system between the use of /-ətjə/ and the other allomorphs exists.

The description of the Dutch diminutive presented in Chapter 2 and the characteristics of /-ətjə/ mentioned above indicate that the allomorph /-ətjə/ stands out from the other allomorphs as the morphophonological pattern for its application is more complex. This complexity may lead to the greater use of the more simple patterns. However, it is also used where the more simple patterns could apply. The question that arises is what the actual relation is between the in theory linguistically described patterns involved in applying the diminutive allomorph /-ətjə/ and the use and comprehension of

/-ətjə/ in reality. To answer this question, this study investigated the production and judgement of the Dutch diminutive.[2] On the one hand, the more complex patterns for /-ətjə/ are seen as the cause for a discrepancy between the linguistic description and actual productivity. The more transparent place of articulation patterns would then be expected to be applied instead of /-ətjə/, i.e., instead of *bommetje* (bomb-DIM) participants are predicted to produce **bompje* which adheres to the place assimilation pattern but disregards the notion that stems with a short vowel should receive /-ətjə/. On the other hand, there are lexicalized examples in dictionaries which are also attested in Dutch corpora where /-ətjə/ is used instead of the more simple allomorphs. It might then be expected that participants overuse /-ətjə/ and produce stem+/-ətjə/ combinations that are not expected based on the linguistic morphophonological patterns as formulated in the literature. In both cases, a discrepancy between the grammatical morphophonological patterns as stated in the linguistic descriptions and actual performance in reality is thus expected.

3.2 Methodology

3.2.1 Participants

Forty-three Dutch university students participated in the study (23 female). All participants were between 18 and 26 years old with a mean age of 23;7 years. They were native speakers of Dutch and raised in monolingual families. None of the participants reported any significant problems, such as hearing or language difficulties, that could affect the outcome of the study. A nonword

[2] Note that it is crucial to test not only real but also nonce nouns as nonce nouns cannot be stored in the lexicon as a whole.

repetition task was used to check their general language abilities; no participant needed to be disqualified. The participants had not followed any courses in linguistics and could thus be considered as naïve for this study.

3.2.2 Test material

The material used in the judgement and production tasks was fully described in Chapter 2.

All five diminutive allomorphs were tested. In the presentation of the stimuli (to ensure the participants did not only focus on the diminutive) the past tense was used as a filler.

3.2.3 Procedure

Approval was obtained from the faculty ethical committee of the University of Amsterdam.[3] Testing took approximately one hour in which participants first completed the production task. The judgement task was split in two, interrupted by the nonword repetition task.[4] This was done in order to separate the presentation of the target and non-target stem+allomorph combinations. Both the judgement and production tasks started with eight practice trials.

3.2.4 Analysis

Generalized linear mixed effects modelling was used. The dependent variable for the production task was whether participants gave a target or non-target response (binary data). For the judgement task, A' scores were derived. An A' score gives an overall accuracy score in terms of accepting the target form of the diminutive forms (hits) and rejecting the non-target forms (false alarm:

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[3] Faculty of Humanities, document number 2014-17. Following ethical procedure participants were informed in advance and signed an informed consent form.

[4] A sony Vaio laptop and Dell laptop were used for testing and an Olympus digital voice recorder to record the sessions.

accepting while rejection is expected) (Linebarger, Schwartz, & Saffran, 1983). A' scores were computed per phonological condition for all participants individually. Table 3.1 gives the formula for computing the A' scores.

Table 3.1
Formula to calculate A' scores

A' = ½ + (hits – false alarms) * (1 + hits – false alarms) / (4*hits)*(1 – false alarms)

Note. The A' values can be interpreted as a two-alternative forced choice task. An A' value of .6 can thus be interpreted as a score of 60% correct when the participant is asked to select which one of two diminutive forms is grammatical. A tendency to reject forms results in an A' score around 0, a tendency to accept in an A' score around .5, and good discrimination between grammatical and ungrammatical diminutives in an A' score around 1 (Rice, Wexler, & Redmond, 1999; Rispens, 2004). Hits = correct judgements of target stem+allomorph combinations. False alarms = incorrect judgements of non-target stem+allomorph combinations.

The data were modelled in R using the lme4 package (Bates, Maechler, Bolker & Walker, 2015; RStudio Team, 2015). Generalized linear mixed effects models are a type of regression model that control for participant and item variability in one model by taking these as the random effect factors (random intercepts). The impact of phonological condition or allomorph on the production or judgement accuracies was tested, i.e., the fixed effects factors were phonological condition in one model and allomorph in the other. Real and nonce nouns were looked at separately.[5] As the goal of this study is to investigate whether the performance on the diminutive suffix

[5] Overall three separate models were looked at (accuracy on the real nouns for all allomorphs was at ceiling level): production nonce phonological condition: response ~ phonological condition + (1 | participant) + (1 | Item), production nonce allomorph: response ~ allomorph + (1 | participant) + (1 | Item), judgement nonce phonological condition: response ~ phonological condition + (1 | participant)

/-ətjə/ is according to the linguistic morphophonological patterns, the phonological conditions that include the allomorph /-ətjə/, vowel length and stress, and the allomorph /-ətjə/ were taken as the intercept with which the other phonological conditions/allomorphs were compared. The next section will first focus on the results of the judgement task followed by the results of the production task.

3.3 Results

Accuracy on the real nouns for all four phonological conditions, and thus all five allomorphs, was at ceiling level. These results will therefore not be reported on further. Accuracy on the nonce nouns was also at ceiling level for all the phonological conditions and allomorphs except /-ətjə/ and the vowel length and stress phonological conditions, i.e., the phonological conditions this allomorph appears in. The following analyses will investigate whether performance on this allomorph and the phonological conditions it appears in are significantly different from the other allomorphs/phonological conditions. Figure 3.1 and 3.2 show the results per phonological condition for respectively the judgement and production task. Figure 3.3 shows the results per allomorph for the production task. Due to the nature of the stimuli set up for the judgement task, A' scores could only be computed per phonological condition and not per allomorph.

3.3.1 Judgement task

As Figure 3.1 shows, the two phonological conditions that include /-ətjə/, vowel length and stress, had lower A' scores than the other two, sonorant type and obstruent. Compare the means of the vowel length phonological condition, M = .87, SD = .13, and stress phonological condition, M = .90, SD = .14, with the other two, obstruent, M = .99, SD = .03, and sonorant type, M = .98, SD = .03. Table 3.2 (intercept vowel length) and Table 3.3 (intercept

stress) show the results of the mixed model analysis and indicate that the vowel length and stress phonological conditions are indeed significantly different from the other two but not from each other.

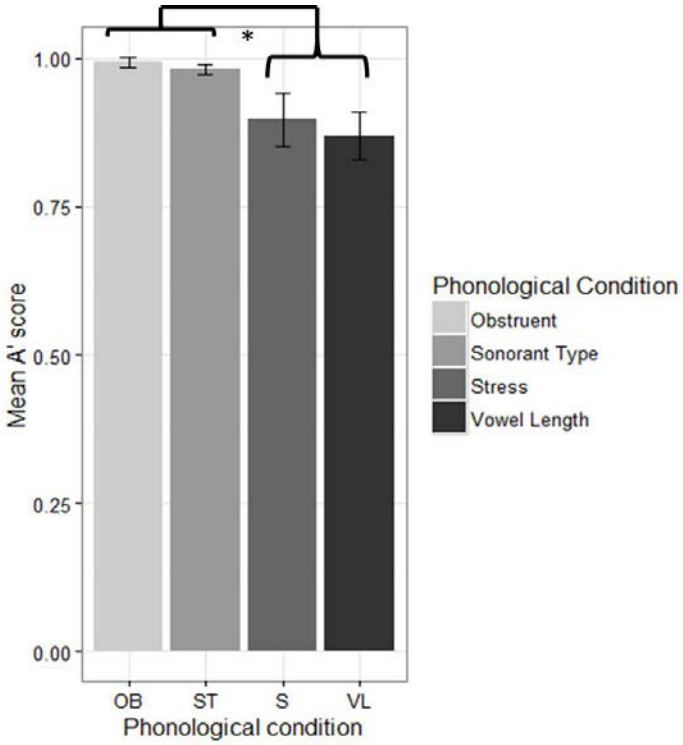

Figure 3.1 Mean A' scores per phonological condition for the judgement task (nonce nouns).
Note. The vowel length and stress phonological conditions are significantly different from the other two conditions. NB. OB = obstruent, ST = sonorant type, S = stress, VL = vowel length

Table 3.2
Model predicting performance on nonce nouns for the judgement task (vowel length intercept)

	Estimate	SE	t value	*p*
Intercept (vowel length)	0.87	0.014	58.13	< .001
Obstruent	0.12	0.020	6.12	< .001
Sonorant type	0.11	0.020	5.56	< .001
Stress	0.03	0.020	1.37	.170

Table 3.3
Model predicting performance on nonce nouns for the judgement task (stress intercept)

	Estimate	SE	t value	*p*
Intercept (stress)	0.90	0.015	59.30	< .001
Obstruent	0.10	0.020	4.73	< .001
Sonorant type	0.08	0.020	4.15	<.001
Vowel length	-0.03	0.020	-1.37	.170

A closer look at the individual errors shows that from the total number of non-target like answers (N = 98) given for nonce nouns that take /-ətjə/, 82 (84%) answers were inconsistent, e.g., participants judged both *vommetje* and **vompje* as correct or incorrect.[6] Only 9 (9%) answers were given in which the target combination was judged as incorrect and the non-target was judged as correct. Very few answers were thus given in which the participants consistently judged not /-ətjə/ but /-pjə/, /-tjə/, or /-kjə/ as the correct answers. Of the 82 answers, 30 were such that participants judged both the target and the non-target stem+/-ətjə/ combinations as incorrect. In 52 cases, participants judged both the target and the non-target stem+/-ətjə/ combinations as correct, which is indicative of a slight yes-bias. The majority of non-target like answers was thus inconsistent. Most of the answers were

[6] In total 215 answers could be given: 43 participants of which 21 answered the first half of the stimuli set and 22 the second (N = 5 stems that take /-ətjə/ per set). Of the answers, 117 (54%) were target-like, i.e., participants judged the target stem+/-ətjə/ combination as correct and the non-target as incorrect. Note that 7 (3%) answers are unavailable, due to missing data.

such that participants accepted both the target and the non-target diminutive forms. In addition, the non-target items were more often judged as correct (N=82) than the target items were judged as incorrect (N=39), e.g., **vompje* was judged more often correct than *vommetje* was judged incorrect.

In sum, the results show that, in contrast to the other four allomorphs, participants are not consistent in following the linguistic morphophonological patterns when judging diminutives with stems requiring the allomorph /-ətjə/.

3.3.2 Production task

As mentioned above, a binomial distribution was specified for the production task as the dependent measure was binary, i.e., correct or incorrect. Two models were run (a model with phonological condition as fixed effect factor, and a model with allomorph as fixed effect factor). Figure 3.2 illustrates that the phonological conditions that include /-ətjə/, that is vowel length and stress, have lower scores than the phonological conditions that do not include this allomorph, obstruent and sonorant type. Compare again the means for the vowel length phonological condition, M = .67, SD = .47, and stress phonological condition, M = .67, SD = .47, with the obstruent phonological condition, M = .96, SD = .19, and sonorant type phonological condition, M = .93, SD = .25. When analyzed per allomorph type (Figure 3.3), /-ətjə/ has much lower accuracy scores than the other allomorphs: /-ətjə/ M = .43, SD = .50, /-jə/ M = .96, SD = .19, /-tjə/ M = .93 , SD = .26 , /-pjə/ M = .93, SD = .25 , /-kjə/ M = .90 , SD = .31. Table 3.4 (intercept vowel length) and Table 3.5 (intercept stress) show that the phonological conditions that include /-ətjə/ are indeed significantly different from the other two but not from each other. Table 3.6 (intercept /-ətjə/) indicates that /-ətjə/ is significantly different from the other

allomorphs. Notice also that the accuracy scores on the production task are relatively low compared to the judgement task.

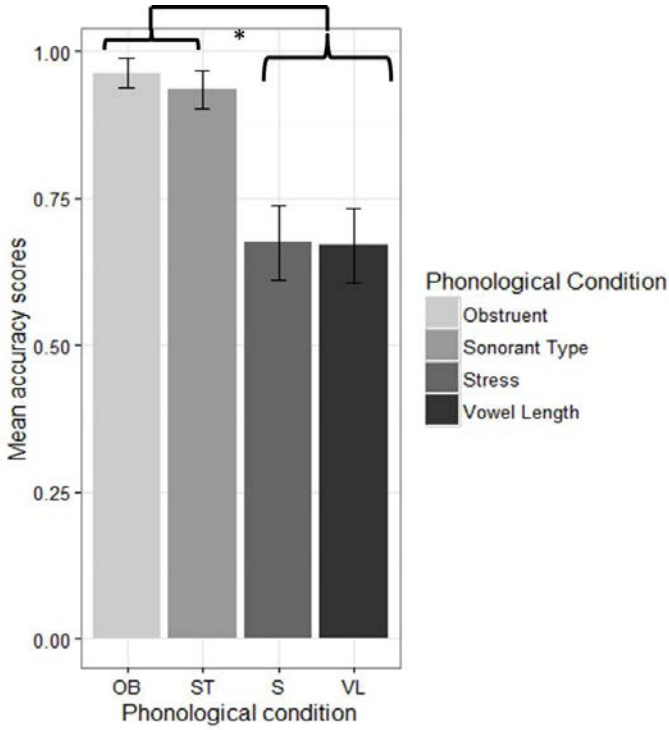

Figure 3.2 Mean accuracy scores per phonological condition on the production task (nonce nouns).
Note. The vowel length and stress phonological conditions are significantly different from the other two conditions NB. OB = obstruent, ST = sonorant type, S = stress, VL = vowel length

Table 3.4
Model predicting performance nonce nouns for the production task (vowel length intercept)

	Estimate	**SE**	**Z value**	***p***
Intercept (vowel length)	1.11	0.49	2.257	.02
Obstruent	2.79	0.78	3.561	< .001
Sonorant type	2.02	0.73	2.772	.006
Stress	0.002	0.68	0.003	.99

Table 3.5
Model predicting performance nonce nouns for the production task (stress intercept)

	Estimate	SE	Z value	*p*
Intercept (stress)	1.11	0.49	2.285	.02
Obstruent	2.79	0.78	3.570	< .001
Sonorant type	2.02	0.73	2.781	.005
Vowel length	-0.002	0.68	-0.003	.99

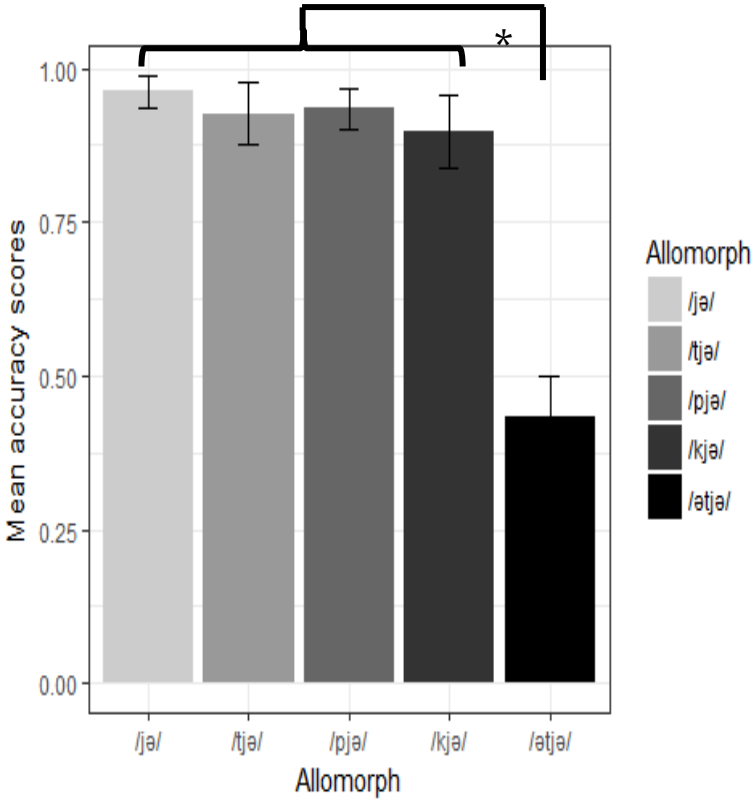

Figure 3.3 Mean accuracy scores per allomorph on the production task (nonce nouns).
Note. The allomorph /-ətjə/ is significantly different from the other allomorphs.

Table 3.6
Model predicting performance per allomorph type nonce nouns for the production task (/-ətjə/ intercept)

	Estimate	**SE**	**Z value**	***p***
Intercept (/-ətjə/)	-0.30	0.24	-1.293	.196
/-jə/	3.75	0.48	7.785	< .001
/-tjə/	3.03	0.52	5.777	< .001
/-pjə/	3.15	0.42	7.516	< .001
/-kjə/	2.68	0.49	5.443	< .001

A closer look at the individual non-target forms indicates that the allomorphs produced instead of /-ətjə/ were based on a simple assimilation process: the participants produced /-pjə/, /-tjə/, and /-kjə/ depending on the final consonant of the stem (see Section 3.1). For example, instead of *vommetje*, **vompje*, instead of *mingetje*, **minkje,* and instead of *golletje*, **goltje* was produced. The non-target forms, thus, follow a pattern. From the total number of non-target forms made with stems requiring /-ətjə/, 86% of these forms in the vowel length condition followed this pattern, e.g., participants used /-pjə/ for stems ending in a labial and /-tjə/ for stems ending with an alveolar as if the vowel in the noun stem would be long. For the stress condition 97% of the non-target forms followed the pattern, e.g., participants used /-kjə/ for stems ending with a velar as if stress did fall on the penultimate syllable. It appears that the length of the vowel and stress placement in the stem are not always taken into consideration. A further analysis was performed to check whether participants were consistent in their choice of using or not using /-ətjə/. The results indicated that only 5% of the participants consistently used the target stem+/-ətjə/, while 23% consistently used a non-target stem+allomorph combination. The remaining 72% switched between the target and non-target stem+allomorph combinations on all the nonce nouns that should receive /-ətjə/ (N=10).

As with the judgement task, the participants did not consistently follow the linguistic patterns for producing the diminutive allomorph /-ətjə/. Moreover, participants were not consistent in their usage/non-usage of this allomorph.

3.4 Discussion and conclusion

The present study investigated whether linguistic patterns as set out in grammatical descriptions of a language are actually applied in reality. This is important for not only a better understanding of productivity in the adult grammar but also for the study of child language. The Dutch diminutive was chosen to study as it is a complex morphophonological system with five allomorphs and widely used by both adults and children. More specifically, this study focused on the allomorph /-ətjə/ since it is, compared to the other allomorphs, more complex and more variable in its use. Although there are many linguistic descriptions of the Dutch diminutive and also specifically of the allomorph /-ətjə/, relatively little is known about its actual productivity. A discrepancy between the linguistic description and productivity was hypothesized. On the one hand, it was expected that the more complex constraints that precede /-ətjə/ would make this allomorph less preferred and that the less complex place of articulation constraints would be applied, i.e., participants were expected to use /-pjə/, /-kjə/, or /-tjə/ instead of /-ətjə/. On the other hand, the variable use of /-ətjə/, with some lexicalized nouns having an alternative diminutive form taking /-ətjə/ alongside the predicted less complex allomorph (*kip – kipje – kippetje*), might cause it to be preferred; participants were then expected to overuse /-ətjə/.

Performance on the real nouns was at ceiling for both /-ətjə/ and the other allomorphs. However, compared to the other allomorphs participants had lower production and judgement accuracy scores for nonce stems requiring the allomorph /-ətjə/. The less complex allomorphs were preferred instead of /-ətjə/, e.g. **vompje* instead of *vommetje*. These findings are in line with the complexity hypothesis and are indicative of a discrepancy between the linguistic morphophonological patterns and the actual productivity of this allomorph. It also strongly suggests that real stem+/-ətjə/ combinations are frozen lexical forms that have not been analyzed into separate units. Compared to the other allomorphs, attaching /-ətjə/ is complex and its variable use provides counter examples of stem+/-ətjə/ combinations that do not necessarily follow the theoretical linguistic descriptions of the Dutch diminutive. It could thus be more efficient for the speaker to store the real stem+/-ətjə/ combinations in the lexicon, which might add to the speakers' problems when applying /-ətjə/ to nonce stems. Moreover, it indicates that speakers do not fully abstract the morphophonological patterns that give rise to /-ətjə/. Examples of how to phonologically analyze the stems that should take this allomorph are thus more limited compared to the other allomorphs. Speakers then possibly resort to a less complex, possibly more default, analysis they do know, i.e., place assimilation of the final stem consonant and the first consonant of the allomorph. In combination with the altogether more complex phonological analysis of /-ətjə/, this could add to the reduced productivity of /-ətjə/.

Accuracy scores were lower in the production task than in the judgement task. In the latter in almost all cases participants judged both the target, i.e., *vommetje* and the non-target, i.e., **vompje* as either correct or incorrect. As mentioned before there are noun stems that can take /-ətjə/ in spite of the phonological characteristics of those noun stems. Speakers tend to

have a preference in production but also usually accept both forms. It was hypothesized that speakers might, similar to what is going on with the nouns that sometimes also take /-ətjə/, use /-ətjə/ instead of the simpler allomorphs. However, the exact opposite is clearly happening. The low accuracy scores in the production task indicate that the participants seem to have a preference for not using /-ətjə/, but /-pjə/, /-tjə/, or /-kjə/ depending on the final consonant of the stem. However, the error analysis of the production task showed that most participants were not consistent in their use of the allomorph /-ətjə/. In addition, participants did not always accept both forms, but tended to reject them as well. These findings indicate that the morphophonological patterns for /-ətjə/ seem to be in a variable phase in the linguistic system in which the patterns are not entirely adhered to but also not entirely unused. Nevertheless, in accordance with the linguistic descriptions, the findings also demonstrate that this allomorph is more complex than the other allomorphs.

In sum, the linguistic description of the diminutive allomorph /-ətjə/ is not in line with its actual productivity in young adult speakers. With nonce nouns the less complex allomorphs are chosen instead. This is an important finding indicating that a more nuanced linguistic description of the Dutch diminutive is necessary. This needs to be taken into account when studying the phenomenon in child language. Moreover, it also demonstrates that linguistic grammatical descriptions are not always clearly based on empirical work. It is however highly desirable that descriptions should reflect the productivity patterns in actual language use.

4
The effects of phonological skills and vocabulary on morphophonological processing*

Abstract

Morphophonological processing involves the phonological analysis of morphemes. Item-specific phonological characteristics have been shown to influence morphophonological skills in children. This study investigated the relative contributions of broad phonological skills and vocabulary to production and judgement accuracies of the Dutch past tense and diminutive, two morphophonological phenomena. Typically developing children (age 5;0 – 10;0 years, N = 114) were asked to produce and judge real and nonce diminutives and regular past tenses. Phonological processing skills were measured using a phonological awareness, digit span, and nonword repetition task; vocabulary using the PPVT. Phonological skills and vocabulary contributed significantly to the production and judgement of the past tense and diminutive. The results underline the relation between phonological skills and the lexicon and the processing of morphophonology. These findings go further than showing the importance of the item-specific phonological context of the stem and suffix: they indicate that more general skills in the domain of phonology and vocabulary are involved.

*A slightly modified version of this chapter appeared as: Boersma, T., Baker, A., Rispens, J., & Weerman, F. (2017). The effects of phonological skills and vocabulary on morphophonological processing. First Language, 1-28. doi: 10.1177/0142723717725430

4.1 Introduction

The interaction between morphosyntax and phonology (morphophonology) gives rise to many alternating forms. The acquisition of morphoponology has been investigated in different morphological paradigms and across different languages (Demuth & Tomas, 2016; Kerkhoff, 2007; Kernan & Blount, 1966; Royle & Stine, 2013; Tomas, Demuth, Smith-Lock, & Petocz, 2015; Tomas, Van De Vijver, Demuth, & Petocz, 2017). Morphophonology follows the phonotactic restrictions of the language by changes in the surface phonological form of the stem or suffix. It is acknowledged as being one of the most complex aspects of grammar to acquire since it reflects not only higher levels of phonological structures but also the interaction between phonology and morphology (Buckler & Fikkert, 2016; Pierrehumbert, 2003; Zamuner, Kerkhoff, & Fikkert, 2012). The challenge for a child is to learn which variant forms are related and which phonological representations must be stored in the lexicon (Buckler & Fikkert, 2016; Fikkert & Freitas, 2006). The current study investigates morphophonological production and processing (Dutch past tense and diminutive) across 5- to 10 -year old typically developing (TD) children. The overall goal of this study is to form a better understanding of which factors contribute to the processing of morphophonology. Specifically, this study assessed whether phonological processing skills and vocabulary size are important contributing factors in morphophonological processing. The next section expands on the idea as to why these skills might be important.

4.1.1 Morpho(phono)logical development: Influences of phonology and vocabulary

Previous literature has shown that both phonological processing skills and vocabulary size contribute to the rate and manner of the acquisition and processing of morphophonology (Marchman & Bates, 1994; Marshall & Van Der Lely, 2006; Matthews & Theakston, 2006; Song, Sundara, & Demuth,

2009). A growing body of literature has established the importance of phonology in morphological development (Marshall & Van Der Lely, 2006; Song et al., 2009; Tomas et al., 2015). Item-specific phonological characteristics significantly affect early production of inflections, with some phonological contexts being more challenging than others (Demuth & Tomas, 2016; Marshall & Van Der Lely, 2006; Tomas et al., 2015). For example, Song et al. (2009) showed in their study of spontaneous speech of six English speaking children between the ages of 1;3 and 3;6 that the item-specific variability in the production of third person singular *–s* could be accounted for by the phonological complexity of the coda. In another study, Jarmulowicz (2006) found that English speaking children (age 6;6 to 10;6) learned and produced derived words with neutral suffixes that do not change stem stress (*-ment*, *-ful*, and *–ness*) better than derived words with rhythmic suffixes that alter stem stress (*-tion*, *-ity*, and *–ic*). Stress-changing suffixes that were phonologically consistent with their stems were thus easier to produce than words that exhibited phonological changes (Jarmulowicz, Hay, Taran, & Ethington, 2008; Jarmulowicz & Hay, 2009; Windsor, 1994). Studies on the English past tense, which has three allomorphs /-Id/, /-d/, and /-t/, have demonstrated that the phonological composition of the verb stem influences past tense productions (Blom, Paradis, & Duncan, 2012; Marchman, 1997). English speaking children used the past tense inflection less when verb stems ended in an alveolar consonant, which requires the /-Id/ allomorph, but used it more when stems ended in a vowel or a liquid. Past tense production thus seems to be dependent on an accurate phonological analysis of the individual verb stems (Blom & Paradis, 2013; Marchman, 1997; Oetting & Horohov, 1997;

Rispens & De Bree, 2014). These studies therefore show that allomorph productions can have a phonological component when the choice of the allomorph is dependent on the phonological structure of the stem. The locus of some of the variability in allomorph productions might then be due to limitations in children's phonological representations or phonological competence (Song et al., 2009).

The present study will expand on these findings. Specifically, we address the idea that children need good phonological processing skills to accurately process the morphophonological properties of the Dutch past tense and diminutive. As such, we moved outside the scope of the morpheme level and investigated whether broader phonological processing skills, i.e., nonword repetition (NWR), digit span, and phonological awareness, are associated with both the production and perception (judgement) of these morphophonological phenomena. There is limited evidence on the relationship between phonological short term memory and processing, and morphophonology. A study by Archibald, Joanisse, and Shepherd (2008) found that performance on a NWR task significantly correlated with regular past tense production (both real and nonce verbs) in a sample of monolingual English TD children (age 6;9 to 11;1). Empirical evidence on associations between other phonological skills such as phonological awareness (potentially implied in the phonological analysis of morphemes) in TD children is limited. The present study fills this gap.

In addition to the influence of phonology, several studies have demonstrated strong relationships between lexical acquisition and morphosyntactic development (Blom & Paradis, 2013; Kidd & Kirjavainen, 2011; Marchman & Bates, 1994; Marchman, Saccuman, & Wulfeck, 2004). It has been suggested that an increase in vocabulary size allows children to abstract general patterns necessary for the productive usage of morphological rules

(Blom & Paradis, 2013; Marchman & Bates, 1994). Song et al. (2009) found strong correlations between children's overall morphological/lexical development and their production of the third person singular morpheme *-s*. Older children with small vocabularies showed poorer grammatical performance, while children with larger vocabularies produced the third person singular morpheme more accurately (Song et al., 2009). Blom and Paradis (2013) found a relation between the past tense use of children with language impairment and their vocabulary size, indicating that deficits in building a lexicon affected past tense use. These and previous studies show that vocabulary size is related to the production of morphosyntax. This study will expand on these findings by examining to what extent receptive vocabulary size is associated with both the production and perception of morphophonological phenomena.

What should be kept in mind is that almost all of the studies mentioned above tested production skills only, but not sensitivity to morphophonology using judgement tasks. No systematic research has investigated the question of whether children are able to detect inappropriate occurrences of allomorphs. As also mentioned in Chapter 2, production data reflect children's ability to apply their knowledge, but not necessarily their processing abilities. In contrast, perception data reflect passive knowledge taking into account that children might know more than they produce (Buckler & Fikkert, 2016; Swingley & Aslin, 2000; Tomas et al., 2015). It may be the case that production is less accurate than perception due to phonological output complexities. Examining both the production and perception of allomorphs will provide a more complete perspective on morphophonological

processing. It will allow us to examine whether phonological and vocabulary skills impact differently on morpohophonological processing. Since perception skills generally precede production, both younger and older children were tested in this study. It was expected that the younger children would perform worse than the older children especially on the production task and to a lesser extent on perception.

In the previously mentioned studies relatively little attention has been paid to morphosyntactic phenomena with more than two or three allomorphs. In the current study we investigated, in addition to the Dutch past tense, the Dutch diminutive which has five allomorphs based on different phonological properties of the noun stem. The results provide insight into whether the previous findings on, for example, the English past tense, English third person singular *–s*, and Dutch plural and past tense are generalizable over other morphophonological phenomena (Kerkhoff, 2007; Matthews & Theakston, 2006; Rispens & De Bree, 2014; Tomas et al., 2015).

4.1.2 Dutch past tense and diminutive

See Chapter 2 for a linguistic description of the Dutch past tense and diminutive.

4.1.3 The current study

The purpose of the current study was to investigate the relationship between phonological processing skills, vocabulary size, and morphophonological processing in Dutch TD children between the ages of 5;0 and 10;0 in both a production and judgement task with both real and nonce items. Because we were also interested in these relationships during development, we also looked at developmental growth of accurately judging and producing the Dutch past tense and diminutive.

We expected that in general the older the children, the better their performance. However, a study with adults using the same tasks found that for the diminutive allomorph /-ətjə/ adults were not 100% accurate when they had to use this allomorph with a nonce noun (see Chapter 3). That is, when asked to inflect and rate nonce nouns that should receive /-ətjə/ according to the established linguistic description, they scored around 87% correct on the judgement task and only 43% on the production task. These findings indicate that /-ətjə/ has a different status compared to the other allomorphs. As such, developmental growth in children can be expected for the four other allomorphs, but not for /-ətjə/. For this allomorph it is not clear what can be expected. Also, as mentioned in the previous section, greater developmental growth is predicted for the production task as the youngest children are expected to perform better on the judgement task due to it testing passive knowledge.

Based on the literature review above, it is predicted that both phonological processing skills and vocabulary size are related to children's past tense and diminutive production and judgement accuracies. Since nonce verbs and nouns have no representation in the lexicon, it is hypothesized that vocabulary size contributes more to the real verbs and nouns than to the nonce verbs and nouns. Furthermore, we expected that phonological processing skills are associated with the production and judgement of both the real and nonce nouns and verbs.

4.2 Methodology

4.2.1Participants

The TD children (n=125) were between the ages of 5;0 and 10;0, native speakers of Dutch, and raised in monolingual families. This broad age range was chosen to obtain insight into development. Eleven children had to be excluded. Two children had very low scores on all tasks and/or missing data on too many tasks. Two other children scored extremely low on the NWR task (administered as part of our test battery, see Chapter 2) indicating a possibility of language impairment. Four children were raised in bilingual families and therefore had to be excluded (this was reported by the teacher after completion of the tasks). Finally, three children (aged between 7;5 and 8;4) scored 1 SD below the mean on the reading tasks (see Table 2.1 in Chapter 2 for an overview of background measures). For four additional children birth dates were missing. To compensate for this, the average age in months of the age group they belonged to was calculated and used in the analyses. After exclusion a total of 114 children (50 female) remained; they were divided into four age groups. See Table 4.1 for mean ages per age group. The children were recruited at five primary schools situated in the northern part of the Netherlands and were tested at their schools during school time. The schools reported no problems such as hearing, sight, or language difficulties that could affect the outcome of the study in any of the children.

Table 4.1
Mean age in months for each age group

Age group	Age in months	
	Mean	SD
5;0 – 5;11 (N = 34)	66.41	3.02
6;0 – 6;11 (N = 28)	78.14	3.74
7;0 – 7;11 (N = 24)	90.04	3.99
8;0 – 10;0 (N = 25)	105.64	6.49

4.2.2 Test material

The children were tested on a battery of four standardised tasks testing their receptive vocabulary and phonological processing skills (predictor variables in the multilevel analyses). The Raven's progressive matrices task (Raven, Raven, & Court, 2003) was used to control for non-verbal IQ performance at time of testing. The reading measures and letter recognition task for the younger children were used to exclude children with lower than average reading scores but who had not been diagnosed with developmental dyslexia (3 children). An experimental production task and a grammaticality judgement task were conducted to test morphophonological performance. See Table 2.1 presented in Chapter 2 for an overview of the tasks used to measure nonverbal intelligence, receptive vocabulary, phonological processing, and reading skills. The material used in the judgement and production tasks was also fully described in Chapter 2.

Analysis of the diminutive nonce and real nouns was done without the allomorph /-ətjə/ for the production task. As mentioned earlier, the study of adult production and judgement of the diminutive using the same tasks (presented in Chapter 3), indicated that this allomorph is not as productive as expected from earlier literature. This was especially the case for the production task in which the participants often used one of the other four allomorphs, based on the final consonant of the noun stem, instead of /-ətjə/. Consequently, for this study we decided to exclude /-ətjə/ from the analyses for the production task. Performance on the judgement task with this allomorph approached ceiling levels in adults and it was therefore decided to retain this allomorph in the judgement task. In addition, due to the nature of

the stimuli set up it would not be possible to calculate A' scores for this task (see analysis section) if /-ətjə/ were omitted from the analysis.

4.2.3 Procedure

The study was reviewed and approved by the ethics review board of the Faculty of Humanities, University of Amsterdam.[1] Schools were approached and asked whether they wanted to participate in the study. Parents were then contacted and received an information letter with an active consent form to be signed if the parents and child were willing to participate.

Children were tested individually at their school during school time. Testing took three to five sessions of approximately 30 minutes. In the first session the children did the production task, in the second the first part of the judgement task, and in the third the second part. In each session, the experimental tasks were always followed by two or three of the standardised tasks. In case not all tasks could be conducted in these three sessions, the children were asked to come back for a fourth or even a fifth session. A Sony Vaio and Dell laptop were used for the production, judgement, and NWR tasks. An Olympus digital voice recorder was used to record all the sessions.

Scoring was done by two native speakers of Dutch who were trained linguists. Approximately 12% of the data from the production and NWR tasks were compared to calculate the interrater reliability. This was high for both the production (Cronbach's $\alpha = .82$) and NWR (Cronbach's $\alpha = .96$) tasks. Any discrepancies were solved by discussion until 100% consensus was reached.

4.2.4 Analysis

ANOVA's were conducted to test for age-effects. Generalized linear mixed effects models were used to analyse the data further. These models are a type of regression model that control for participant and item variability by taking

[1] Dossier 2014-27

these as the random effect factors (random intercept). Data were modelled in R (RStudio Team, 2015) using the lme4 package (Bates, Maechler, Bolker, & Walker, 2015). Separate models were built to predict production and judgement of the diminutive and past tense with real or nonce nouns and verbs from the four predictor variables taking age and IQ (Raven) into account, i.e., the dependent variables were diminutive and past tense real and nonce production and judgement accuracies and the independent variables (fixed effect factors in the models) were performance on the phonological processing and PPVT tasks.[2] Random intercepts for participant, item, and school the child attended were included to account for random by-participant, by-item, and by-school variation in one model for the production task. Random intercept for item could not be included for the judgement task models as composite A' scores were calculated (see below). In the final mixed effects analysis, three children had to be excluded due to missing data in one of the tasks (2 NWR and 1 Raven, these children were included in the analyses testing for age-effects).

The dependent variable for the production task was whether the child gave a correct (target/expected) or incorrect (non-target/unexpected) response (binary data). In the judgement task the dependent variable was the A' score. An A' score gives an overall accuracy score in terms of accepting the target form of the items (hits) and rejecting the non-target items (false alarm: accepting where rejection is expected) (see Table 4.2) (Linebarger, Schwartz, & Saffran, 1983). The values can be interpreted as an answer to a two-

[2] In total eight different models were tested. Real and nonce nouns and verbs in the production and judgement task were thus tested in separate models.

alternative forced choice task. An A' value of .6 can thus be interpreted as a score of 60% correct if a participant had been asked to select which one of two forms is grammatical.

Table 4.2
Formula to calculate A' scores

A' = ½ + (hits – false alarms) * (1 + hits – false alarms) / (4*hits)*(1 – false alarms)

Note. A tendency to reject forms results in an A' score around 0, a tendency to accept in an A' score around .5 and good discrimination between grammatical and ungrammatical diminutives in an A' score around 1 (Rice, Wexler, & Redmond, 1999; Rispens, 2004). Hits = correct judgements of target stem + allomorph combinations. False alarms = incorrect judgements of non-target stem + allomorph combinations.

The raw scores of the predictor variables were zero centred to make sure the eigenvalue ratios of the models were not too large. Age was centred around 90 months (7;6) as this is the exact middle between the different ages tested in this study (5;0 – 10;0).

Forward selection was used to enter the predictor variables in the model as performance on the tasks testing IQ, receptive vocabulary size, phonological processing skills, and also age in months were intercorrelated. To ensure that the predictor variables added to the prediction over and above age and IQ, both were always included in the models independent of whether they significantly added to the null and age models (Tabachnick & Fidell, 2013). As is common when using forward selection, predictor variables were added to the model based on the strength of their correlation with the dependent variable and excluded if they did not improve the model significantly. However, because the predictor variables were highly intercorrelated, whether other predictor variables added to the age + Raven model significantly was also reported. Models were compared to each other

using log-likelihood comparisons (using analysis of variance function in R). The model comparisons are presented in the results section.

Conditional R^2 values were calculated with the MuMIn package based on Nakagawa & Schielzeth (2013). The conditional R^2 was interpreted as variance explained by both the fixed and random effect factors.

4.3 Results

4.3.1 Descriptive statistics and age effects

The descriptive statistics for the standardised tasks (predictor variables) can be found in Table 4.3. It shows the mean raw and standardised scores on the non-verbal intelligence measure (Raven), vocabulary measure (PPVT), and phonological processing measures (phonological awareness, NWR, and digit span composite score forward and backward). All children scored within the normal range on all tasks. In addition, as expected, the older the children were, the better they scored on the Raven (raw scores).

The mean accuracy scores on the production task and the mean A' scores on the judgement task are presented in Figures 4.1 (production) and 4.2 (judgement). ANOVA's with Bonferroni post hoc tests were conducted to test whether the age groups were significantly different from each other. The significant results are presented below the figures. Overall, the results indicate a jump in performance between the five- and six-year olds and the seven- and eight-year olds on the production and judgement task with both the diminutive and past tense. An interesting result is also that especially the five-year olds, and to a certain extent the six-year olds, had considerable difficulties with the past tense and the standard deviations are large, indicating a great deal of variation in past tense production.

Table 4.3
Mean raw and standardized scores for predictor variables for each age group

Predictor variable		**Age group**			
		5;0 – 5;11	**6;0 – 6;11**	**7;0 – 7;11**	**8;0 – 10;0**
PPVT					
Raw	Mean	85.00	94.00	104.17	110.72
	SD	8.13	8.00	8.14	11.09
Standardised	Mean	111.50	108.64	109.43	105.82
	SD	9.64	10.70	8.73	13.48
Phonological awareness					
Raw	Mean	29.47	32.86	39.00	40.64
	SD	7.07	7.64	3.23	2.77
Standardised	Mean	11.59	11.07	11.26	9.68
	SD	1.59	1.71	2.05	2.72
NWR					
Raw	Mean	0.85	0.86	0.89	0.91
	SD	0.06	0.07	0.05	0.04
Digit span					
Raw	Mean	9.32	10.25	12.00	11.80
	SD	1.92	2.23	2.33	2.37
Standardised	Mean	12.38	11.32	11.13	9.59
	SD	2.30	2.59	2.21	2.59
Raven (IQ)					
Raw	Mean	22.35	23.50	28.42	32.88
	SD	4.33	6.93	5.75	5.96
Standardised	Mean	NA	59.04	54.47	49.74
	SD	NA	22.79	20.82	21.26

Note. The standardised scores indicate that all children scored within the norms of normal language development.

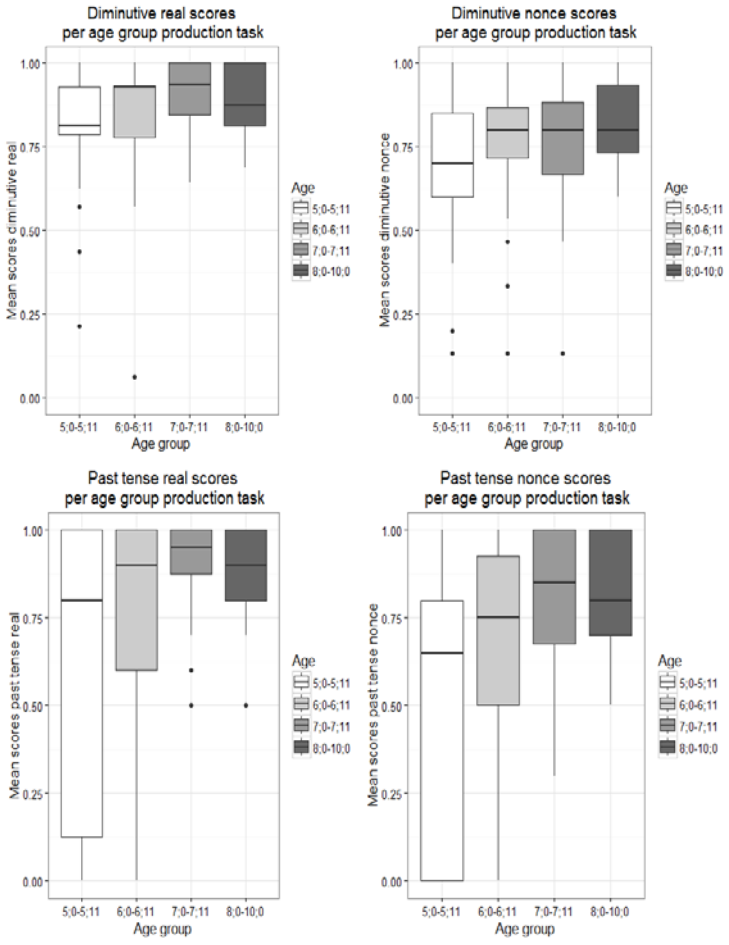

Figure 4.1 Boxplots production task diminutive and past tense real and nonce items.

Note. Significant differences were found for production of nonce diminutive items: five-year olds differed significantly from the eight-year olds, $p < .05$; real and nonce past tense: five-year olds differed significantly from the eight-year olds, $p < .001$

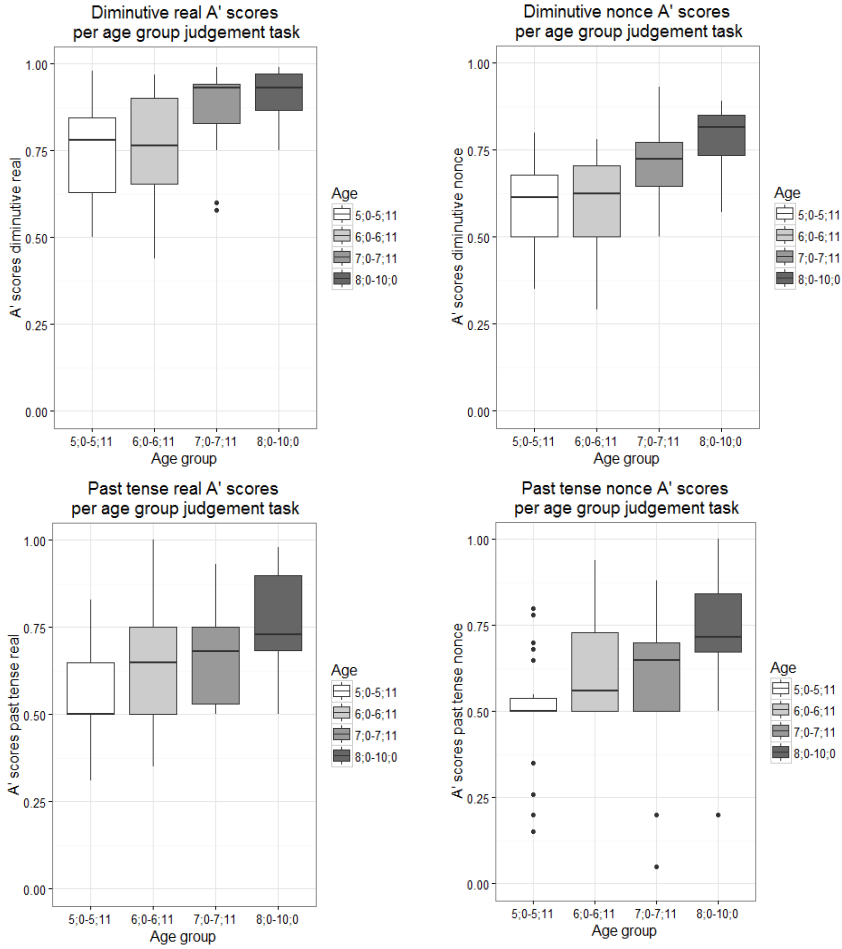

Figure 4.2 Boxplots judgement task diminutive and past tense real and nonce items.

Note. Significant differences were found for judgement of the real diminutive items: five-year olds differed significantly from the seven- and eight-year olds, $p < .001$, six-year olds differed significantly from the seven-year olds, $p < .05$, and eight-year olds, $p < .001$; nonce diminutive items: five- and six-year olds differed significantly from the seven-, $p < .05$ and eight-year olds, $p < .001$; real past tense items: five-year olds differed significantly from the six-, seven-, $p < .05$, and eight-year olds, $p < .001$, and six-year olds differed significantly from the eight-year olds, $p < .05$; nonce past tense items: five-year olds differed significantly from the eight-year olds, $p < .001$.

Table 4.4
Pearson's correlations between the accuracy scores on the production task or A' scores on the judgement task and the predictor variables (raw scores)

	Diminutive real	**Diminutive nonce**	**Past tense real**	**Past tense nonce**
Production				
Age months	.233*	.271**	.344***	.392***
Raven	.236*	.259**	.351***	.295**
PPVT	.270**	.202*	.429***	.433***
Phonological awareness	.318***	.281**	.455***	.423***
NWR	.225*	.275**	.323**	.354***
Digit span total	.201*	.139	.379***	.397***
Judgement				
Age months	.486***	.541***	.582***	.449***
Raven	.477***	.485***	.451***	.351***
PPVT	.512***	.545***	.505***	.367***
Phonological awareness	.509***	.485***	.545***	.414***
NWR	.372***	.342***	.357***	.285**
Digit span total	.490***	.407***	.475***	.361***

Note. * < .05, ** < .01, *** < .001

4.3.2 The contribution of phonological processing skills and vocabulary

Table 4.4 shows the correlations between the production or judgement task and the predictor variables. All predictor variables were significantly correlated with diminutive and past tense production and judgement accuracies. Only performance on the digit span task was not correlated with the production of diminutive nonce nouns. As mentioned in the analysis section, the predictor variable with the highest correlation with the dependent variable was put in the model first (after age and IQ). It should be

kept in mind that the predictor variables were all significantly intercorrelated and also correlated with age and IQ. This means that if two or more predictor variables overlap in how they explain the dependent variable in the linear mixed effect models, that overlap will not be reflected in either regression coefficient. As such, we report which model worked best, i.e., had the lowest *p*-value compared to the model without the predictor variable(s), but also report which models worked as well. The model comparisons of the linear mixed effects models are presented. Table 4.5 shows the model comparisons for the production task and Table 4.6 for the judgement task. The details of the final models can be found in the Appendix.

Production past tense

The null model for performance on the production tasks with real verbs was significantly improved by age. IQ significantly improved the age model. Accuracy scores correlated strongest with performance on the phonological awareness task. This task improved the age + Raven model significantly, p = .002. Performance on the PPVT, the NWR, and the digit span tasks also improved the age and Raven model significantly: respectively p = .009, p = .02, and p = .03, but the significance levels were higher compared to the phonological awareness task. Performance on the NWR (p = .05) and PPVT (p = .02) tasks improved the model with phonological awareness significantly. The PPVT improved the model with the lowest *p*-value. The NWR and the digit span tasks did not further improve the model with phonological awareness and PPVT.

The null model for performance on the production task with nonce verbs significantly improved by age, but the age model did not improve significantly after adding IQ. Performance on the PPVT tasks correlated the strongest with the accuracy scores and improved the age + IQ model significantly, p = .04, but performance on the phonological awareness task (p

= .005), NWR task (p = .007) and the digit span task (p < .001) also improved this model. The model with the digit span task added was the best model. The other variables did not further improve this model.

Production diminutive

The null model for performance on the production task with real nouns significantly improved after adding age but the age model did not significantly improve after adding IQ. The phonological awareness task had the highest correlation with the accuracy scores. This was also the only predictor variable that significantly improved the age + IQ model (p = .027). None of the other predictor variables significantly improved the model with phonological awareness.

The null model for performance on the production task with nonce nouns significantly improved after adding age, but the age model did not significantly improve after adding IQ. Again the phonological awareness task correlated strongest with the accuracy scores. However, it did not significantly improve the age + IQ model. Performance on the NWR task did significantly improve the age + IQ model (p = .02). None of the other predictor variables improved the age + IQ model nor the model with the NWR task included.

Table 4.5
Model comparisons for performance on the production task with the real and nonce diminutive and past tense

Production			
Model	Log Likelihood	X^2	*p*
Past tense real			
Null + Age (df = 5)	-408.89	5.78	.016
+ Raven (df = 6)	-406.61	4.58	.032
+ Phonological awareness (df = 7)	-401.78	9.65	.002
+ PPVT (df = 8)	-399.40	4.762	.030
Past tense nonce			
Null + Age (df = 5)	-517.48	10.36	.001
+ Raven (df = 6)	-517.05	.85	.36
+ Digit span (df = 7)	-511.49	11.12	< .001
Diminutive real			
Null + Age (df = 5)	-508.93	4.30	.038
+ Raven (df = 6)	-508.35	1.16	.282
+ Phonological awareness (df = 7)	-505.90	4.91	.027
Diminutive nonce			
Null + Age (df = 5)	-770.10	7.529	.006
+ Raven (df = 6)	-768.89	2.408	.12
+ NWR (df = 7)	-766.25	5.284	.02

Note. Real diminutive model: conditional R^2 = .591, Nonce diminutive model: conditional R^2 = .455, Real past tense model: conditional R^2 = .745, Nonce past tense model: conditional R^2 = .666

Judgement past tense

The null model for performance on the judgement task with real verbs significantly improved after adding age. The age model significantly improved after adding IQ. The A' scores correlated strongest with performance on the phonological awareness task, but this task did not significantly improve the age + IQ model (p = .07). Performance on the digit span task significantly improved the age + IQ model (p = .02). None of the other predictor variables significantly improved the age + IQ model nor the model with digit span included.

The null model for performance on the judgement task with nonce verbs significantly improved after adding age, but IQ did not significantly improve the age model. Again, performance on the phonological awareness task correlated strongest with the A' scores and this task significantly improved the age + IQ model (p = .04). However, performance on the digit span task also improved the age + IQ model with an even slightly lower p-value (p = .03). None of the other predictor variables further improved the digit span or phonological awareness models. The digit span and phonological awareness tasks also did not significantly improve the phonological awareness respectively digit span models further.

Judgement diminutive

The null model for performance on the judgement task with real nouns did not significantly improve after adding age. However, IQ did significantly improve the age model. The PPVT task had the highest correlation with the A' scores and significantly improved the age + IQ model, p = .02. However, performance on the phonological awareness, NWR, and digit span tasks also improved the age + IQ model: respectively p = .007, p = .04, and p = .001. Performance on the digit span task improved the age + IQ model with the lowest p-value. Adding the PPVT task improved the model with digit span near significance. None of the other predictor variables significantly improved the model with the digit span task included.

The null model for performance on the judgement task with nonce nouns significantly improved after adding age and the age model significantly improved after adding IQ. Again performance on the PPVT task correlated the strongest with the A' scores. However, it did not significantly improve the age

+ IQ model (p = .08). None of the other predictor variables significantly improved the age + IQ model, although performance on the phonological awareness task approached significance (p = .07).

Table 4.6
Model comparisons for performance on the judgement task with the real and nonce diminutive and past tense

Judgement			
Model	Log likelihood	X^2	*p*
Past tense real			
Null + Age (df = 5)	25.32	14.66	<.001
+ Raven (df = 6)	28.24	5.84	.02
+ Digit span total (df = 7)	31.15	5.81	.02
Past tense nonce			
Null + Age (df = 5)	28.51	9.67	.002
+ Raven (df = 6)	29.38	1.73	.19
+ Digit span (df = 7)	31.71	4.66	.03
Diminutive real			
Null + Age (df = 5)	132.59	1.93	.17
+ Raven (df = 6)	137.11	7.10	.008
+ Digit span (df = 7)	142.26	10.31	.001
Diminutive nonce			
Null + Age (df = 5)	38.90	18.15	<.001
+ Raven (df = 6)	41.61	5.41	.02
+ PPVT (df = 7)	43.15	3.09	.08
+ Phonological awareness (df = 7)	43.29	3.37	.07

Note. Real diminutive model: conditional R^2 = .364, Nonce diminutive model: conditional R^2 = .115, Real past tense model: conditional R^2 = .200, Nonce past tense model: conditional R^2 = .136

4.4 Discussion and conclusion

The present study was designed to increase our understanding of morphophonological processing by testing the Dutch diminutive and past tense in both a production and judgement task. More specifically the study examined to what extent broad phonological processing skills and vocabulary size contribute to the processing of the past tense and the diminutive.

A difference in performance between the younger and older children was expected and obtained. A (significant) jump in performance between the six- and the seven-year olds in both the past tense and diminutive was apparent. For the diminutive this finding confirms two earlier studies by Den Os and Harder (1987) and Peelaerts (2008). Both studies found that diminutive allomorphs are only fully acquired from the age of seven onwards with some allomorphs being acquired at an even later age. In the present study even the oldest children at age ten years had difficulties with appropriately inflecting nonce nouns with a diminutive marker.

Surprisingly, the five-year olds in particular scored relatively low and showed a great deal of variation in production of the past tense. Further error analyses will have to clarify whether the children in the present study had difficulty using the two allomorphs accurately or whether they simply had not yet acquired the concept of past tense to the extent that is required for the task. In Dutch, the simple past tense is less frequent in the input and in child usage at this age than the present perfect, which might have had an effect. Although it was expected that the gap between the younger and older children would be larger in the production than in the judgement task, this was not necessarily found. For the past tense, the variation seems to be less,

but the younger children are close to scoring at chance level. Also, the gap between the younger and older children seems to be even larger in the judgement task. We will expand below on why this might be the case.

Table 4.7
Results of the multilevel analysis showing the relationships between the tasks, structure, and type of stimuli

	Production		Judgement	
	Phonological processing	**Receptive vocabulary**	**Phonological processing**	**Receptive vocabulary**
Diminutive				
Real	Yes	No	Yes	No
Nonce	Yes	No	No	No
Past tense				
Real	Yes	Yes	Yes	No
Nonce	Yes	No	Yes	No

Note. Where the phonological processing and vocabulary tasks contributed to the scores, a Yes is indicated. Where this was not the case, a No is indicated. The findings that were hypothesised in the introduction are marked in grey.

Table 4.7 gives an overview of the results from the generalized linear mixed effect models. Based on previous studies it was hypothesized that phonological processing skills for the real and nonce items and vocabulary size for the real items would significantly contribute to the production and judgement of the past tense and diminutive.

As expected, performance on the phonological processing tasks was significantly associated with both the production and judgement of the past tense and diminutive. Interestingly, it differed per condition which phonological processing task made the largest contribution. For example, for production of the nonce nouns this was the NWR task, while for the nonce verbs this was the digit span task. Both are measures of phonological working memory. However, the NWR task taps more language specific knowledge while the digit span task involves sequencing highly familiar items and is

purely a phonological short-term memory task (Baddeley, 2003; Gathercole, Willis, Baddeley, & Emslie, 1994; Gathercole, 2006; Rispens & Baker, 2012; Rispens, Baker, & Duinmeijer, 2015). The NWR task might be more predictive for the diminutive, as selecting the appropriate allomorph is a phonologically more complex process than for the past tense, which has only two allomorphs and where the only phonological process that needs to be taken into account is voicing.

Interestingly, the digit span task made a significant contribution to performance on the judgement task with both the diminutive and past tense. The digit span task is, as mentioned above, a measure of how well children can temporarily store and manipulate verbal information, which closely resembles what the children had to do in the judgement task (Baddeley, 2003). It is also a good measure of attention and concentration span (Semel, Wiig, & Secord, 2010), which might have been taxed to a greater extent in the judgement task (Astheimer, Janus, Moreno, & Bialystok, 2014).

The findings of this study underline the results of previous research in showing that both phonology and vocabulary are important contributing factors in the development of morphophonological phenomena. The study by Archibald, Joanisse, and Shepperd (2008) already found correlations between the NWR task and English past tense production. This study goes beyond this finding by showing that phonological processing skills in general contribute to performance on both processing and producing morphophonology. Moreover, it supports, to a certain extent, the studies of, for example, Blom and Paradis (2013) and Marchman and Bates (1994), as vocabulary size was associated with past tense production with real verbs. However, although performance of the

PPVT task correlated strongly with both production of the diminutive and judgement of the diminutive and past tense, it did not occur in the final most explanatory models. A possible explanation for this finding could be that past tense formation is explicitly learned at primary school where children learn how to spell the past tense. They learn the difference between the voiced and voiceless allomorphs explicitly, which might then be explicitly linked to the verbs in their mental lexicon (De Bree, Van Der Ven, & Van Der Maas, 2017). This difference between explicit learning (past tense) and implicit learning (diminutive) might have had an influence on the children's performance. Also, the past tense is a morphosyntactic inflection, while forming the diminutive is a derivational phenomenon based on phonological derivations of the stem. Choosing the appropriate allomorph when forming the diminutive is phonologically complex. Children, therefore, might have to rely more heavily on their knowledge of Dutch phonotactics when producing the diminutive.[3]

Although it is not possible to directly compare the findings from the production and judgement tasks as they involve different statistical analyses, we would like to speculate tentatively about the differences found between the two tasks. These differences might to a large degree be attributed to the extent that general metalinguistic competence is implied in a grammaticality judgement task (Rice et al., 1999). The metalinguistic demands might have been too challenging for some children, which means that their performance did not reflect their actual knowledge, i.e., they might have known what the

[3] Note that when doing the analysis including the diminutive /-ətjə/ the PPVT is the only significant predictor, which indicates that children seem to store the stem + /-ətjə/ combinations in their lexicon. This corresponds with the findings in the adult study where the participants scored at ceiling on the real nouns but below 50% on the nonce nouns, indicating that adults stored the real stem + /-ətjə/ combinations in their lexicon.

appropriate and inappropriate diminutive and past tense forms were, but accepting or rejecting these and having to come up with the (in their view) correct form was too demanding. Children in general have a bias to say "yes" in their responses and this might have been what especially the younger children resorted to (Rice et al., 1999). For example, the finding that none of the predictor variables made a significant contribution over and above age and IQ for judgement of the nonce diminutive may be attributed to the fact that the children benefitted more from their increased age, nonverbal intelligence, and metalinguistic awareness.[4]

In sum, in accordance with the hypotheses formulated on the basis of previous literature, this study found that phonological processing skills and receptive vocabulary significantly contribute to the processing of morphophonology, even though there are differences between the past tense and diminutive and between the production and judgement tasks. This implies a relation between phonological processing skills, the lexicon, and the processing of morphophonology for both production and perception. Moreover, the results extend the findings of previous studies as they go beyond the importance of the item-specific phonological context of the stem and allomorph and show that more general skills in the domain of phonology and vocabulary are involved.

[4] Although note that the models with either the phonological awareness or PPVT task included almost reached significance compared to the model with only age and the Raven included.

5
The acquisition of diminutive allomorphs*

Taking item specific characteristics into account

Abstract

Differences in phonological characteristics and frequencies of stems and allomorphs have been explored as possible factors causing differences in production accuracies between allomorphic forms. However, previous findings are not consistent and the relation between the two factors is unclear. This study investigated target and erroneous productions of the Dutch diminutive, which has five allomorphs with varying type frequencies and of which the selection depends on the phonological characteristics of the stems. Typically developing children (N = 115, 5;1 – 10;3) were tested on their production of real and nonce diminutives. Linear mixed effects modelling was used to analyze the data taking nonverbal IQ into account. Type frequencies of the allomorphs and differences in the complexity of the phonological characteristics of the stems were found to be related to differences in production accuracies between the allomorphs. However, phonological characteristics of the stems appeared to have a bigger impact. Especially the complexity of these phonological characteristics was found to play a role.

*A slightly modified version of this chapter has been submitted as: Boersma, T., Rispens, J., Baker, A., & Weerman, F., (submitted). Acquiring diminutive allomorphs: Taking item specific characteristics into account. *Journal of Child Language*

5.1 Introduction

Using morphophonological constructions involves changes in surface phonological forms of morphemes and therefore requires the phonological analysis of these morphemes. Morphophonological patterns are complex to acquire and are likely to entail many errors (Buckler & Fikkert, 2016; Pierrehumbert, 2003; Tomas, Van De Vijver, Demuth, & Petocz, 2017; Zamuner, Kerkhoff, & Fikkert, 2012). Differences in production accuracies of allomorphs, i.e., in the case of this dissertation phonologically variant forms of morphemes, have been observed in many languages with some allomorphic forms reaching adult-like accuracies before others (Bybee & Slobin, 1982; Kerkhoff, 2007; Matthews & Theakston, 2006; Rispens & De Bree, 2014; Royle & Stine, 2013; Song, Sundara, & Demuth, 2009; Tomas, Demuth, Smith-Lock, & Petocz, 2015; Tomas et al., 2017; Zamuner et al., 2012 amongst others). Some researchers attribute this variation to effects of type or phonotactic frequencies mostly (among others Blom, Paradis, & Duncan, 2012; Bybee & Slobin, 1982; Bybee, 2007; De Bree & Kerkhoff, 2010; Marchman, 1997; Matthews & Theakston, 2006; Zamuner et al., 2012), while others acknowledge the different phonological characteristics of the stems that give rise to the allomorphs (among others Berko, 1958; Marchman, Wulfeck, & Weismer, 1999; Marshall & Van Der Lely, 2006; Mealings, Cox, & Demuth, 2013; Oetting & Horohov, 1997; Song et al., 2009; Tomas et al., 2015; Tomas, Demuth, & Petocz, 2017).

The main aim of the present study was to investigate possible factors involved in the production of morphophonological patterns: phonological characteristics of the stem, type frequency of the allomorphs, and phonotactic frequencies of the stem+allomorph combinations. In addition, the relation between the factors was explored. Production accuracies of the five allomorphic forms of the Dutch diminutive were investigated. Substitutions,

i.e., which allomorph is used instead of the target (correct/expected) allomorph, were also looked at. Below, we will first report on previous studies that have found a protracted course of acquisition of some allomorphs and the factors they attribute this to. Subsequently, the formation of the Dutch diminutive will be expanded on, followed by a more extensive overview of the goals and expectations of the current study.

5.1.1 The acquisition of morphophonological phenomena

The acquisition of a range of morphophonological phenomena has been studied in different languages and across different populations. The general finding across these studies is that morpho(phono)logical phenomena, such as the past tense or subject-verb agreement, are not acquired 'all-at-once', but that variation in the speed of acquisition exists between the different allomorphic forms involved in these phenomena (Berko, 1958; Blom, 2003; Blom et al., 2012; Kerkhoff & De Bree, 2004; Marchman et al., 1999; Oetting & Horohov, 1997; Paradis, Tulpar, & Arppe, 2016; Rispens & De Bree, 2014). For example, the regular past tense in English can be expressed by three allomorphs /-t/, /-d/, and /-Id/. Several studies have reported that the past tense forms of verbs that take the syllabic /-Id/ allomorph are acquired more slowly by typically developing (TD) children, children with English as their second language, and in children with language impairments (Blom & Paradis, 2013; Marchman, 1997; Matthews & Theakston, 2006; Oetting & Horohov, 1997; Paradis et al., 2016; Tomas et al., 2017). Different explanations have been given for this protracted acquisition of some allomorphs. Frequency of the stems and stem+allomorph combinations, and complexity of the phonological characteristics of the stems may play a role in this morphophonological development. The sections that follow will first expand on studies showing

effects of frequency and will then describe studies that have found complexity of the phonological characteristics of the stems to play a role.

Previous research has shown that the higher the type frequency, the earlier the allomorph is acquired (Blom et al., 2012; Bybee & Slobin, 1982; Bybee, 2007; Marchman, 1997; Matthews & Theakston, 2006). Type frequency is a measure of how many items a certain pattern, such as an allomorph, is applicable to and has been shown to play a role in morphological productivity (Bybee, 1985; Bybee, 2007). The allomorph that is attached most often to known items will most probably also be applied to new items (Bybee, 2007). It is, for example, assumed that highly frequent past tense markers, i.e., with the highest type frequency, are the most productive. In the case of the English past tense, the /-Id/ allomorph has the lowest type frequency and also seems to be the least productive (Blom et al., 2012; Blom & Paradis, 2013; Marchman, 1997; Matthews & Theakston, 2006; Tomas et al., 2017). As will be elaborated on in the next section, the few studies that have tested the Dutch diminutive have also found that type frequencies of the different diminutive allomorphs affected production accuracies (Den Os & Harder, 1987; Peelaerts, 2008; Snow, Smith, & Hoefnagel-Höhle, 1979). Contradicting these results, Rispens and De Bree (2014) did not find an effect of type frequency on production accuracies of the Dutch past tense in TD children and children with specific language impairment. They found that children produced the voiceless /-tə/ past tense allomorph more accurately compared to the voiced /-də/ allomorph, although the /-də/ allomorph has a higher type frequency (62%) compared to the /-tə/ allomorph (38%) (Rispens & De Bree, 2014). However, the final consonants of the verb stems included in their study combined with the allomorph /-tə/ had a higher phonotactic frequency than the final consonants of verb stems with /-də/. They argued that this made it easier for the children to use /-tə/ as the phonemic combinations of stem+/-tə/ are more frequent in Dutch than stem

+/-də/ (Rispens & De Bree, 2014). Phonotactic probability or frequencies are defined as the probability/frequencies that adjacent phonemes (biphones) appear together in a language. In several previous studies effects of phonotactic frequency have also been found (De Bree & Kerkhoff, 2010; Kerkhoff, 2007; Zamuner, Kerkhoff, & Fikkert, 2006; Zamuner et al., 2012).

As well as these frequency accounts, many phonologically based explanations have been given for findings in studies investigating the English past tense, plural, and 3rd person singular marking. For example effects of coda complexity, articulatory difficulties, and perceptual saliency have been found (Berko, 1958; Marchman et al., 1999; Marshall & Van Der Lely, 2006; Mealings et al., 2013; Oetting & Horohov, 1997; Song et al., 2009; Tomas et al., 2015; Tomas et al., 2017). Variations in the phonological characteristics of stem+allomorph combinations might therefore delay or enhance children's morpheme production. Song et al. (2009) tested the 3rd person singular in English TD children between the ages of one and three-and-a-half. Their findings provided support for the role of phonological complexity at the level of the syllable as they found that the children produced the morphemes more accurately in phonologically simple coda contexts, e.g., *see<u>s</u>*, as compared to complex coda contexts, e.g., *nee<u>ds</u>*. Results of many studies indicate that children tend to acquire syllabic allomorphs later than segmental ones (Berko, 1958; Marchman, 1997; Matthews & Theakston, 2006; Mealings et al., 2013; Song et al., 2009; Tomas et al., 2015; Tomas et al., 2017). In the case of the English past tense and plural, stems that take the syllabic allomorphs (/-Iz/ and /-Id/) already end in an alveolar (past tense) or sibilant (plural) phoneme, which might make children think that these stems are already inflected (Berko, 1958; Marchman, 1997; Matthews & Theakston, 2006). However,

Mealings, Cox and Demuth (2013) tested the English plural in two-year olds and did not find any evidence for this hypothesis. They argued on the basis of their results that the children understood that something needed to be added to the noun, but had difficulty articulating the entire morpheme as it involves a complex phonemic sequence. Testing derivational morphology in children between the ages of eight and ten, Jarmulowicz and Hay (2009) showed that children found it easier to produce derived forms that were phonologically consistent with their noun stems in terms of stress placement and syllabification, e.g., *kind – kindness*, than words that exhibited changes, e.g., *álphabet – alphábetic*. Together these studies indicate that the variable production accuracies of allomorphs seem to be related to the phonological characteristics and complexity of the stems to which the allomorphs are attached.

In sum, the studies discussed above provide evidence for the importance of both frequency, not only type but also phonotactic frequency, and complexity of the phonological characteristics of the stems and allomorphs. However, it is unclear which of these factors affects morphophonological development the most. Moreover, the (possible) interplay between frequency and phonological effects is unclear. The goal of this study is to gain a better understanding of why some allomorphs are acquired before others by focusing on the Dutch diminutive. By doing so it is possible to evaluate the relation between effects of frequency and phonological characteristics as the Dutch diminutive entails five allomorphs based on different phonological characteristics and with varying type and phonotactic frequencies (see Chapter 2 and below).

5.1.2 The Dutch diminutive

As mentioned above, studies have found that syllabic allomorphs have lower production accuracies compared to segmental allomorphs (Song et al., 2009; Tomas et al., 2015; Tomas et al., 2017). In addition, based on the linguistic description of the Dutch diminutive as presented in Chapter 2, the allomorph /-ətjə/ seems to be phonologically more complex to apply correctly as multiple phonological characteristics of the stem need to be taken into account (see Chapter 3 and Dahl (2004) for a definition of complexity that relates to the idea of complexity used here). As a consequence, it might be expected that /-ətjə/ is more difficult to acquire in an appropriate manner. In the study presented in Chapter 3, it was found that for nonce nouns, that according to the linguistic rules should take /-ətjə/, adults only produced the target stem+/-ətjə/ combinations 43% of the time. They instead constructed their answers following place assimilation constraints adding /-tjə/, /-pjə/, and /-kjə/ based on the final consonant of the stem. This indicates that /-ətjə/ is not as productive as the other allomorphs and is more complex to use in a target-like manner even in adults (see Chapter 3). As was also stated in Chapter 2, the four short diminutive allomorphs without a schwa follow from regular phonotactic nasal-obstruent cluster generalisations in Dutch (Booij, 1995). This makes these four allomorphs fairly transparent and relatively easy to apply. In contrast, /-ətjə/ is more complex and less transparent in its use, as is also reflected in the adult findings.

Table 5.1
Type frequencies per allomorph expressed as percentage of all diminutive use

Allomorph	***Type frequency (%)***
/-jə/	56.8
/-tjə/	32.6
/-ətjə/	7.4
/-pjə/	1.9
/-kjə/	1.3

Note. The type frequencies are based on the SUBTLEX-NL database, which is a database based on subtitles (Keuleers, Brysbaert & New, 2010).

In addition to the phonological characteristics of the nouns as presented in Chapter 2, the diminutive allomorphs need to also be considered in terms of their frequency of occurrence. Table 5.1 gives an overview of the type frequencies of the allomorphs (based on the SUBTLEX-NL database (Keuleers, et al., 2010)). It appears that /-jə/ has the highest and /-kjə/ and /-pjə/ the lowest type frequency, with /-ətjə/ being located somewhere in between but at the lower end. Therefore, in terms of type frequency /-kjə/ and /-pjə/ would be expected to have lower production accuracies due to their low type frequencies. As mentioned above, although production accuracies of the Dutch diminutive in children have not been studied extensively, results from previous studies do indeed confirm that type frequency has an effect. Snow et al. (1979) assessed both adult second language learners and four-and-a-half and seven-year old native Dutch children on their production of the diminutive allomorphs. Considerable variation was found between the acquisition of the different diminutive allomorphs, which was attributed to the specific type frequencies of the allomorphs: the higher the type frequency, the earlier the allomorph seemed to be acquired. In their study testing four-to twelve-year old native speakers of Dutch, Den Os and Harder (1987) found that the allomorph /-jə/ was acquired first followed by /-tjə/. Thereafter the other allomorphs appeared with /-kjə/ only being acquired around the age of

twelve. Note that they also found /-ətjə/ to be less productive than initially expected even in adults. More recently Peelaerts (2008) confirmed the findings from the Snow et al. (1979) and Den Os and Harder (1987) studies. She tested four- to ten-year old children and also found that the lower the type frequency of the allomorph, the later it was acquired.

Finally, the Rispens and De Bree (2014) study, but also many other studies (among others De Bree & Kerkhoff, 2010; Zamuner et al., 2012), indicate that phonotactic frequencies might also influence production accuracies and morphophonological development. The phonotactic frequency of the final phonemes of the noun stems and the allomorphs were calculated by averaging the log value of the biphone transitional probabilities (Dutch phonotactic frequency database (Adriaans, 2006), derived from the corpus of spoken Dutch (Oostdijk, 2000)). Although these were similar for /-tjə/, /-pjə/, /-kjə/, and /-ətjə/ (between -1.3 and -1.8), the phonotactic frequencies of the final phoneme of the stem and /-jə/ was relatively low (-2.6).

5.1.3 The current study

The goal of the present study was to explore the effect of item specific factors, i.e., phonological characteristics (in terms of complexity), type frequency of the allomorphs, and phonotactic frequency of the stem+allomorph combinations, on production accuracies in five- to ten-year old typically developing children. The diminutive has five allomorphs based on different phonological characteristics of the noun stem and with different type and phonotactic frequencies (see section 5.1.2). As such, the diminutive in Dutch provides information about the influence of both phonological complexity and type and phonotactic frequency and makes it possible to evaluate the relation between these factors. In order to gain a better understanding of the

extent to which these factors are related to the development of the different allomorphs we looked at the age at which the allomorphs are acquired and at the pattern of development. In addition, we looked at the error patterns of the children, focusing on the (possible) substitutions of allomorphs. As such, this study tried to answer the following questions: 1) Is there an influence of the phonological characteristics of the stems, type frequency of the allomorphs, and phonotactic frequency of the stem+allomorph combinations on the production accuracies of the different diminutive allomorphs? 2) Do children make erroneous stem+allomorph combinations, and, if so, do they overgeneralize specific allomorphs?

Diminutive derivations of both real and nonce nouns were assessed. As also mentioned in Chapter 2, nonce forms typically follow the same structural patterns of real items but by definition have no lexical representation stored in long-term memory that can be retrieved. Children are thus required to make use of their knowledge of morphophonological patterns to apply the appropriate allomorphs to the nonce nouns. Generalizations of the diminutive to nonce items thus give extra information as to whether the children actually use a morphophonological rule. Previous studies have indicated that only from around the age of five children start to make generalizations about morphophonological forms to inflect nonce items (Tomas et al., 2017; Zamuner et al., 2012). The children tested in this study are five and above and should therefore be able to inflect nonce nouns. Nevertheless, we expected to find the younger children to have more difficulties with inflecting nonce items than the older children. Moreover, all children were expected to perform better on real versus nonce items.

Hypotheses

Based on previous studies the following hypotheses were formed:

1) We expected to find improvement with age, i.e., the older the children the better they are with inflecting the Dutch diminutive in an appropriate manner. Children's sensitivity to morphophonological patterns appears to increase with age (Tomas et al., 2017), and we expected to find this in this study as well. However, in Chapter 3 adult's production accuracies with the Dutch diminutive were tested and it was found that when inflecting nonce nouns, instead of the target /-ətjə/, adults often produced /-tjə/, /-pjə/, and /-kjə/ based on place assimilations of the final phoneme of the stem. Although, the adults performed at ceiling on the other allomorphs with both real and nonce items and adult-like behaviour is thus reflected by around a 100% accuracy scores for these allomorphs, this was thus not entirely the case for /-ətjə/. For this allomorph we hypothesized that the children would overgeneralize the (sonorant) allomorphs based on place assimilation when the target was /-ətjə/.
2) Based on the morphophonological patterns for forming the diminutive, we hypothesized lower production accuracies relative to the other allomorphs for /-ətjə/ due to phonological complexity effects (see above), and /-kjə/ and /-pjə/ based on the relative low type frequencies of these two allomorphs, /-kjə/ (1.3%) and /-pjə/ (1.9%) (Den Os & Harder, 1987; Peelaerts, 2008; Snow et al., 1979).
3) The phonotactic frequencies of the stem+/-jə/ combinations are lower than the other phonotactic frequencies. We thus hypothesized that

children show difficulties with this allomorph if phonotactic frequency influences production ability.

4) When children produce erroneous stem+allomorphs combinations, we expected, based on the type frequencies of the allomorphs, to find overgeneralizations of /-jə/ and /-tjə/. However, the first allomorph only follows stems ending in an obstruent. Assuming that the children adhere to the basic manner of articulation obstruent – sonorant distinction, we expected to find mainly overgeneralizations of /-tjə/. As also mentioned above, for /-ətjə/ we expected overgeneralizations of /-tjə/, /-pjə/, and /-kjə/ as was also found in the adult study reported in Chapter 3.

5.2 Methodology

5.2.1 Participants

The participants were 125 TD children. All children were between the ages of 5;0 and 10;0, native speakers of Dutch, and raised in monolingual families. The children were tested on a large test battery that included other general language and reading measures, which are not incorporated in this study (but see Chapter 4). Ten children had to be excluded. Three children did not complete the test battery and had scores on the tasks testing general language measures that fell below the norm. Four children were raised in bilingual families (as reported by their teachers after completion of the tasks) and were therefore excluded. Three children scored 1 SD below the mean on the Dutch real and pseudo word reading tasks (Brus & Voeten, 1979; Van Den Bos, Spelberg, Scheepstra, & De Vries, 1994), indicating a possibility of a reading impairment. After exclusion a total of 115 children remained. They were divided into four age groups. An overview of the participant characteristics per age group can be found in Table 5.2.

The children were recruited at five primary schools and were tested at their schools during school time. The teachers reported no problems such as hearing, sight, or language difficulties that could affect the outcome of the study in any of the children.

Table 5.2
Mean age per age group

Age group	Age in months	
	Mean	SD
5;0 – 5;11 (N = 36)	66.28	3.0
6;0 – 6;11 (N= 29)	77.93	3.8
7;0 – 7;11 (N= 24)	90.04	3.9
8;0 – 10;0 (N = 26)	105.73	6.3

5.2.2 Test material

The tasks administered to the children relevant for this study are the production task testing production accuracies of the diminutive allomorphs and the Raven progressive matrices task (Raven, Raven, & Court, 2003). The Raven was used to control for non-verbal IQ performance at time of testing. The test items and the production task are fully described in Sections 2.4.1 and 2.4.2.

5.2.3 Procedure

The study was reviewed and approved by the ethics review board of the Faculty of Humanities, University of Amsterdam. Schools were approached and asked whether they wanted to participate in the study. Parents were then contacted and received an information letter with an active consent form they needed to sign if the parent and child were willing to participate.

Children were tested individually at their school during school time. Testing took three to five sessions of approximately 30 minutes. The children

were also tested on the past tense and more tasks than reported on in this study were included in the test battery. Results on a judgement task and associations between morphophonological processing and other language measures are presented in Chapter 4. In the first session the children did the production task followed by some of the other tasks such as for example the Raven. Sessions two and three consisted of the other tasks. A Sony Vaio and Dell laptop were used for the tasks that had to be administered online. An Olympus digital voice recorder was used to record all the sessions.

Scoring was done by two native speakers of Dutch who were trained linguists. Approximately 12% of the data from the production task was compared to calculate the interrater reliability. This was high (Cronbach's α = .82). Any discrepancies were solved by discussion until 100% consensus was reached.

5.2.4 Analysis

Boxplots representing differences between age groups and within age groups between allomorphs for both real and nonce nouns are presented in Figures 5.1 and 5.2 (hypothesis 1). Generalized linear mixed effects modelling was used to analyze the data. The analysis addressed the questions whether a child gave a target (correct) or non-target (incorrect) answer (binary data) and whether this was dependent on which allomorph was to be used and the age of the child, i.e., the fixed effect factors were allomorph and age in months. This was done in order to be able to evaluate hypotheses 2 and 3 (Section 5.1.3) concerning differences in production accuracies between the allomorphs; and hypothesis 1 concerning development of the allomorphs. Performance scores on the Raven were included to control for the effect of IQ. The models with age, age+Raven, and age+Raven+allomorph were compared to each other using log-likelihood comparisons (using the analysis of variance function in R). If age and allomorph significantly improved the model, the interaction

between age and allomorph was examined as well. This was done in order to assess whether production of the different allomorphs had similar or diverging developmental pathways in this group of children (hypothesis 1). Participant and item were taken as random effect factors (random intercept) to control for participant and item variability. Data were modelled in R (RStudio Team, 2015) using the lme4 package (Bates, Maechler, Bolker, & Walker, 2015). Separate models were built to see whether production performance of the diminutive with real or nonce nouns differed for the different allomorphs.

The fixed effect factor allomorph was modelled by means of contrasts between levels. Each level of this factor is contrasted to a specified reference level. We hypothesized that both /-ətjə/ and /-kjə/ would have the lowest accuracy scores (hypothesis 2). Therefore these two allomorphs were taken as the reference levels to which the other allomorphs were contrasted. Hypotheses 2 and 3 also stated that /-pjə/ and /-jə/ would have lower production accuracies. However, Figures 5.1 and 5.2 clearly show that both allomorphs are produced at ceiling level in all age groups. Consequently, no models were run with /-pjə/ and /-jə/ as the reference levels.

Finally, to be able to evaluate hypothesis 4, the erroneous productions of the children were assessed per age group. Specifically, the erroneous forms were grouped according to which allomorph was used instead of the appropriate allomorph. In this way we could investigate whether the children based their erroneous answers on the phonological characteristics of the stems, or phonotactic and type frequencies of the stems and allomorphs. In addition, we also looked at whether the substitutions changed between the different age groups. Two-tailed chi-square tests were conducted and followed

up by post-hoc analyses with Bonferonni corrections. Standardized residuals, z-scores, of each allomorph per age group were also assessed to gain a better idea of which allomorphs were used more and which less often than expected. As is the case with z-scores if the value lies outside of ±1.96 it is significant at $p < .05$, if it lies outside ±2.58 it is significant at $p < .01$, and if it lies outside ±3.29 it is significant at $p < .001$.

5.3 Results

Figures 5.1 and 5.2 show the boxplots for the different allomorphs per age group for the real and nonce diminutives respectively. As the figures indicate, improvement with age was found. The results from the multilevel models confirm this (Table 5.3 model comparisons; final optimal models can be found in the Appendix): diminutive real, null model compared to model with age included $p = .05$; diminutive novel, null model compared to model with age included $p = .02$. In addition, the figures indicate that for both the real and the nonce diminutives, production accuracies were low for /-ətjə/ and /-kjə/ while accuracies were higher for the other allomorphs and approached ceiling levels in all the age groups and especially in the older age groups with the real diminutive.

The model comparisons as presented in Table 5.3 confirm the findings from the figures: for the real diminutives performance with /-ətjə/ and /-kjə/ was significantly worse compared to the other allomorphs, respectively $p < .001$ and $p = .002$. For the nonce diminutives a significant difference between /-ətjə/ and the other allomorphs was found ($p < .001$), but this was not the case when /-kjə/ was taken as the reference level, although it is marginally significant ($p = .08$). No significant interaction between age and /-kjə/ contrasted to the other allomorphs was found with either the real or the nonce items (respectively $p = .16$ and $p = .7$). A significant interaction between age and allomorph when /-ətje/ was contrasted to the other allomorphs was

found for both the real and nonce items (respectively p = .02 and p < .001). These significant interaction effects indicate that /-ətjə/ seems to follow a different developmental pattern compared to the other allomorphs. The interaction for the real nouns was caused by /-ətjə/ not improving to the same extent with age as the other allomorphs. Interestingly, for the nonce diminutive, the significant interaction is caused by the accuracy scores for /-ətjə/ actually decreasing with age.

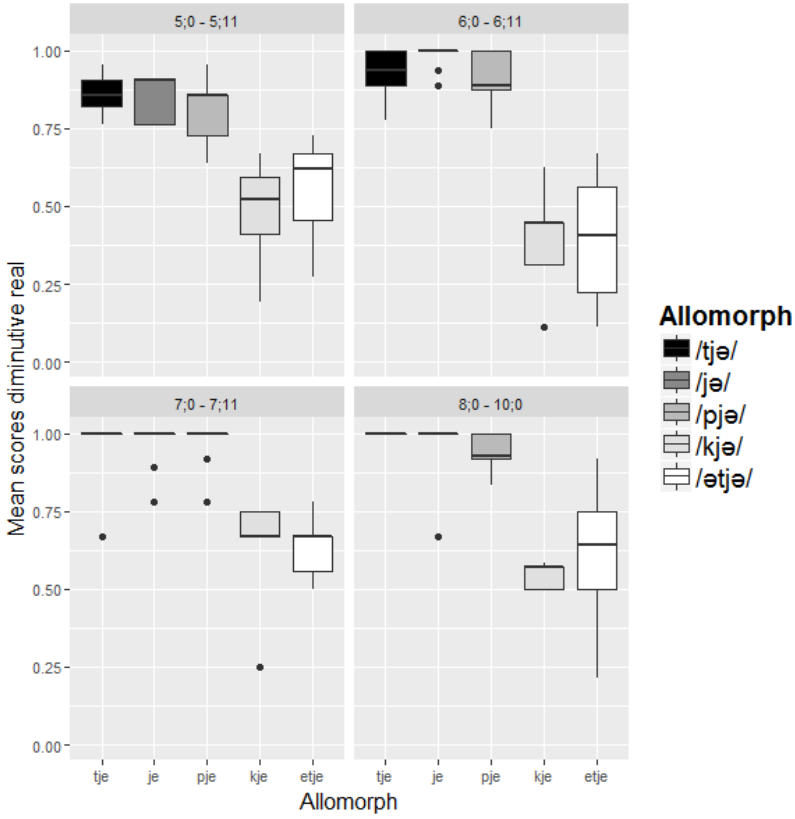

Figure 5.1 Mean accuracy scores on the production task per age group for the real diminutive; allomorph type is expressed on the x-axis

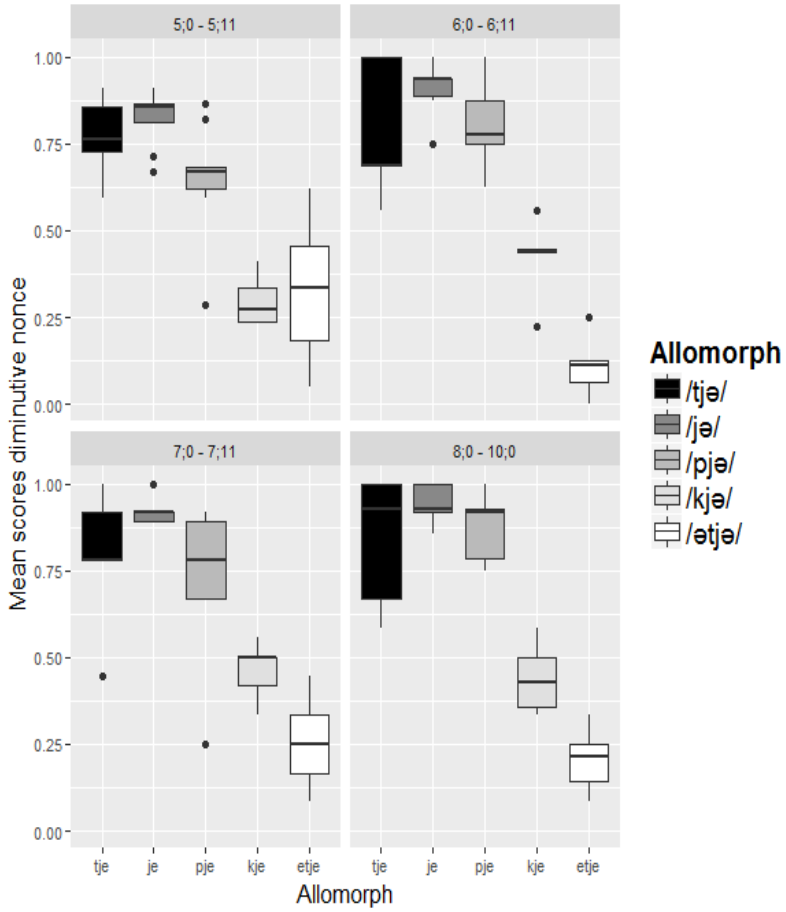

Figure 5.2 Mean accuracy scores on the production task per age group for the nonce diminutive; allomorph type is expressed on the x-axis

Table 5.3
Linear mixed effects model comparisons production accuracies real and nonce diminutive

Model	Log Likelihood	X^2	*p*
Diminutive real production /-ətjə/			
Null + Age	-938.08	7.7	.006
+ Raven	-936.21	3.7	.05
+ Allomorph (/-ətjə/ vs others)	-926.22	20.0	< .001
+ Age * Allomorph	-923.62	5.2	.02
Diminutive real production /-kjə/			
+ Allomorph (/-kjə/ vs others)	-931.45	9.5	.002
+ Age * Allomorph	-930.45	2.0	.16
Diminutive nonce production /-ətjə/			
Null + Age	-1171.7	5.7	.02
+ Raven	-1169	5.4	.02
+ Allomorph (/-ətjə/ vs others)	-1151	36.1	< .001
+ Age * Allomorph	-1138.3	25.3	< .001
Diminutive nonce production /-kjə/			
+ Allomorph (/-kjə/ vs others)	-1167.4	3.2	.08
+ Age * Allomorph	-1167.4	0.1	.7

In order to explore hypothesis 4 (Section 5.1.3) we performed follow-up analyses to gain a better understanding of the factors influencing acquisition during the course of development. For production of the real diminutive there was a significant association between the age group the child was in and the erroneous productions, χ^2 (15) = 71.7, p < .001. Figure 5.3 (upper graph) gives the percentage of substitutions instead of the target allomorphs per age group. Post hoc analyses with Bonferonni correction indicated that all age groups, except the six- and seven-year olds, were significantly different from each other: five- vs six-year olds, five- vs eight-year olds and six- vs eight-year olds, p < .001, five- vs seven-year olds, p = .01, seven- vs eight-year olds,

p = .05. The bar chart and the standardized residuals indicate that the five-year olds gave significantly more non-target answers that could be classified as *other,* used /-ətjə/ more often than expected (respectively z = 3.1, z = 2.7), and used /-tjə/ (z = -2.5) less than expected. The six-year olds used /-ətjə/ (z = -2.5) significantly less often than expected, while the eight-year olds used /-jə/ and /-tjə/ significantly more often than expected (respectively z = 2.2, z = 3.0), and had significantly fewer answers that could be classified as *other* (z = -3.4).

For production of the nonce diminutives there was also a significant association between the age group the child was in and the erroneous productions, χ^2 (15) = 94.4, p < .001. Figure 5.3 (lower graph) gives the percentage of substitutions instead of the target allomorphs per age group. Post hoc analysis with Bonferonni correction indicated that all age groups were significantly different from each other: five- vs six-year olds, five- vs seven-year olds, five- vs eight-year olds, and six- vs seven-year olds, p < .001, six- vs eight-year olds, p = .002, seven- vs eight-year olds, p = .02. The bar chart and the standardized residuals indicate that the five-year olds gave significantly more non-target answers that could be classified as *other* (z = 3.4), used /-ətjə/ more often than expected (z = 2.8), and used /-tjə/ and /-pjə/ (respectively z = -2.1, z = -2.3) less than expected. The six-year olds used /-ətjə/ (z = -2.5) significantly less often than expected and /-kjə/ more often than expected (z = 2.5), while the seven-year olds used /-tjə/ significantly more often than expected (z = 2.4) and had significantly fewer answers that could be classified as *other* (z = -2.7). The eight-year olds used /-ətjə/ significantly less often and had fewer answers that could be classified as *other* (respectively z = -2.8, z = -2.2), while they used the allomorphs /-tjə/ and /-pjə/ significantly more often than expected (respectively z = 2.7, z = 2.9).

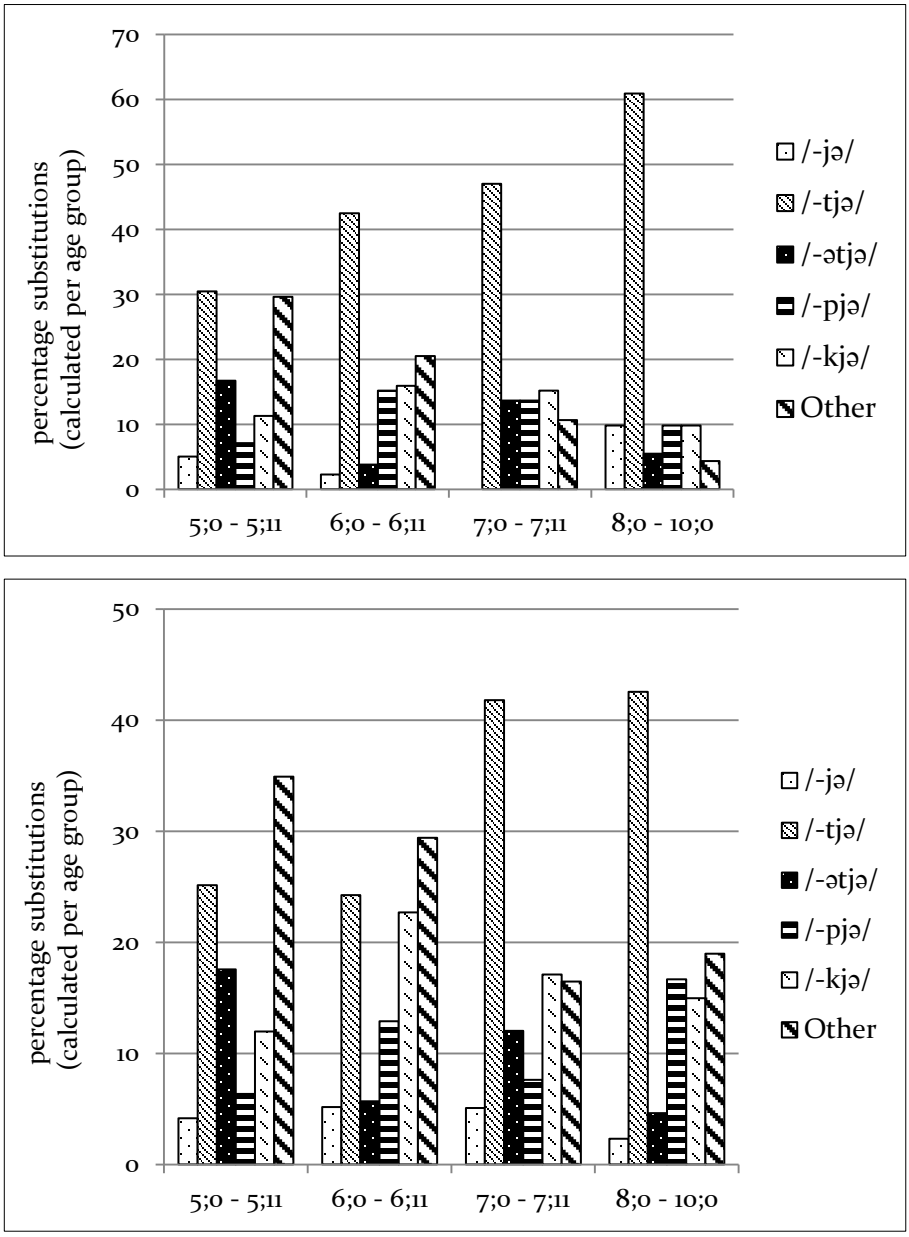

Figure 5.3 Substitutions per allomorph calculated per age group (upper graph real diminutive, lower graph nonce diminutive)

Because accuracy scores on the allomorphs from the phonological conditions involving vowel length (/-tjə/, /-pjə/, and /-ətjə/) and stress (/-kjə/ and /-ətjə/) were significantly lower than the accuracy scores on the other allomorphs, a separate substitution analysis was carried out for these two conditions. Recall that in our adult study with the same production task, the adults scored significantly lower on the nonce nouns that (should) take /-ətjə/ (see Chapter 3). They substituted this allomorph with /-tjə/ for nouns ending in an alveolar, /-pjə/ for stems ending in a labial, and /-kjə/ for stems ending in a velar. The adults relied on regular place assimilation processes instead of the more complex phonological characteristics of the stems. We investigated whether the children's substitutions for nouns that take /-ətjə/ were also based on place assimilation constraints and whether there were differences between the age groups. In addition, the substitutions for /-kjə/ were examined.

Figure 5.4 shows the probabilities of allomorph substitutions per age group for respectively the real (upper graph) and nonce (lower graph) diminutive in the vowel length condition (allomorphs /-ətjə/, /-tjə/, and /-pjə/). What is clear from these graphs is that the older the children are, the more adult-like they become in their choice of non-target allomorphs, i.e., substitutions: real vowel length χ^2 (15) = 32.5, $p < .001$, five- vs eight-year olds $p = .04$, six- vs eight-year olds $p = .02$, seven- vs eight-year olds $p = .04$; nonce vowel length χ^2 (15) = 29.4, $p = .01$, five- vs six-year olds $p = .01$, five- vs eight-year olds $p = .01$. Especially when inflecting the real diminutive in a non-target manner the eight-year olds mainly replaced the target allomorph with either /-tjə/ or /-pjə/. Surprisingly, however, the eight-year olds replaced some target allomorphs with the non-target allomorph /-jə/, violating the phonological rule that stems ending in a sonorant do not combine with /-jə/. A closer look at these substitutions shows that the eight-year olds used /-jə/ for the stems

ending in the labial sound /m/. The substitutions for the nonce diminutive forms are more diverse and many *other* answers were given by children in all the age groups. Yet, similar to the real items, the older the children were, the more they started to rely on simple place assimilation processes in their substitutions. It should also be noted that even the youngest children based many of their non-target stem+allomorph answers on simple place assimilation processes when inflecting both real and nonce nouns.

In the stress phonological condition (allomorphs /-ətjə/ and /-kjə/), Figure 5.5 (respectively real (upper graph) and nonce (lower graph)) indicates that especially for the real items, the older the children are the more consistent they are in their substitutions: real stress χ^2 (15) = 44.3, $p < .001$, five- vs seven-year olds $p = .04$, five- vs eight-year olds $p < .001$, six- vs eight-year olds $p = .005$; nonce stress χ^2 (15) = 99.3, $p < .001$, five- vs seven-year olds, five- vs eight-year olds, and six- vs eight-year olds $p < .001$, five- vs six-year olds and six- vs seven-year olds $p = .009$, seven- vs eight-year olds $p = .04$. The older the children, the more they replaced the target allomorph with /-tjə/. A closer inspection of the substitutions indicates that they mostly replaced /-kjə/ with /-tjə/. Similar to the adult findings (Chapter 3), all age groups replaced /-ətjə/ to a large extent with /-kjə/.

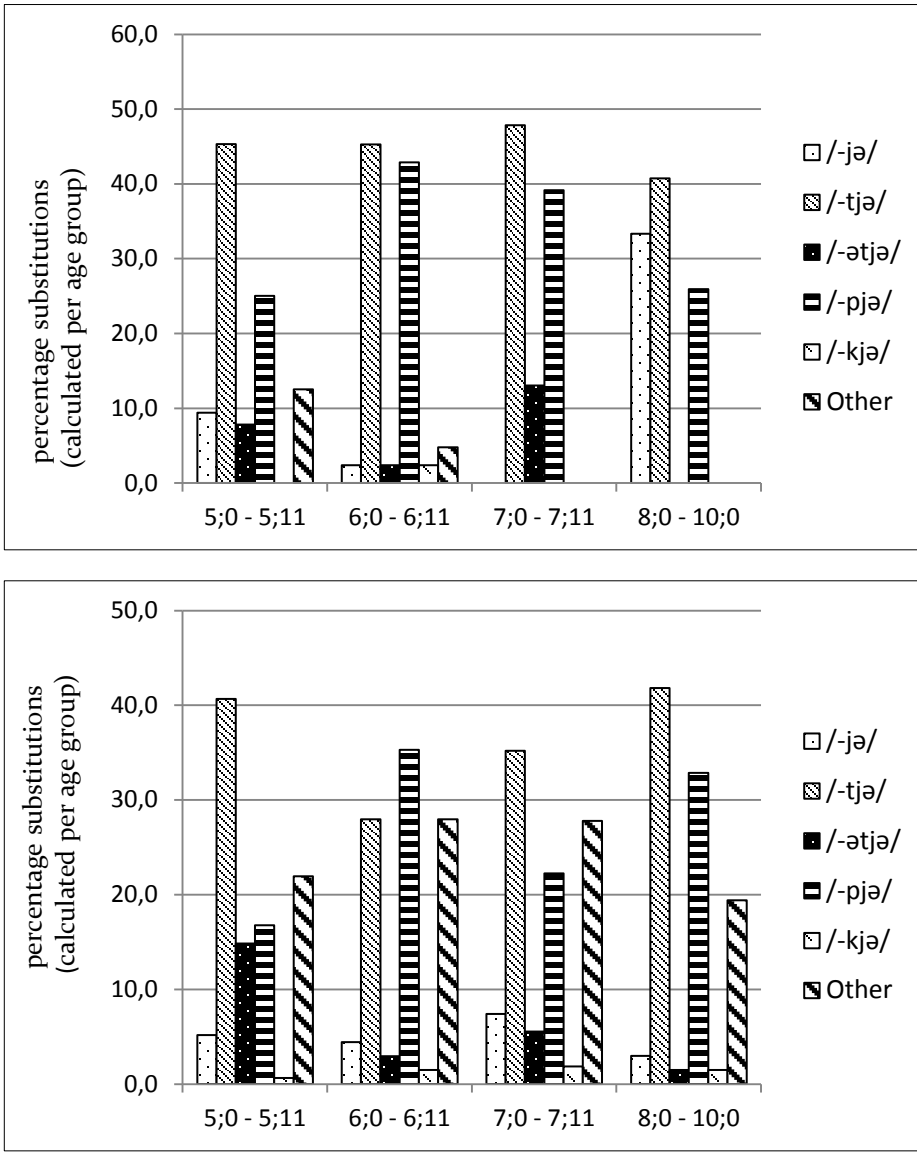

Figure 5.4 Substitutions per allomorph calculated per age group for the vowel length phonological condition (above real diminutive, below nonce diminutive)

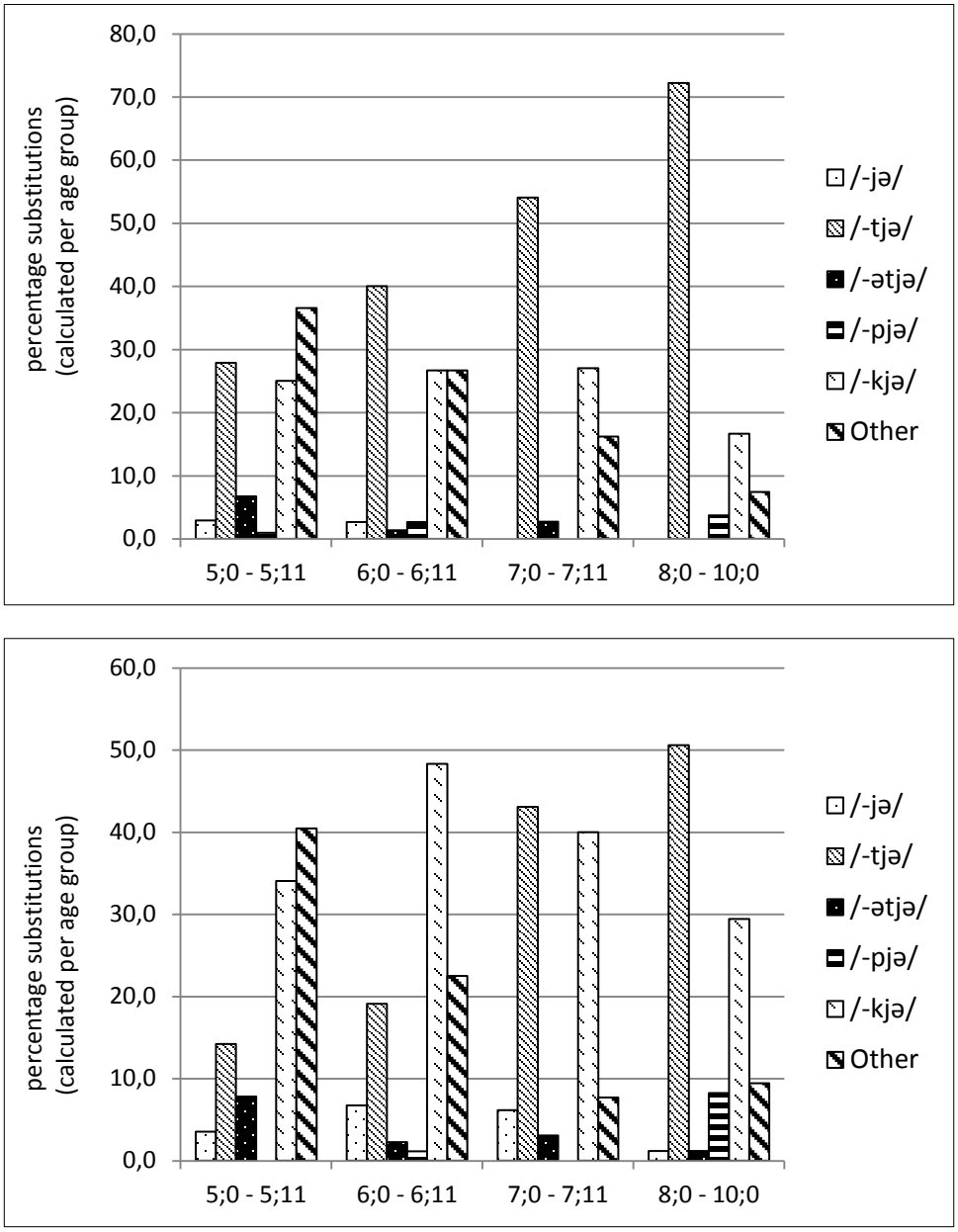

Figure 5.5 Substitutions per allomorph calculated per age group for the stress phonological condition (above real diminutive, below nonce diminutive)

5.4 Discussion

This study investigated the development of the Dutch diminutive allomorphs in a group of five- to ten-year old typically developing children. More specifically, we investigated whether phonological characteristics of the stems, type frequency of the allomorphs, and phonotactic frequency of the stem+allomorph combinations influence production accuracies of the diminutive allomorphs, their erroneous productions, and whether the influence of these factors changes during development. A wug-type production task was used to study children's ability to produce diminutive allomorphs in Dutch. Based on previous studies in both English and Dutch, it was hypothesized that type and phonotactic frequencies of the (stem+) allomorph and complexity of the phonological characteristics of the stem would have an effect on production accuracies and that an age-effect would be found, i.e., the older the children, the more adult-like their performance.

Table 5.4 gives a general overview of the results found in this study in terms of production accuracies. The two diminutive allomorphs /-ətjə/ and /-kjə/ had the lowest production accuracies for both the real and nonce diminutive as expected (see hypothesis 2 Section 5.1.3).

Table 5.4
Overview of the findings in terms of production accuracies

Diminutive	
Real	**Nonce**
/-jə/, /-tjə/, /-pjə/ >^{A} /-kjə/	/-jə/, /-tjə/, /-pjə/ >* /-kjə/
/-jə/, /-tjə/, /-pjə/ > */-ətjə/	/-jə/, /-tjə/, /-pjə/ >* /-ətjə/

Note. * = significantly lower production accuracies compared to the other allomorphs, A = not significant, but approaches significance

We expected (hypothesis 1) and found higher production accuracies in older children compared to younger children. In addition all age groups had lower production accuracies for nonce nouns compared to real nouns. The results moreover indicated that, while even the youngest children were

already sensitive to the morphophonological contexts for the use of the /-jə/, /-tjə/, and /-pjə/ allomorphs for both real and nonce nouns, all the children, including the oldest, had problems using /-ətjə/ and /-kjə/ in an appropriate manner (hypothesis 2).

The findings indicate that type frequencies of the allomorphs had some influence as hypothesized based on previous studies (Den Os & Harder, 1987; Jolly & Plunkett, 2008; Peelaerts, 2008; Snow et al., 1979; Tomas et al., 2015; Tomas et al., 2017; Tomas et al., 2017). As previously mentioned, /-jə/ has the highest type frequency followed by /-tjə/, while /-kjə/ has a relatively low type frequency of only 1.3%. Since children used the /-jə/ allomorph in an appropriate manner and at ceiling level in all age groups, it can be concluded that phonotactic frequency did not have an effect (hypothesis 3).

Type frequency does not explain why even the youngest children performed in a target-like manner on the /-pjə/ allomorph, as this allomorph has a similar (low) type frequency as /-kjə/ (1.9%). As was discussed, /-pjə/ follows regular place assimilation constraints in that it always follows a labial, i.e., *boom – boompje* (tree). The stem+/-pjə/ combinations are relatively easy and straightforward to pronounce as they follow regular articulatory processes. In contrast, although /-kjə/ also follows place assimilation constraints in that it always follows a velar nasal, i.e., *koning – koninkje* (king), velars are different from other nasals as they are subject to some strong phonotactic constraints, have been shown to be relatively difficult in terms of articulation, and are acquired relatively late (Mennen, Levelt, & Gerrits, 2006; Trommelen, 1984). Stem+/-kjə/ combinations might therefore be harder to produce than stem+/-pje/ combinations. An effect of token frequency might also be apparent. Even though every attempt was made, we could not always

control for the lexical frequencies of the diminutive forms. The token frequency of the diminutive forms taking /-kjə/ could either not be found, i.e., were not represented in the database, or were as low as 0.02 instances per million (taken from the SUBTLEX-NL database (Keuleers et al., 2010)). Experimental evidence has shown that token frequency, the number of times a specific item appears, influences past tense marking of both regular and irregular verbs (Matthews & Theakston, 2006; Oetting & Horohov, 1997; Rispens & De Bree, 2014). Stems taking the /-kjə/ allomorph are thus quite infrequent in their diminutive form in child (directed) speech, e.g., the diminutive form of *verwarming* (heater) – *verwarminkje* (heater-DIM) is not something children hear on a daily basis. Finally, stems taking /-kjə/ consist of two or more syllables as only stems that have stress on the penultimate syllable can take this allomorph. This makes these stems more complex compared to the other segmental stems. In sum, the low type frequency of /-kjə/, the low token frequency of stem and /-kjə/ combinations, the late and more complex acquisition of the velar nasal, and the fact that the stems always consisted of more than one syllable, most probably caused the difficulties children had with appropriately using /-kjə/. Thus, although this confirms our second hypothesis, this is not entirely due to this allomorph's low type frequency as was expected, but also due to the phonologically more complex characteristics of the stems that give rise to this allomorph.

The substitution analyses indicated that /-tjə/ most often replaced /-kjə/. This confirms our fourth hypothesis and follows the type frequency account, as the children thus replaced /-kjə/ with the allomorph with the highest type frequency for stems ending in a sonorant. Especially the older children appeared to be strongly influenced by type frequency. Note that the children adhered to the obstruent – sonorant distinction and did not replace

/-kjə/ with /-jə/ which, although it has a higher type frequency than /-tjə/, only comes after stems ending in an obstruent.

As hypothesized (hypothesis 2), low production accuracies for /-ətjə/ were also found for both real and nonce items. Although this allomorph does not have a very low type frequency, it is used with stems with the phonologically most complex characteristics (see the introduction Section 5.1.1). In addition, in a previous study testing diminutive production in adults, it was found that adults did not always apply /-ətjə/ in the way predicted according to previous theoretical linguistic rules for nonce nouns. They often replaced it with /-tjə/, /-pjə/, and /-kjə/ based on place assimilation between the final phoneme of the stem and the first phoneme of the allomorph (see Chapter 3). In this study it was also found that most substitutions for /-ətjə/ were allomorphs that assimilated with the final phoneme of the stem, i.e., **vompje* instead of the target *vommetje* (as predicted in hypothesis 4). This was the case for both the real and the nonce items and was already apparent in the youngest children. Nonetheless, the nonce items were clearly more difficult as even the oldest children still had relatively many answers that could be classified as *other*. Surprisingly, the children even replaced /-ətjə/ with /-kjə/ although they found this latter allomorph difficult to use in a target-like manner. Apparently, when phonological characteristics are complex, children will apply other allomorphs even if they are infrequent.

As mentioned above, in Chapter 3 non-target forms based on place assimilation were only found for nonce nouns, but adults performed at ceiling when inflecting real nouns. The adults seemed to have stored real stem+/-ətjə/ combinations in their lexicon. In this study, production accuracies for /-ətjə/ improved with age for the real diminutive, i.e., the older children were more

accurate on the real items, but in contrast not on the nonce diminutive. Based on these findings and on previous studies showing effects of vocabulary size (Chapter 4; Marchman & Bates, 1994; Paradis et al., 2016; Rispens & De Bree, 2014), it can be argued that older children have stored more instances of real stem+/-ətjə/ combinations in their lexicons.

As a final point, surprisingly many instances of non-target uses of /-ətjə/ were found (not hypothesized). Despite it being phonologically complex to use appropriately, it is rather often used inappropriately. Especially the five-year olds used /-ətjə/ relatively often. A possible explanation could be that /-ətjə/ is more salient due to it having multiple syllables. Syllabic allomorphs have more phonological content than their segmental counterparts (Mealings et al., 2013) and this might have made children more prone to use /-ətjə/ when they were unsure about which allomorph to produce. However, in several studies the opposite has been found: syllabic allomorphs were more difficult than segmental allomorphs. Further studies should be undertaken to explore children's non-target uses of allomorphs.

5.5 Conclusion

This study explored production accuracies of the Dutch diminutive in five- to ten-year old typically developing children. The complexity of the phonological characteristics of the stem to which the allomorphs attach, type frequency of the allomorphs, and phonotactic frequency of the stem+allomorph combinations in relation to production accuracies and erroneous productions of the Dutch diminutive were explored. Investigating the Dutch diminutive made it possible to evaluate the relation between phonological and frequency effects.

An age-effect was found in that older children showed higher accuracy scores (hypothesis 1). However, no improvement with age was found

for production of real and nonce nouns that take /-ətjə/. This allomorph, which is based on the phonologically most complex characteristics of the noun stems, was found to have significantly lower production accuracies than the other allomorphs (hypothesis 2). Additionally, although it was hypothesized that /-kjə/ and /-pjə/ would have lower production accuracies due to their low type frequencies (hypothesis 2), this was only the case for /-kjə/ which was most probably also due to the more complex phonological characteristics of the stems it attaches to. No effect of phonotactic frequency was found (hypothesis 3). In addition, an age-effect was found with respect to the substitution of /-ətjə/. The older children were more adult-like in their performance in terms of their substitutions for /-ətjə/, i.e., substitutions were based on place assimilation with the final phoneme of the stem (hypothesis 4). Erroneous productions for stems that should receive /-kjə/ were mostly productions with the allomorph with the highest type frequency for stems ending in a sonorant /-tjə/ (hypothesis 4). Children of all ages were able to generalize to nonce items and their performance with nonce nouns also improved with age.

In conclusion, this study has shown that, at least from the age of five, children are sensitive to the morphophonological patterns of Dutch. The phonological characteristics of stems and type frequency of the allomorphs were found to be related to not only appropriate but also erroneous diminutive productions. However, complexity of the phonological characteristics of stems appeared to have a bigger impact than type frequency. The findings indicate that both input and phonological skills are important when learning the morphophonological properties of a language, but that, for

five- to ten-year old children, especially phonological complexity has a big impact on production accuracies.

6
Allomorphy in children with reading difficulties*

Associations between morphophonology, phonology, and rapid automatized naming

Abstract

This study investigated two morphophonological phenomena, the Dutch past tense (two allomorphs), and diminutive (five allomorphs), in children with reading difficulties (RD). Earlier studies have shown that the acquisition of allomorphs is influenced by children's phonological processing skills and the complexity of the phonological characteristics of the stem the allomorph is attached to. RD children show variability with regards to their phonological processing skills. Evidence for impairments in phonological awareness, phonological short term memory, and lexical retrieval, but also morphophonological processing has been found across studies. We investigated whether RD children are impaired in their use of allomorphy and whether such an impairment is associated with weaknesses in other phonological skills.

Three groups of Dutch children: 1) RD (9;3, n=20), 2) a chronological age match group (CA, 8;11, n=20), and 3) a reading age match group (RA, 6;10, n=20) were tested using a production and judgement task. Tasks tapping into phonological awareness, nonword repetition, digit span, and rapid naming were also administered. No significant group differences were found on the past tense and diminutive and the tasks testing phonological awareness and phonological short term memory. Only the rapid naming task differed between the RD children and their CA peers. Significant correlations were found between the phonological tasks and the production and judgement task. These results underline the previously found associations between sensitivity to allomorphy and other phonological skills. They further suggest that, at the group level, lexical retrieval difficulties in the absence of other phonological impairments are not sufficient to cause morphophonological difficulties.

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6.1 Introduction

6.1.1 Morpho(phono)logical performance in children with reading difficulties

Oral morpho(phono)logical skills of children with reading difficulties have been investigated in several studies. The core deficit in these children is problems with word decoding which also impacts their spelling and reading fluency (Snowling, 2013). As such the predominant difficulty these children have is decoding text into speech fluently and accurately. Nevertheless, these children's reading comprehension skills are at a relatively normal level. Quite a few studies have focused on morphological processing, morphophonological processing, and morphological awareness in oral production and judgment tasks in both children and adults with poor reading abilities. Shankweiler et al. (1995) studied the production of morphologically derived forms such as *five - fifth* in a study of children aged 7;5 to 9;5 with dyslexia. They concluded that the morphological difficulties were largely due to weaknesses in the phonological domain as they found a strong association between phonological awareness, phonological short term memory, and morphological skills. Their conclusion was strengthened by the finding that these same children did not show any weaknesses in their syntactic knowledge on relative clauses, passives, control properties of adjectives, and pronoun co-reference, i.e., morphosyntactic phenomena without a morphophonological component. Fowler and Liberman (1995) obtained similar findings in their study of children with poor reading skills (also aged 7;5 to 9;5). The children in this study had particular difficulties in the production of morphological forms that involved a phonological change in the base form, e.g., *courage – courageous*, but had no difficulties with forms that did not have a phonological change,

e.g., *danger – dangerous*. They thus concluded that weaknesses in the phonological domain made some morphological relationships particularly difficult to learn. Similar conclusions have been drawn from studies testing inflectional morphology. Joanisse, Manis, Keating, and Seidenberg (2000) tested production of both regular and irregular plural noun and past tense marking. They found a considerable amount of heterogeneity between the children in speech perception, phonology, and morphology. Based on these results they divided the children with dyslexia into three groups: a general language impaired (LI) group, a phonological group, and a delay-type group[1] that was characterized by having poorer reading skills but no phonological impairments. The study showed that the phonological group and LI group had reduced knowledge of inflectional morphology compared to their age-matched typically developing (TD) peers. It was concluded that the children's phonological impairments were related to their broader language deficits in the morphological domain. In a study comparing a group with LI with a group with dyslexia, Robertson, Joanisse, Desroches, and Terry (2012) drew similar conclusions since their results indicated that both groups had difficulty generating past tenses overall, although the deficit was less pronounced in the group with dyslexia than LI. Both groups also showed problems with phonological processing and the children with especially poor phonological abilities showed greater problems with inflectional morphology.

[1] Note that the children were all classified as children with poor reading skills, but did not have a formal diagnosis of dyslexia; they had been referred by their teachers and had scores at or below the 25th percentile on the Woodcock reading mastery task-revised.

The studies discussed above linked morphological difficulties of children with reading difficulties to difficulties in the phonological domain. These findings relate closely to studies that have indicated that morphophonological development is associated with the complexity of the phonological characteristics of lexical items and children's phonological processing skills in TD children (see also below and Chapter 4, Demuth & Tomas, 2016; Mealings, Cox, & Demuth, 2013; Rispens & De Bree, 2014; Robertson, Joanisse, Desroches, & Terry, 2012; Song, Sundara, & Demuth, 2009; Tomas, Demuth, Smith-Lock, & Petocz, 2015; Tomas, Van De Vijver, Demuth, & Petocz, 2017). Since the findings in the studies with children with poor reading skills discussed above involved morphophonological phenomena, i.e., derivations with different phonological forms and allomorphs, they complement the findings of studies testing TD children on their morphophonological acquisition and strengthen the idea that impairments in phonological processing skills are associated with problems in the morphophonological domain.

Other researchers, however, argue that morphological limitations are independent of phonological deficits (Cantiani, Lorusso, Guasti, Sabisch, & Männel, 2013; Deacon & Kirby, 2004; Law, Wouters, & Ghesquière, 2015). For example, in an ERP study by Cantiani et al. (2013) studying adults with dyslexia in a German grammaticality judgement task, differences in ERP waveforms and longer reaction times in response to agreement violations were found between adults with and without dyslexia (see also Rispens, Been, and Zwarts (2006) for similar ERP results in Dutch). This was especially apparent when morphosyntactic violations were expressed by both vowel changes in the verb stem and inflectional changes. Cantiani et al. (2013) proposed that these morphosyntactic difficulties were therefore driven by other linguistic factors, such as the detection and integration of lexical cues,

rather than being due to phonological processing. Leikin and Hagit (2006) also found slower reaction times in their group with dyslexia in a masked priming study on the morphological ability of adults in Hebrew. They concluded that the morphological knowledge of readers with dyslexia did not notably differ from that of the control group. In contrast, they posited that, compared to the controls, the readers with dyslexia appeared to benefit more from morphologically based priming. The differences in reaction times could, according to the authors, be attributed to a slow speed of information processing in the group with dyslexia, but this slowness was not related to a deficit in the morphological domain or in phonological or lexical processing. These studies therefore did not find a link between phonological and morphological processing skills. However, what was tested were morphological inflections that did not include a morphophonological component. Phonological skills therefore seem to only be associated with morphological processing when the morphological phenomena include a morphophonological component.

This association between phonological skills and the acquisition of morphophonology is also supported by other evidence. Some of these earlier studies show a large variability in accuracy scores in the tasks testing morpho(phono)logical skills in the children with reading impairments. This is attributed to whether the children had phonological impairments or not. For example, in the study by Joanisse et al. (2000) discussed above, the participant sample with dyslexia was divided into distinct groups based on their scores on the tasks testing phonological, reading, but also morphological skills. Only the children with phonological problems also had problems with appropriately inflecting the past tense.

In sum, previous studies testing morphological skills in children with reading difficulties have revealed impaired production of inflectional morphology and weaknesses in derivational morphology tasks (Cantiani et al., 2013; Fowler & Liberman, 1995; Joanisse, Manis, Keating, & Seidenberg, 2000; Robertson et al., 2012; Shankweiler et al., 1995; Van Alphen et al., 2004). Phonology is important for the morphological phenomena tested in these studies for discovering the structural relationship between the stem and the derived form (Chiat, 2001; Joanisse et al., 2000; Robertson et al., 2012; Shankweiler et al., 1995). Morpho(phono)logical difficulties are therefore claimed to stem from the phonological impairments of children with reading difficulties. The main goal of this study was to further investigate this claim. More specifically this study focused on these children's sensitivity to allomorphy, i.e., phonologically variant forms of morphemes, and investigated the associations between allomorphy and a range of other phonological skills. These results will provide empirical evidence on the assumed relationship between morphophonology and other phonological skills in children with and without reading difficulties. The next section will expand on allomorph productions in TD children and its relation to their phonological processing skills.

6.1.2 Allomorph production in relation to phonological processing skills

Earlier studies testing TD children have found differences in production accuracies of allomorphs with some allomorphic forms reaching adult-like accuracies before others (Bybee & Slobin, 1982; Jarmulowicz, 2006; Jarmulowicz & Hay, 2009; Matthews & Theakston, 2006; Mealings et al., 2013; Song et al., 2009). These studies have, for example, shown that the English regular past tense syllabic /-Id/ allomorph, as in *'waited'*, is produced less accurately than the /-d/, *'washed*, and /-t/, *'danced'*, allomorphs (Bybee, 1985;

Marshall & Van Der Lely, 2006; Matthews & Theakston, 2006; Oetting & Horohov, 1997). Allomorphs can stem from the phonological characteristics of the noun or verb as an accommodation to the phonotactic and/or phonological restrictions of the language (Buckler, 2014; Kerkhoff, 2007; Zamuner, Kerkhoff, & Fikkert, 2012), e.g., the English past tense /-Id/ allomorph only follows stems ending with an alveolar. Earlier studies have shown that these item-specific phonological characteristics significantly affect early productions of allomorphs, with some phonological contexts being more challenging than others (Demuth & Tomas, 2016; Mealings et al., 2013; Rispens & De Bree, 2014; Robertson et al., 2012; Song et al., 2009; Tomas et al., 2015; Tomas et al., 2017). Song et al. (2009) analyzed the spontaneous speech of six English speaking toddlers (age 1;3 – 3;6) and found that the variability of these children's third person singular *–s* productions was related to the phonological complexity of the coda of the stems, i.e., children produced 3rd person singular morphemes in simple coda contexts such as *'sees'* more accurately than in complex coda contexts such as *'needs'*. Other studies have in addition shown that perceptual saliency, phonetic substance, stress, and syllabicity are also related to allomorphic productivity and development (among others Baer-Henney & Van De Vijver, 2012; Jarmulowicz, 2006; Jarmulowicz & Hay, 2009; Mealings et al., 2013; Song et al., 2009; Tomas et al., 2017). In addition, studies that moved outside the scope of these item specific characteristics found that phonological processing skills influenced production and judgement accuracies of allomorphs in TD children (see also Chapter 4, Archibald, Joanisse, & Shepherd, 2008; Joanisse et al., 2000).

Together the findings of studies in which both children with and without reading difficulties participated, suggest that limitations in children's

phonological processing skills can lead to difficulties with choosing the correct allomorph. As mentioned before, children with reading difficulties (henceforth RD) have been found to show poorer performance on tasks testing phonological processing skills. More specifically, these children have been found to show impairments in 1) phonological awareness (PA), e.g., phoneme manipulation, 2) phonological short term memory, e.g., digit span and nonword repetition (NWR), 3) fast retrieval of familiar lexical items, i.e., rapid automatized naming (RAN), (Denckla & Rudel, 1976; Marshall, Ramus, & Van Der Lely 2010; Ramus, Marshall, Rosen, & Van Der Lely, 2013), and 4) grapheme to phoneme linking (Aravena, 2017). Results from studies on RD children's phonological skills are relatively consistent in that RD children appear to have a phonological deficit. However, there is variability in which domain of phonology this impairment is most apparent (Aravena, 2017; Gallagher, Frith, & Snowling, 2000; Peterson & Pennington, 2015; Wolf & Bowers, 2000). The RD group is thus a heterogeneous group with respect to their phonological skills. A common view is that the phonological impairments can be grouped, on the one hand, into phonological awareness and phonological short term memory impairments and, on the other hand, into more implicit phonological problems in lexical retrieval (Aravena, 2017; Bowers & Wolf, 1993; Wolf & Bowers, 2000; Wolf, Bowers, & Biddle, 2000). Bowers and Wolf (1993) proposed the double deficit hypothesis as a broader explanation for poor reading abilities. According to this hypothesis both RAN and phonological impairments contribute separately to reading difficulties. Individuals who have both of these deficits show greater reading impairments compared to those with a single deficit (phonological skills or RAN) (Bowers & Wolf, 1993; Wolf et al., 2000).

6.1.3 The current study

In the current study, sensitivity to allomorphy in RD children was assessed to address our two main research aims. We first of all wanted to investigate whether RD children are less sensitive to past tense and diminutive allomorphy. We further wanted to establish whether these potential difficulties are associated with problems in phonological awareness, phonological processing, and/or RAN. The earlier studies mentioned in the introduction have found links between children's phonological processing and morphophonological skills. However, these studies did not focus on the potential link between RAN and morphophonological processing. This is, nevertheless, interesting to explore especially in RD children as multiple studies have found a direct link between RAN and reading skills (Aravena, 2017; Norton & Wolf, 2012; Peterson & Pennington, 2012). As the focus of this study is on morphophonology in RD children, the question whether there is also a link between RAN and sensitivity to allomorphy will be explored as well.

The allomorphs tested in this study were the Dutch past tense and diminutive allomorphs. See Chapter 2 for a description of the Dutch past tense and diminutive. Both are interesting morphophonological phenomena to test in RD children since the allomorphs are derived from the phonological characteristics of the stem. Children thus need to be sensitive to these phonological characteristics, learn which variant forms are related, and be able generalize over the morphophonological patterns.

Since a significant proportion of school-aged children's language ability is influenced by written text, limited exposure to written text could delay the language development in children with poor reading abilities

(Robertson et al., 2012). It is thus important to control for this by comparing the morphophonological abilities of RD children to a younger reading-age (RA) matched group. If the RD children perform similarly on the production and judgement task as their RA peers, the possibility that these differences are due to limited and/or impoverished reading experience cannot be ruled out (Robertson et al., 2012).

In sum, the main questions addressed in this study are whether RD children are less sensitive to allomorphy relative to their normal reading peers and whether associations between phonological awareness, phonological short term memory, RAN, and allomorphy are apparent in RD children. Based on the literature we formulated the following hypotheses:

1) RD children are less sensitive to allomorphy and show phonological processing and lexical retrieval deficits.
2) Associations between phonological awareness, phonological short term memory, RAN, and sensitivity to allomorphy are also expected.

In addition we explored whether the error patterns of the RD children were different from that of their normally reading peers.

6.2 Methodology

6.2.1 Participants

In total 27 RD children (9 female), 25 TD children matched on chronological age (CA, 10 female), and 27 TD children matched on reading age (RA, 15 female) participated in the study. The RD and CA children were between the ages of 8;0 and 10;0 and the RA children between the ages of 5;9 and 7;11. All children were native speakers of Dutch and came from monolingual Dutch speaking families. For three children in the CA group birth dates were missing. To compensate for this, the average age in months of the CA group was calculated and used in the analyses.

Almost all the children (24/27) included in the RD group were attending treatment centres that provide specialized intervention for children with developmental dyslexia at the time of testing. Entry requires a diagnosis of dyslexia by an educational psychologist based on the protocol diagnosis and treatment of dyslexia 2.0 (Nationaal Referentiecentrum Dyslexie (NRD), 2013). All children in the RD group were diagnosed with developmental dyslexia following this protocol. In addition, the children needed to have a normal non-verbal IQ (tested with the Raven (Raven, Raven, & Court, 2003)) and absence of hearing loss, neurological impairments, or another diagnosis that could account for their reading impairment. Three children tested at regular primary schools were placed in the RD group having been either in the process of getting diagnosed with developmental dyslexia or having scored 1 standard deviation below the mean on the real and nonce word reading tasks and scoring 15% below the national average on the CITO reading and spelling tests, which are part of the larger CITO battery of standardised tests administered at primary schools in the Netherlands. Finally, to be labelled as a RD child in this study, the children had to score at least one standard deviation below the mean on the real and nonce word reading tasks. Although almost all children had been diagnosed with dyslexia, seven had reading scores in the average or even above the average range. Those children who scored above average on **both** the real and nonce word reading tasks were excluded from our study. If they scored at least 1 SD below average on one task and around average on the other task, they were included in the study.

The 20 remaining children were matched on reading and chronological age with the TD children (see Table 6.1).[2]

The children in the RA group were taken from the larger data set of TD children and matched with the children in the RD group based on their raw scores on the real and nonce word reading tasks. If this was not possible, because none of the TD children had exactly the same scores, the RD child was matched with a younger TD child based on the scores on only the nonce word reading task and, if that was not possible, on the scores of the real word reading task. The children in the CA group were also taken from the larger data set of TD children and matched on chronological age with the RD children. This procedure resulted in three groups of 20 children each, which were then analysed in this study.

The CA and RA children were thus a subgroup of the children tested in Chapters 4 and 5. They were recruited at five primary schools situated in the northern part of the Netherlands and were tested at their schools during school time. None of the children had any reported problems such as hearing, sight, or language difficulties that could affect the outcome of the study and scored within the normal range on the reading tasks and the non-verbal IQ task.

[2] Note that the RD children are not called children with developmental dyslexia as the cut-off of 1 standard deviation is considered somewhat too lenient in an international context.

Table 6.1
Mean age in months and scores on the real and nonce word reading tasks per group

Group	Age		Age range	Real word reading				Nonce word reading			
				Raw		Stand.		Raw		Stand.	
	M	SD		M	SD	M	SD	M	SD	M	SD
RD	111	6.1	91 - 120	33	11.3	5.9	2.2	24	9.2	6.4	1.5
RA	82	5.6	69 - 95	26	9.9	10.3	2.7	24	9.9	10.6	2.6
CA	107	6.1	97 - 123	57**	15.2	10.6	2.3	55**	19.4	11.8	3.1

Note. ** $p < .001$, * $p < .05$ indicate whether the CA and/or RA groups are significantly different from the RD group (i.e., the RD group is taken as the reference level to which the other two groups are compared). N = 20 per group. Age is in months. RD = children with reading difficulties, RA = Reading age match, CA = Chronological age match, Raw = raw scores, Stand. = standardised scores, M = mean, SD = standard deviation

6.2.2 Test material

The children were tested on a battery of five standardised tasks tapping into phonological and lexical skills; the RAVEN testing their nonverbal IQ; a real word and nonce word reading task, and an experimental production and grammaticality judgement task (see Table 2.1). See Chapter 2 for a description of the tasks and test items.

Analysis of the diminutive nonce and real nouns was done excluding the allomorph /-ətjə/ for the production task. In Chapter 3 it became clear that this allomorph is not as productive as initially thought. This was especially the case for the production task in which the adults often used one of the other four allomorphs instead of /-ətjə/, basing their choice on the final consonant of the noun stem. Since performance on the judgement task with /-ətjə/ reached almost ceiling levels in adults, it was decided to retain this allomorph in that task. See Chapter 2 for a further description of the test items.

6.2.3 Procedure

The study was reviewed and approved by the ethics board of the Faculty of Humanities, University of Amsterdam. The RD children were recruited via two treatment centres. Parents were contacted and received an information letter. If the parent and child were prepared to participate in the study, the parent signed the informed consent form attached to the information letter and handed it in at the treatment centre. The TD children were recruited via their primary schools. Schools were approached and asked whether they wanted to participate in the study, after which the parents were then contacted and received an information letter. If the parent and child agreed to participate in the study, the parent signed the informed consent form attached to the information letter and handed it in at the school of their child.

The RD children diagnosed with developmental dyslexia were tested individually at their treatment centre after or before their treatment. The TD children and three RD children were tested at school during school time. Testing took three sessions of approximately 30 minutes. In the first session the children did the production task, in the second the first part of the judgement task, and in the third the second part. In each session, the experimental tasks were always followed by two to three of the standardised tasks, reading tasks, or the Raven. A Sony Vaio and Dell laptop were used for the production, judgement, and NWR tasks. An Olympus digital voice recorder was used to record all the sessions.

Scoring was done by two native speakers of Dutch who were trained linguists. All of the data from the production task of the RD group was scored by two experimenters and interrater reliability scores were calculated. Interrater reliability was high for the data from the RD children (Cronbach's α = .95). The data from the TD children had a high interrater reliability as well

(Cronbach's *a* = .82, see also Chapter 4 and 5). Any discrepancies were solved by discussion until 100% consensus was reached.

6.2.4 Analysis

Generalized linear mixed effects models were used to analyse the data concerning the first hypothesis. These models are a type of regression model that control for participant and/or item variability in one model by taking these as the random effect factors (random intercept). Data were modelled in R (RStudio Team, 2015) using the lme4 package (Bates, Maechler, Bolker, & Walker, 2015). The dependent variable for the production task was whether the child gave a correct (target/expected) or incorrect (non-target/unexpected) response (binary data). In the judgement task the dependent variable was the A' score. An A' score gives an overall accuracy score in terms of accepting the target form of the items (hits) and rejecting the non-target items (false alarm: accepting while rejection is expected) (see Table 6.2) (Linebarger, Schwartz, & Saffran, 1983). The values can be interpreted as an answer to a two-alternative forced choice task. An A' value of .6 can thus be interpreted as a score of 60% correct if a participant had been asked to select which one of two forms was grammatical.

Table 6.2
Formula to calculate A' scores

A' = ½ + (hits – false alarms) * (1 + hits – false alarms) / (4*hits)*(1 – false alarms)

Note. A tendency to reject forms results in an A' score around 0, a tendency to accept in an A' score around .5 and good discrimination between grammatical and ungrammatical items in an A' score around 1 (Rice, Wexler, & Redmond, 1999; Rispens, 2004). Hits = correct judgements of target stem + allomorph combinations. False alarms = incorrect judgements of non-target stem + allomorph combinations.

Separate models were built to see whether performance on the phonological tasks, background tasks, and production and judgement of the diminutive and past tense with real or nonce nouns and verbs was significantly different for the RD group (reference level) compared to the two TD groups, i.e., the independent variable (fixed effect factor in the models) was group with the RD children taken as the reference level (treatment coding). For the production task random intercepts for participant and item were included to account for random by-participant and by-item variation. Random intercept for item could not be included for the judgement task models as composite A' scores were calculated. Random intercept for item and subject could also not be included for the phonological and background tasks as the analysis was done on the mean scores and each subject had one score for every task. In this case, school, grade, and treatment centre were included as random factor. Model comparisons between the models without the random factors and models with the random factors were conducted. For judgement of the nonce diminutive and the real and nonce past tense the model did not significantly improve after including the random intercept item. For production of the nonce past tense including the random factor item did improve the model, but including subject did not further improve the model. However, in order to remain as consistent as possible in the analysis, it was decided to retain the random intercepts in all models.

For our second hypothesis, correlation analyses (Pearson's r) between the accuracy scores on the phonological awareness, phonological short term memory, RAN, and production and judgement tasks were conducted for the data from the RD children. This made it possible to gain a better understanding of the relations between phonological skills, RAN, and sensitivity to allomorphy in the individual RD children. Finally a follow-up

analysis that looked at the non-target answers given by the children was also conducted.

6.3 Results

Table 6.3 shows the raw and standardised scores for the Raven, receptive vocabulary, and phonological processing tasks (scores on the reading tasks are presented in Table 6.1), and Table 6.4 shows the mean scores on the production and grammaticality judgement tasks testing the Dutch diminutive and past tense allomorphs. Significant differences between the RD group and the CA and RA groups are presented in the tables. The mixed linear effects models can be found in the Appendix.

Significant differences between the RD and CA groups were found, as expected, on the real and nonce word reading tasks. The RD group was also worse on the RAN task. No other significant differences were found between these two groups. Significant differences between the RD and RA groups were found in that the RA group performed worse on the Raven (non-verbal IQ), the PPVT (vocabulary), and the NWR task. Surprisingly, no differences were thus found on the three phonological tasks (PA, NWR, and digit span) between the RD group and their CA peers.

No significant differences in performance between the RD group and the two TD groups were found for production of the past tense nor the diminutive. Performance on the judgement task was significantly different between the RA and the RD groups for the real and nonce diminutive. The mean scores (and model summaries) show that the RA group scored significantly worse than the RD group. Performance on judging the past tense showed no significant differences between the RD and the TD groups.

Table 6.3
Mean raw and standardized scores on the tasks testing receptive vocabulary and phonological processing

	Raven (IQ)				PPVT				Phonological awareness			
	RAW		Stand.		RAW		WBQ		RAW		Stand.	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
RD	37.2	4.8	64.1	14.1	112	7.2	102.2	6.4	39.6	4.0	9.3	2.6
RA	25.2**	7.0	57.5	23.6	98	7.0	108.3	10.8	36.7	4.2	11.2	1.9
CA	33.3	6.3	48.0	22.8	109	11.8	102.3	13.7	40.5	2.8	9.7	2.7

Table 6.3 continued

	NWR		DS total				RAN time			
	RAW		RAW		Stand.		RAW		Stand.	
	M	SD	M	SD	M	SD	M	SD	M	SD
RD	0.91	0.04	11.4	1.7	8.6	1.7	113	36.5	6.8	2.7
RA	0.87	0.05	10.8	1.9	11.0	2.2	108	31.2	10.2	2.4
CA	0.90	0.05	11.5	2.4	9.2	2.7	87 *	24.5	9.9	3.5

Note. ** $p < .001$, * $p < .05$ indicate whether the CA and/or RA groups are significantly different from the RD group (i.e., the RD group is taken as the reference level to which the other two groups are compared). Stand. = standardised score, M = mean, SD = standard deviation

Table 6.4
Mean accuracy scores production task and A' scores judgement task

	Production							
	Diminutive real		Diminutive nonce		Past tense real		Past tense nonce	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
RD	0.90	0.11	0.78	0.12	0.85	0.18	0.83	0.17
RA	0.86	0.12	0.78	0.14	0.81	0.25	0.73	0.25
CA	0.88	0.09	0.83	0.09	0.87	0.14	0.80	0.18
	Judgement							
RD	0.87	0.13	0.75	0.15	0.69	0.20	0.63	0.21
RA	0.77*	0.16	0.60**	0.13	0.63	0.12	0.57	0.19
CA	0.90	0.08	0.78	0.09	0.78	0.12	0.76	0.12

Note. ** $p < .001$, * $p < .05$ indicate whether the CA and/or RA groups are significantly different from the RD group (i.e., the RD group is taken as the reference level to which the other two groups are compared).

6.3.1 Correlation analyses RD group

Pearson's correlations were conducted to test for associations between the phonological awareness, phonological short-term memory, RAN, and production and judgement tasks in RD children. Skewness and kurtosis were in the normal range (±2) except for the data from the phonological awareness task (kurtosis of 2.21) and the data from the judgement task with the real diminutive (kurtosis of 2.71).

The results as depicted in Table 6.5 indicate that performance on the phonological awareness, digit span, and NWR tasks and production accuracies for the real and nonce diminutive were significantly correlated. Marginally significant correlations were found between the RAN task and production accuracies of the real and nonce diminutive. Significant correlations were found between judgement accuracies of the real and nonce diminutive and the phonological and RAN tasks. No significant correlations were found between production accuracies of the real and nonce past tense and the phonological and RAN tasks. Only a marginally significant correlation between the digit span task and production accuracies of the nonce past tense was found. There were also no significant correlations between the phonological and RAN tasks and judgement accuracies of the real and nonce past tense. Marginally significant correlations were found between the judgement accuracies of the nonce past tense and the phonological awareness and RAN task.

Table 6.5
Pearson correlations between the phonological awareness, phonological short term memory, RAN, production, and judgement tasks

	Phonological awareness	**RAN**	**Digit span**	**NWR**
Phonological awareness	-			
RAN	-.62**	-		
Digit span	.51*	-.56*	-	
NWR	.55*	-.45*	.56*	-
Production				
Real diminutive	.55*	-.41[A]	.45*	.52*
Nonce diminutive	.41[A]	-.42[A]	.53*	.52*
Real past tense	.08	.23	-.05	-.29
Nonce past tense	.31	-.07	.41[A]	.25
Judgement				
Real diminutive	.63**	-.78**	.48*	.56*
Nonce diminutive	.67**	-.74**	.59*	.34
Real past tense	.54*	-.32	.22	.29
Nonce past tense	.41[A]	-.43[A]	.31	.25

Note. N = 20 (only RD group), * $p < .05$, ** $p < .001$, [A] $p < .08$

6.3.2 Follow-up analysis: Non-target answers

A follow-up analysis for performance on the production task was conducted to investigate whether the three groups were different in their error patterns, i.e., productions of non-target (unexpected/incorrect) allomorphs instead of the target (expected/correct) allomorphs (substitutions). The outcomes of two-tailed chi-square tests showed that there were no significant associations between group and error type for the real and nonce past tense and the real diminutive. Only for the nonce diminutive a significant association between group and error type produced was found, χ^2 (10) = 33.8, $p < .001$. Figure 6.1 gives an indication of the errors for the nonce diminutive, i.e., the probability of substitutions per reading group. A post hoc analysis with Bonferroni correction indicated that the RD group was significantly different in errors

from both the CA (p = .02) and the RA (p > .001) groups. Figure 6.1 shows that the RD children used /-ətjə/ more often and made fewer errors that can be classified as other. In addition, they were more varied in their substitutions than the other two groups.

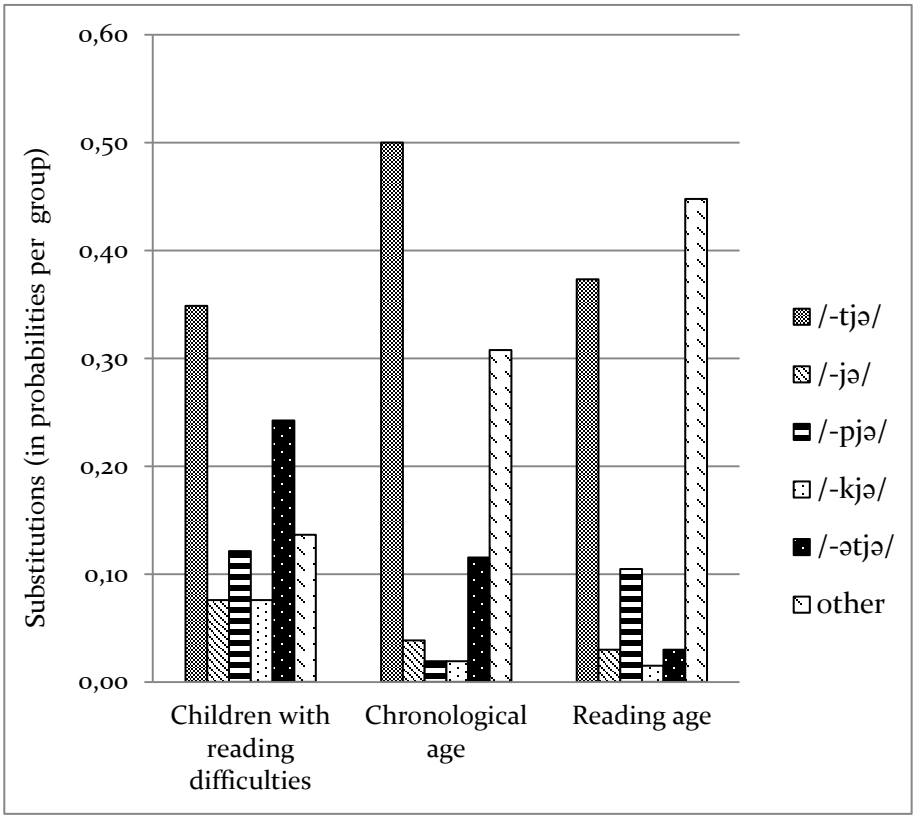

Figure 6.1 Substitutions per group for the nonce diminutive in the production task

A follow-up analysis for the judgement task was conducted on the inappropriately rejected target forms (correct) and accepted non-target forms (incorrect). The outcomes of two-tailed chi-square tests indicated that there

was a significant association between group and accepting non-target forms for the real and nonce past tense and real and nonce diminutive. However, the only interesting condition is the nonce diminutive as here the RD group accepted significantly more non-target forms than the CA group, χ^2 (2) = 62.5, p < .001, post-hoc with Bonferroni correction, p = .05 for RD vs CA. For the other conditions the children in the RA group accepted significantly more non-target forms than the children in the CA and RD groups. The errors (in raw numbers) for the nonce diminutive can be found in Figure 6.2.

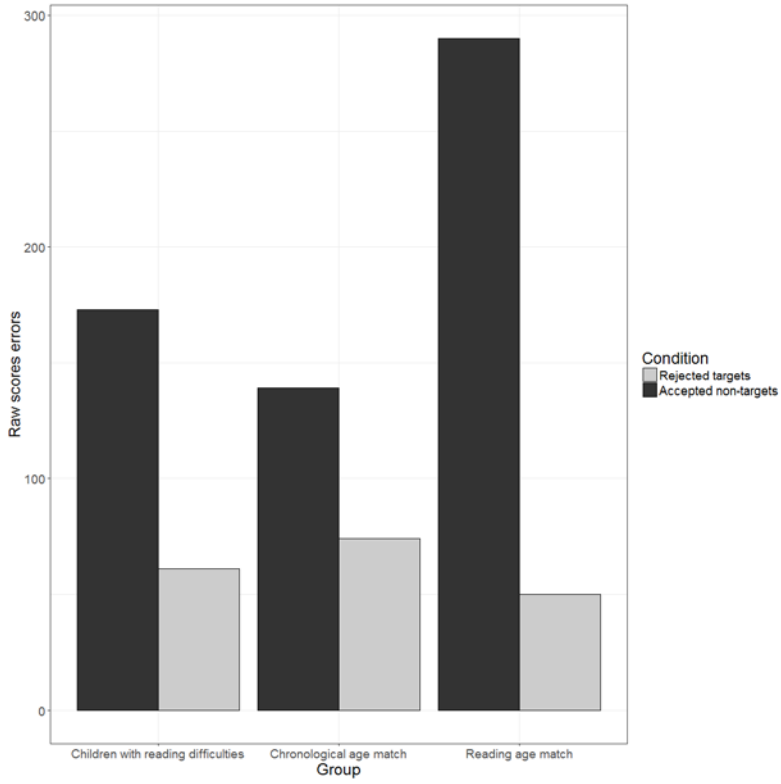

Figure 6.2 Errors per group for the nonce diminutive in the judgement task.
Note. Dark grey = Accepted non-targets, e.g., **vompje* accepted, Light grey = Rejected targets, e.g., *vommetje* rejected. Left is RD children, middle is CA match, and right is RA match

6.4 Discussion and conclusion

The first goal of this study was to investigate whether RD children are less sensitive to allomorphy in their spoken language compared to their normal reading and reading level matched peers. No significant differences between the RD children and their CA peers in producing and judging the Dutch past tense or diminutive were found. The RD children were also found to not have any problems with phonological awareness and phonological short term memory (digit span and NWR). They did, however, show problems in automatized lexical retrieval as tested with the RAN. As discussed earlier, many studies have shown that RD children have problems with phonological processing tasks, such as tasks tapping phonological awareness (Hulme & Snowling, 2009; Melby-Lervag, Halaas Lyster, & Hulme, 2012; Pennington, Cardoso-Martinis, Green, & Lefly, 2001; Robertson et al., 2012; Snowling, 2013). Nevertheless, the literature also shows that these deficits vary in nature as well as severity between children (Melby-Lervag et al., 2012; Snowling, 2008; Snowling, 2013). The group of RD children studied here consisted mainly of children with problems in automatized lexical retrieval and naming speed. In the studies of Robertson et al. (2012) and Joanisse et al. (2000), children with especially poor phonological abilities showed greater problems with inflectional morphology. In the latter study, a group of delay-type dyslexics was identified, which is particularly interesting with regard to the present study. This group had reading skills that closely matched the younger reading age matched children, but did not show any morphological inflection difficulties, and most importantly did not show signs of a specific phonological impairment (in contrast to the language impaired and phonological dyslexics also identified in that study). This group thus appears

to be similar to the RD children tested in the present study who also did not show any clear phonological impairments, except for lexical retrieval difficulties.

A second aim of our study was to establish whether the potential difficulties with allomorphy in poor reading children are associated with weaknesses in a more broad phonological domain. Even though we did not find group effects regarding sensitivity to allomorphy, the correlation analyses underline previous findings regarding the relations between morphophonology and other phonological (processing) skills. The findings demonstrate that these associations also surface in poor reading children and that these encompass a broad phonological domain including RAN. As mentioned already throughout this paper, the group of RD children is a heterogeneous group with regard to the extent that they exhibit impaired use of language. Our group of RD children with 'only' RAN impairments did not demonstrate, as a group, problems in the morphophonological domain. At the individual level, however, it is clear that not only phonological awareness and phonological short term memory are associated with sensitivity to allomorphy, but RAN performance as well, at least in the RD children assessed in this study. RAN is a measure of fluency in that it depends on not only accuracy but also automaticity of multiple cognitive and linguistic processes (Norton & Wolf, 2012). As with reading, RAN depends on the retrieval of phonological codes (Norton & Wolf, 2012). Precisely this automatic retrieval of phonological codes and the necessity of automatizing multiple linguistic and cognitive processes might be why an association between sensitivity to allomorphy and RAN was found.

A follow-up analysis was conducted to see whether the children differed in their error patterns, i.e., substituting the target allomorph for a non-target allomorph in the production task and in accepting non-target and

rejecting target forms in the judgement task. Significant associations between non-target stem+allomorph productions and group were only found for the nonce diminutive, which is arguably the phonologically most complex condition. The RD children were less consistent in their non-target productions and made more use of the allomorph /-ətjə/ compared to the CA and RA groups. Using /-ətjə/ correctly is multifaceted as complex phonological constraints, such as vowel length, e.g., *boom-pje* (tree) vs *bom-etje* (bomb), and stress placement, e.g., *konin-kje* (king) vs *ring-etje* (ring), need to be taken into account that go beyond simple place assimilation (see the description of how to form the Dutch diminutive in Chapter 2). A possible explanation could be that /-ətjə/ is more salient because it has two syllables. Syllabic allomorphs have more phonological content than their segmental counterparts (Mealings et al., 2013). Similarly, in a study conducted with TD children as young as five years old, the youngest children also substituted other allomorphs with /-ətjə/ more often (see Chapter 5). Although it is thus the most complex allomorph to apply correctly, its saliency might make it more noticeable and therefore an easier candidate to use erroneously. However, the opposite has been found in other studies, i.e., that syllabic allomorphs are more difficult than segmental allomorphs (Mealings et al., 2013). Nevertheless, the RD children do seem to use this allomorph as a kind of default when the morphophonological pattern becomes phonologically too complex. The error patterns for the nonce diminutive also indicated that the RD children accepted significantly more non-target forms than their CA peers in the judgement task. Even though the RD children did not show any significant problems in the phonological domain, they exhibited a delay compared to their TD peers when asked to use their phonological skills in a

phonologically-dependent and complex task such as inflecting and judging nonce diminutive forms. Producing and judging the nonce diminutive might be argued to be even more complex than performing the NWR and digit span tasks as it requires the processing of nonce nouns; choosing the correct allomorph out of five possible allomorphs obeying the phonological constraints; and producing or judging the diminutive form. Studies that have investigated sensitivity to phonotactic information, in, for example, the NWR task, support this idea (Griffiths & Snowling, 2001; Rispens, Baker, & Duinmeijer, 2015). In the study by Rispens, Baker, and Duinmeijer (2015), it was found that RD children performed poorly only on multi-syllabic nonce words with low phonotactic probability. It could be argued that this is also why the RD children in this study were different in their errors on the nonce diminutive as here too they had to deal with sometimes novel and complex phonological and phonotactic patterns. The findings of this follow-up analysis also underline the findings of the correlation analyses that show significant correlations between producing and judging the real and nonce diminutives, phonologically complex morphophonological processes, and the tasks testing phonological skills in RD children (see above).

In sum, no significant differences were found between the RD children and their CA and RA matched peers on the tasks testing sensitivity to allomorphy, but also not on the tasks testing phonological awareness and phonological short term memory skills. Empirical evidence for the assumed relationships between phonological processing skills, RAN, and morphophonological skills in RD children was nevertheless found. This indicates that, as has also been found in TD children, phonological processing skills are associated with sensitivity to allomorphy in RD children. The results further suggest that when RD children have only lexical retrieval difficulties, they are not significantly different from their normal reading peers in their

ability to use the appropriate allomorph and in their awareness of the morphophonological patterns.

7
Discussion and conclusion

7.1 Aims and background

The aim of the present dissertation was to examine the development and productivity of allomorphs in adults, typically developing children, and children with reading difficulties. Allomorphs, phonological surface forms of morphemes, follow in many cases from the phonological characteristics and structures of the stems they attach to as an accommodation to the phonological and/or phonotactic constraints of the language (Kerkhoff, 2007; Zamuner, Kerkhoff, & Fikkert, 2012). Results from previous studies have indicated that the production accuracies of such allomorphs are affected by the complexity of these phonological characteristics (Demuth & Tomas, 2016; Mealings, Cox, & Demuth, 2013; Rispens & De Bree, 2014; Robertson, Joanisse, Desroches, & Terry, 2012; Song, Sundara, & Demuth, 2009; Tomas, Demuth, Smith-Lock, & Petocz, 2015; Tomas, Van De Vijver, Demuth, & Petocz, 2017). Phonology is thus an important component of allomorphy. Consequently, it might then also be expected that variabilities in children's phonological processing skills will have an influence on allomorphic development. One of the objectives of this dissertation was to investigate associations between the complexity of the phonological characteristics of stems, children's phonological processing skills, and sensitivity to allomorphy.

Additionally, many previous studies have indicated that frequency effects need to be taken into account when investigating linguistic development (Ambridge, Kidd, Rowland, & Theakston, 2015; Blom, Paradis, & Duncan, 2012; Bybee, 2007; Bybee, 2010; Nicoladis & Paradis, 2012; Paradis, Tulpar, & Arppe, 2016). It has repeatedly been found that children acquire more frequent language structures before less frequent structures across

phonology, morphology, syntax, and semantics (Ambridge et al., 2015; Blom et al., 2012; Bybee & Slobin, 1982; Bybee, 2007; Marchman, 1997; Matthews & Theakston, 2006; Rispens & De Bree, 2014; Tomasello, 2003; Zamuner, Kerkhoff, & Fikkert, 2006). As such, it is expected that the ease with which children acquire morphophonological patterns and allomorphs will vary according to the relative frequencies of these patterns. Frequency effects were therefore also studied; both the influence of phonotactic and type frequency. Related to these effects of frequency, the importance of children's vocabulary size was also investigated.

The purpose of the current dissertation was to expand on previous findings by investigating both item specific characteristics (phonological characteristics of stems and type and phonotactic frequency effects), and children's linguistic skills (phonological processing and vocabulary skills), and their influence on the acquisition of the Dutch diminutive and past tense allomorphs. It was therefore also possible to bring together different factors that potentially influence children's acquisition of allomorphs and to gain a more coherent picture of the protracted acquisition of some allomorphs compared to others. This concluding chapter will first briefly summarize the main findings of the different studies presented in this dissertation. Thereafter the main conclusions and theoretical implications that can be drawn from these findings will be presented followed by an overview of some possible future research directions.

7.2 Main findings

As stated in Chapter 1, the adult study (Chapter 3) was necessary since the properties of the adult system need to be clear. It showed that the diminutive allomorphs /-jə/, /-tjə/, /-pjə/, and /-kjə/ are fully productive in adults, but that the allomorph /-ətjə/ is not. Linguistic productivity reflects the way people creatively reuse stored linguistic patterns to construct novel items. As

such, a notion of productivity provides us with evidence about the generalizations that speakers make (Bybee, 2001; Matthews & Theakston, 2006). However, it is important to bear in mind that these generalizations do not necessarily follow the theoretical linguistic descriptions capturing the underlying patterns. As Booij (1995) and Huber (2005) have stated, not all of the diminutive phenomena need to be productive per se in present day language use. The existing theoretical linguistic descriptions of the Dutch diminutive already indicated that the allomorph /-ətjə/ is different from the other four allomorphs. It is described as phonologically more complex as multiple phonological characteristics of the stem need to be taken into account (see Dahl, 2004). The empirical study showed a discrepancy between what we expected to find based on the theoretical linguistic descriptions and the actual use of /-ətjə/. This allomorph appeared to be far less productive. Adults scored at ceiling on the real items. In contrast, the nonce items that should take /-ətjə/ were scored on significantly lower than the other allomorphs. The differences between real and nonce items suggest that adults have stored the real stem+/-ətjə/ combinations in their lexicon. The morphophonological patterns that govern this allomorph appeared often not to be generalized by the adults and were thus not generalized to nonce nouns. Instead, the adults applied place assimilation with the final phoneme of the noun (for example *vom* – **vompje* rather than *vom* – *vommetje*) and judged both the target (stem+/-ətjə/), but also non-target stem+allomorph combinations based on this place assimilation, as correct. In the following studies testing children's abilities to produce and judge the diminutive allomorphs, we took this finding into account.

Chapter 4 focussed on children's linguistic skills in relation to their production and perception accuracies of allomorphs. Associations between five- to ten-year old children's phonological processing skills, as measured with an NWR, phonological awareness, and digit span task, vocabulary size, measured with the PPVT, and ability to produce and judge stem+allomorph combinations, were investigated. The study in Chapter 3 had shown that /-ətjə/ is less productive than the other allomorphs. Since we wanted to be able to extend our findings to allomorphic forms in general, we decided to exclude this allomorph from the analyses for the production task. In addition, instead of looking at the accuracies of the separate allomorphs (as was done in Chapters 3 and 5), we looked at production and judgement accuracies of the past tense and diminutive allomorphs taken together. Children's phonological processing skills were found to be significantly associated with production and judgement accuracies of the past tense and diminutive. Although vocabulary size was significantly correlated with performance on the production and judgement tasks for both the past tense and diminutive and was significant in some of the suboptimal models, it was only significantly associated in the optimal model predicting production accuracies of the real past tense items. The size of children's (receptive) lexicon appeared to have a smaller effect on children's accuracy scores than their phonological awareness and phonological working memory skills. In sum, the results of this study suggest a relation between phonological processing, the lexicon, and the production and perception of allomorphs in primary school age children. However, the findings also indicated that phonological processing skills are more strongly associated with allomorphic production and judgement accuracies than vocabulary size.

The study presented in Chapter 5 focussed on item specific characteristics in relation to production accuracies of the Dutch diminutive.

This was a study that looked at productivity of the Dutch diminutive in the same children as tested in Chapter 4. The effects of phonological internal characteristics of the stem, and type and phonotactic frequencies of the (stem+) allomorphs were examined. We investigated which stem- and allomorph-specific factors contribute to the protracted acquisition of some allomorphs and their non-target productions. In addition we looked at whether these factors change during development. Although previous studies have indicated that phonological characteristics and frequency of stems, allomorphs, and stem+allomorph combinations are important, the relation between these item specific characteristics and sensitivity to allomorphy is unclear. The Dutch diminutive allomorphs have varying type frequencies and their use is determined by different phonological characteristics of the noun stems. Consequently, investigating the Dutch diminutive made it possible to investigate this relation. As was also found in the adult study, the allomorph that is related to the most complex phonological characteristics of noun stems, /-ətjə/, had the lowest production accuracies. In addition, the allomorph with the lowest type frequency /-kjə/ also caused difficulties for the children. However, /-pjə/ which has a similar low type frequency was produced at ceiling level in all age groups. This is probably because it is phonologically less complex than /-kjə/. The allomorph /-kjə/ follows the velar nasal which is acquired late, comes after stems with multiple syllables, and is affected by stress. The erroneous productions indicated that especially for stems that should receive /-ətjə/, the complexity of the phonological characteristics of the stems appeared to overrule the frequency effects. Similarly to the adults, children produced the allomorphs based on place assimilations with the final phonemes of the stems and even used /-kjə/

although they had problems using this allomorph in an appropriate manner (and substituted it with /-tjə/). The main findings of this study therefore indicated that both the complexity of the phonological characteristics of stems and type frequency of the allomorphs are important in the acquisition of the Dutch diminutive, but that complexity seemed to have a larger influence on diminutive production accuracies than frequency (note that no effect of phonotactic frequency was found). These findings show that although the number of times children encounter an allomorph has an effect, children need to be aware of the phonological characteristics of the stems and, based on this, be able to generalize over multiple items. Overall, the findings underline the findings of Chapter 4 that showed the importance of phonological skills in allomorphic development.

Finally, in Chapter 6, the relations between phonological skills and sensitivity to allomorphy in children with reading difficulties were investigated. Again, both the past tense and diminutive were tested with a production (excluding /-ətjə/) and a grammaticality judgement task. Previous studies have often observed phonological weaknesses in children with reading difficulties. Consequently, we first of all expected to replicate results showing difficulties in a range of phonological skills (awareness, processing, and RAN). Based on the previously discussed evidence on the relation between phonological skills and the sensitivity to allomorphy it was further expected that the children with poor reading skills would perform less well on the production and judgement task relative to the TD children and that these difficulties would be related. The results did not provide evidence for an effect of group with respect to sensitivity to allomorphy. Interestingly, the children with reading difficulties did not differ from the control groups on phonological awareness and phonological processing, but significant associations were found between the phonological tasks and the tasks testing

sensitivity to allomorphy. The group of children with reading impairments had difficulties with automatized lexical retrieval only. The absence of allomorphic difficulties is thus in line with the hypothesis that there is a group of children with reading difficulties who do not display broad language difficulties (Melby-Lervag, Halaas Lyster, & Hulme, 2012; Snowling, 2008; Snowling, 2013). This is also in line with other studies that have shown that only children with especially poor phonological abilities have problems with morphophonology, while children with good phonological skills have none (Griffiths & Snowling, 2001; Joanisse, Manis, Keating, & Seidenberg, 2000; Robertson et al., 2012). Moreover, the results fit with the findings from the study presented in Chapter 4 that showed significant associations between phonological skills and the ability to use and judge the appropriate allomorph. Finally, the children with reading difficulties were more varied in their errors than their chronologically age matched peers for the most taxing condition in terms of phonological processing, the nonce diminutive. This indicated that, even if these children did not have clear phonological processing impairments, novel and complex phonological and phonotactic patterns still caused difficulties in children with reading difficulties. Again, the results from this study are in line with the other findings of this dissertation in that they point towards both phonological skills and phonological characteristics of stems having a substantial influence on the development of allomorphic patterns.

In sum, the results of the studies conducted in this dissertation confirm the association between linguistic skills, item specific characteristics, and allomorphic development in primary school-aged children. More specifically, phonological processing skills and phonological characteristics

seemed to have a large influence since better phonological skills and less complex phonological characteristics were related to higher accuracy scores on the judgement and production task. Frequency effects and vocabulary size appeared also to have an influence, but a weaker one. Clearly, acquiring the allomorphs is impossible without enough input and the more often children encounter a phonological pattern, the more instances there are available from which they can learn, generalize, and then choose the correct allomorph. In addition, as the studies presented in this dissertation focussed on both item specific characteristics and linguistic skills, it is now possible to bring together the factors found to be relevant in the acquisition of allomorphs and gain a more unified understanding of why some allomorphs are acquired before others.

The following section (Section 7.3) will discuss the findings in relation to phonological skills and complexities of the phonological characteristics. Type frequency and vocabulary size effects will be discussed in more detail in Section 7.4. Finally, in Section 7.5 it will be argued that type frequency and vocabulary size have a more indirect influence on the development of allomorphic patterns. Familiarity with the phonological characteristics of the stem that give rise to the allomorphs and enough instances of stem+allomorph combinations in the lexicon are necessary. However, the variation found in the acquisition of allomorphs is proposed to follow mainly from differences in children's phonological processing skills and variations in complexity of the phonological characteristics of the stems.

7.3 Morphophonology implies phonology

In Chapters 4 and 6, children's phonological skills were investigated in relation to their ability to choose and judge correct stem+allomorph combinations. Chapter 4 indicated that children's phonological awareness abilities, i.e., a child's awareness of the phonological structure of words, and

phonological short term memory and processing skills were associated with their ability to choose and judge the correct Dutch past tense and diminutive allomorphs. These findings suggest that variations in the development of allomorphic forms are influenced by children's awareness of the phonological characteristics of the stem, and their ability to process and hold the stem in working memory. Chapter 6 underlines this idea in that the children with reading difficulties did not show any deficits in phonological awareness, phonological processing, or phonological short-term memory and performed at a similar level on the production and judgement diminutive and past tense tasks as their chronologically age matched peers. Yet, in the phonologically most complex condition, i.e., the nonce diminutive, the children with poor reading skills were significantly different from their chronologically age matched peers in their substitutions of the appropriate allomorph. As was discussed in Chapter 6, producing and judging the nonce diminutive can be seen as even more complex than the tasks testing phonological processing skills. Dealing with novel and sometimes complex phonotactic patterns appeared to put a burden on these children's phonological skills and made it difficult for them to generalize over different and new items. These findings fit together well with the findings from Chapter 5 that showed complexity of the phonological characteristics of the stem to be associated with children's ability to produce the correct diminutive allomorph. The most complex phonological characteristics of the noun stems, i.e., the characteristics that give rise to /-ətjə/ but also /-kjə/, were found to be most difficult for the children to deal with appropriately. It can therefore be assumed that the more complex the phonological characteristics of the stems, the better children's phonological skills need to be to acquire and to generalize over the

stem+allomorph combinations. This implies that complex phonological characteristics of stems might lead to later acquisition, but also that phonological skills positively influence the acquisition of allomorphic patterns.

Our results match and underline those observed in earlier studies. As also mentioned in Chapter 5, the results from the study of the Dutch diminutive by Den Os and Harder (1987) are similar to our results. They also found that the oldest children (aged twelve), still had problems with /-kjə/ and /-ətjə/ and that even adults did not always give the appropriate answers for nonce nouns that take /-ətjə/. They cautiously concluded that, as well as frequency effects, different mechanisms based on the phonological characteristics of the stem might play an important role when forming nonce stem+allomorph diminutive forms. The findings from this dissertation indicate that even stronger conclusions can be drawn: phonological characteristics of the stems are indeed important. In a study testing the regular English past tense in school-aged children (3;8–13;5), Marchman (1997) found that item-level phonologically-based factors were related to children's production accuracies. In addition, phonological characteristics of the verb stems were strong predictors of zero-markings, i.e., stems that end in an alveolar and should therefore receive the /-Id/ allomorph are often zero-marked. Many other studies have also concluded that children variably produce inflectional and derivational morphemes in different prosodic or phonological contexts (among others Demuth & Tomas, 2016; Jarmulowicz, 2006; Jarmulowicz & Hay, 2009; Mealings et al., 2013; Song et al., 2009; Tomas et al., 2015; Tomas, Demuth, & Petocz, 2017; see also previous chapters). Song et al. (2009) posited that some of the variability in morpheme production is thus due to limitations in children's phonological representation or phonological competence. Indeed this was found in Chapter 4. Related,

previous studies, as was also discussed in Chapter 6, have shown phonological processing difficulties to be associated with children's morphological difficulties (although other studies see the two as independent difficulties) (Cantiani, Lorusso, Guasti, Sabisch, & Männel, 2013; Joanisse et al., 2000; Rispens, Roeleven, & Koster, 2004; Robertson et al., 2012; Scarborough, 1990; Shankweiler et al., 1995). The findings in this dissertation underline the earlier studies in showing that both child internal phonological skills, and item specific phonological characteristics influence children's acquisition of allomorphic forms.

7.4 What about frequency?

Prior studies have noted the importance of taking into account effects of frequency and input when investigating linguistic development (Ambridge et al., 2015; Bybee, 1985; Bybee, 2001; Tomasello, 2003). Frequent forms appear to be acquired before less frequent forms (Bybee, 1985; Bybee, 2010). Earlier studies also found that vocabulary size is a strong predictor of achievements in morphology. These studies show that morphological development is predicted by lexical level, that is once the items in a child's vocabulary reach a 'critical mass' (Kerkhoff, 2007; Marchman & Bates, 1994). An increase in vocabulary knowledge triggers re-organization of the mental lexicon in such a way that abstraction of general patterns and productive usage can occur (Blom & Paradis, 2013; Bybee, 2001; Kerkhoff, 2007; Kidd & Kirjavainen, 2011; Marchman & Bates, 1994; Marchman, Saccuman, & Wulfeck, 2004). Children's generalizations are initially item-based, but gradually, based on this 'critical mass' of lexical items, become more and more abstract (Bybee, 2001; Kerkhoff, 2007; Tomasello & Slobin, 2005). Marchman and Bates (1994) found that in

very young children (2;0), the size of the vocabulary mediated different aspects of morphosyntactic acquisition at different points in development. Effects of frequency and size of the lexicon have also been found in four- to ten-year old children with English as their second language. These children were found to be more accurate with 3rd person singular *–s* when they had a larger lexicon and when they inflected verbs with a high frequency of the inflected form (Blom et al., 2012). Kidd and Kirjavanen (2011) observed a significant relationship between lexical and morphological knowledge in four- to seven-year old Finnish children, but also pointed out that the precise nature of the interaction between the lexicon and morphological development is unclear. In her dissertation, Kerkhoff (2007) found that typically developing Dutch children aged three, five, and seven years rely on lexical information when forming the Dutch plural. The Dutch plural is based on an alternation pattern for nouns that end in a voiced phoneme due to final devoicing in Dutch. The results from her study seemed to indicate that due to its low type frequency and high token frequency, children's attention is not drawn to the morphophonological alternation, and that children are likely to store the plural forms individually in their lexicon.

The studies discussed above seem to indicate that familiarity with morpho(phono)logical patterns is necessary to be able to detect regularities. The more frequent a pattern, the more familiar the child will be with that pattern, and the larger the child's lexicon, the more instances of a pattern the child will have encountered. The findings from Chapters 4 and 5 support this notion but with some qualifications. In Chapter 4 correlations between children's vocabulary size and their production and judgement accuracies were found for both the past tense and diminutive. However, although the scores on the tasks testing phonological skills were significant predictors in all optimal models, only in the optimal model predicting production accuracies

with the real past tense was accuracy on the PPVT task a significant predictor. These results suggest that children's phonological processing skills were more influential than the size of their (receptive) lexicon. In Chapter 5 it was hypothesized that both /-kjə/ and /-pjə/ would have lower accuracy scores due to their low type frequencies. However, the children scored at ceiling when they had to inflect real and nonce nouns with /-pjə/. It was argued that this was probably related to the more complex phonological characteristics of the noun stems that give rise to /-kjə/. As such, /-kjə/ does not only have a low type frequency, but also follows from a phonologically more complex stem than /-pjə/, which seems to have caused it's low production accuracies.

In general, the results from the studies presented in this dissertation indicate that a theory which is based on frequency and input effects alone is not sufficient to explain the variability in the development of allomorphic patterns. The few earlier studies that have looked at both effects of frequency and complexity of the phonological characteristics of the stem, again, seem to be in agreement with this. Oetting and Horohov (1997) found that phonological features of the lexicon exerted a greater influence on English past tense inflectional use than frequency in six-year old typically developing children and children with SLI. Productivity of the regular past tense was affected by the phonological composition of the items as both groups inflected verbs ending in vowels and liquids more often than other verbs. In their view the frequency characteristics of the items influenced early morphological use, but this was mainly related to the lexical limitations of the children. They found a high correlation between stems and inflected forms and argued that there was a strong possibility that the frequency effects they found were linked to the ability of the children to access the relevant stems. In

a different study, Baer-Henney and Van De Vijver (2012) examined the acquisition of morphophonological alternations in an artificial language paradigm in adults. They found that amount of exposure played a role if and only if the alternation facilitated perception and production, was grounded in phonetics, and when there was a local phonological dependency between the stem and the alternation. Although learners were thus more successful the more they were exposed to a pattern, this was only the case if that pattern conformed to phonotactic and phonological restrictions. These studies thus show that, as also mentioned above, frequency effects as such are not enough to fully explain the acquisition and productivity of linguistic patterns as in, for example, allomorphs.

Thus, in order to learn morphophonological patterns, or in the case of this dissertation allomorphic patterns, children need to encounter and make themselves familiar with the different phonological forms and phonological characteristics of the morphological inflections and derivations. The larger their lexicon, the more items they can generalize over, and the higher the frequencies of the items and/or inflections/derivations, the more exemplars. Put differently, the smaller the input, the fewer opportunities for the child to phonologically analyse the stem and/or morpheme. This also means that phonologically more complex morphophonological phenomena take longer to acquire as more experience with the input is needed to make correct generalizations (Paradis, 2010), i.e., an infrequent and phonologically complex pattern will take even longer to acquire. The general idea is then that the less frequent forms provide fewer opportunities to learn what the stem looks like phonologically and which phonological characteristics need to be taken into account. A critical amount of input is thus needed to be able to abstract the patterns: the more instances, the more exemplars in the lexicon, the more opportunities to abstract the phonological patterns. Importantly, what the

findings of this dissertation also show is that effects of input, item specific characteristics, and children's linguistic skills should not be looked at separately. By combining the different findings and relating the factors implied in children's acquisition of allomorphs, a more general idea of how this acquisition looks like can be constructed. The following section will discuss this in more depth.

7.5 A proposal for the mechanisms implied in the acquisition of allomorphs

The results of this dissertation in combination with findings from earlier studies support the idea that it is essential to take into account the phonological complexities of the stems and the demands on the phonological abilities of children when dealing with morphophonological patterns as these will have an effect on children's ability to generalize over and cluster these patterns (see for example Abbot-Smith & Tomasello, 2006; Baer-Henney & Van De Vijver, 2012; Matthews & Theakston, 2006). Type frequencies of the allomorphs and the size of the children's lexicon are also related to the development of allomorphic forms, but the findings from this dissertation indicate that this is only in the sense that enough input is necessary to have enough instances to abstract from and generalize over.

Taken together, the findings of this dissertation therefore suggest that what is available in the language, as measured by analysing type frequency effects, and what is known to the child, vocabulary size, have an effect on the child's experience with stem+allomorph combinations, the phonological characteristics of the stems, and the allomorphs these characteristics give rise to. The complexity of the characteristics and the child's ability to deal with the

morphophonological patterns, i.e., their phonological processing skills, are more directly related to the child's awareness of and sensitivity to the different allomorphs. As such, the child's phonological processing skills and the complexity of the phonological characteristics of the stems have a direct influence on the extent that a child is aware of and is able to generalize over the morphophonological patterns. These factors are thus directly linked to children's ability to learn allomorphic patterns and the variable production and judgement accuracies of allomorphs. A final note that should be kept in mind is that this explains the acquisition of allomorphs when these depend on the phonological composition of the stem. As mentioned earlier, for some phenomena in some languages, such as the plural in German, this is not the case: allomorphs are then lexically specified. In such cases, the acquisition of allomorphs is expected to be more dependent on effects of frequency and children's vocabulary size.

7.6 Future directions and concluding remarks

One of the goals of this dissertation was to assess not only production, but also perception abilities to investigate whether children are able to detect inappropriate occurrences of allomorphs. It has long been recognised that children's comprehension abilities precede their productive knowledge, but many previous studies on the development of morphophonological phenomena have focussed on production accuracies only (Buckler, 2014; Buckler & Fikkert, 2016; Swingley & Aslin, 2000; Zamuner et al., 2006). In the study presented in Chapter 4, the data from both the wug-type production task and the grammaticality judgement task were presented. It was expected that in general the children would perform better on the judgement than on the production task. Additionally, it was predicted that the younger children would perform worse than the older children but this would mostly be apparent in the production task and, to a lesser extent, in comprehension.

However, the children did not perform better on the judgement task. As expected, the younger children performed significantly worse than the older children on the production task, but also on the judgement task. It seemed that the judgement task was metalinguistically too complex and did therefore not reflect children's actual perceptual knowledge. Although these results do not necessarily change the general conclusions of this dissertation, a perception task that tests children's comprehension skills without the confounding effect of metalinguistic knowledge is needed. A combination of behavioural and online tasks might be valuable to understand children's comprehension skills better. For example an eye-tracking experiment with a visual world paradigm in which children have to choose the correct picture after hearing a correct or incorrect stem+allomorph combination might be metalinguistically less demanding and yield more insightful results than the grammaticality judgement task used in this dissertation.

Electrophysiological experiments in combination with a version of the grammaticality judgement task might clarify the relation between children's phonological and morpho(phono)logical skills further in both typically developing children and children with reading impairments. This dissertation and earlier studies have found acquisition differences between the different allomorphs. As such, variations in ERP components might be expected between those allomorphs that are produced correctly and those that elicit errors. Furthermore, variations between ERP components might also be expected between children with better versus worse phonological processing skills. It would be interesting, not only in children but also in adults, to investigate the time course and amplitude of a phonological component (for example the PMN) and the morphological component (for example LAN

and/or P600) in reaction to allomorph violations. Especially the phonological component would be expected, based on the current findings, to deviate for allomorphs that are produced and judged incorrectly and for children with worse phonological processing skills. Based on the findings from Chapter 6, it might then also be expected that, although the children with reading difficulties did not show any phonological processing impairments, they might show a deviating phonological ERP component when presented with an incorrect allomorph. The expectation would be that this could be particularly the case with the allomorphs based on the phonologically most complex stem characteristics.

Finally, the studies in this dissertation looked at development using a cross-sectional design. Further longitudinal research is needed to establish the relative effects of phonological skills and characteristics of stems and frequency across development in the same child. A good understanding of whether and how frequency effects change over the course of development as a consequence of children's increasing linguistics knowledge is still lacking (Ambridge et al., 2015). Exposure will most probably have a larger effect on young children as they still have more to learn and have had less experience altogether than in older children. It could be argued that, at a certain age, frequency effects and size of the lexicon become less important or have reached a substantial size and that different language skills, in the case of this dissertation phonological skills, become more important. It could be that younger children rely more on frequency effects and the size of their lexicon to acquire the different allomorphs. When, at around primary school age some allomorphs have not yet been fully acquired, this might be caused by the complexity of the phonological characteristics of the stems that give rise to these allomorphs. Children might then rely more on their phonological processing skills. The results of the present dissertation seem to be in

agreement with this hypothesis. However, further research needs to be done to assess frequency effects across development in a longitudinal manner. Younger children need to be tested and longitudinal data will make it possible to assess frequency and phonology effects within children across different ages.

To conclude, the evidence from this dissertation suggests that both children's linguistic skills, i.e., phonological processing and (receptive) vocabulary skills, and item specific characteristics, complexity of the phonological characteristics of the stem and type frequency of the allomorphs, are associated with children's ability to produce and judge stem+allomorph combinations. Type frequency and vocabulary size play a role in the sense that children need input to be able to abstract the morphophonological patterns that are based on the phonological characteristics of the stems. However, children will have to be able to deal with these phonological characteristics before they can actually be aware of the different morphophonological patterns and choose the correct allomorph. The better the phonological skills of the children, the better they will be able to understand these characteristics and be able to generalize over the morphophonological patterns. The more complex the phonological characteristics, the harder it is for the children to generalize over these patterns. What these results thus show is that frequency and vocabulary size are indirectly related to children's acquisition of allomorphs, while their phonological processing skills and the complexity of the phonological stem characteristics appear to be the more direct causes of children's protracted acquisition of some allomorphs compared to others.

Bibliography

Aalberse, S. (2009). Inflectional economy and politeness: Morphology-internal and morphology-external factors in the loss of second person marking in Dutch (PhD). Universiteit van Amsterdam, Amsterdam. Available from LOT publications. (LOT Number: 208).

Abbot-Smith, K., & Tomasello, M. (2006). Exemplar-learning and schematization in an usage-based account of syntactic acquisition. *The Linguistic Review*, 23, 275-290.

Adriaans, F. (2006). PhonotacTools (Test version ed.). Utrecht, The Netherlands: Utrecht Institute of Linguistics OTS.

Ambridge, B., Kidd, E., Rowland, C. F., & Theakston, A. L. (2015). The ubiquity of frequency effects in first language acquisition. *Journal of Child Language*, 42(02), 239-273.

Aravena, S. (2017). Letter-speech sound learning in children with dyslexia (PhD). Universiteit van Amsterdam, Amsterdam.

Archibald, L. M., Joanisse, M. F., & Shepherd, M. (2008). Associations between key language-related measures in typically developing school-age children. *Zeitschrift Für Psychologie/Journal of Psychology*, 216(3), 161-171.

Astheimer, L., Janus, M., Moreno, S., & Bialystok, E. (2014). Electrophysiological measures of attention during speech perception predict metalinguistic skills in children. *Developmental Cognitive Neuroscience*, 7, 1-12.

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

Baer-Henney, D., & Van De Vijver, R. (2012). On the role of substance, locality and amount of exposure in the acquisition of morphophonemic alternations. *Laboratory Phonology*, 3(2), 221-249.

Bakema, P., Defour, P., & Geeraerts, D. (1993). De semantische structuur van het diminutief (The semantic structure of the diminutive). *Forum Der Letteren*, , 121-137.

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67(1), 1-48.

Berko, J. (1958). The child's learning of English morphology. *Word*, 14, 150-177.

Blom, E. (2003). From root infinitive to finite sentence: The acquisition of verbal inflections and auxiliaries (PhD). Universiteit Utrecht, Utrecht. Available from LOT Publications. (LOT Number: 70).

Blom, E., & Paradis, J. (2013). Past tense by English second language learners with and without language impairment. *Journal of Speech, Language and Hearing Sciences*, 56, 281-294.

Blom, E., Paradis, J., & Duncan, T. S. (2012). Effects of input properties, vocabulary size, and L1 on the development of third person singular -s in child L2 English. *Language Learning*, 62(3), 965-994.

Boersma, T., Baker, A., Rispens, J., & Weerman, F. (submitted). The Dutch diminutive allomorph /-ətjə/: Description versus productivity. *Dutch Journal of Applied Linguistics*

Boersma, T., Baker, A., Rispens, J., & Weerman, F. (2017). The effects of phonological skills and vocabulary on morphophonological processing. *First Language*, 1-28. doi: 10.1177/0142723717725430

Boersma, T., Rispens, J., Weerman, F., & Baker, A. (submitted). Acquiring diminutive allomorphs: Taking item specific characteristics into account. *Journal of Child Language*

Boersma, T., Rispens, J., Baker, A., & Weerman, F. (submitted). Allomorphy in children with reading difficulties: Associations between morphophonology, phonology, and rapid automatized naming. *Journal of psycholinguistic research*

Booij, G. (1995). The phonology of Dutch. Oxford: Oxford University Press.

Bowers, P. G., & Wolf, M. (1993). Theoretical links among naming speed, precise timing mechanisms and orthographic skills in dyslexia. *Reading and Writing: An Interdisciplinary Journal*, 5, 69-85.

Brus, B. T., & Voeten, M. J. M. (1979). EMT (one minute real word reading test). Amsterdam: Pearson.

Buckler, H. (2014). The acquisition of morphophonological alternations across languages (PhD). Radboud Universiteit, Nijmegen

Buckler, H., & Fikkert, P. (2016). Using distributional statistics to acquire morphophonological alternations: Evidence from production and perception. *Frontiers in Psychology*, 7(540), 1-16.

Bybee, J. L. (1985). Morphology: A study of the relation between meaning and form. Amsterdam/Philadelphia: John Benjamins Publishing Company.

Bybee, J. L. (2001). Phonology and language use. Cambridge: Cambridge University Press.

Bybee, J. L. (2007). Frequency of use and the organization of language. New York: Oxford University Press.

Bybee, J. L. (2010). Language usage and cognition (1st ed.). Cambridge, UK: Cambridge University Press.

Bybee, J. L., & Slobin, D. I. (1982). Rules and schemas in the development and use of the English past tense. *Language*, 58(2), 265-289.

Cantiani, C., Lorusso, M. L., Guasti, M. T., Sabisch, B., & Männel, C. (2013). Characterizing the morphosyntactic processing deficit and its relationship to phonology in developmental dyslexia. *Neuropsychologia*, 51, 1595-1607.

Chiat, S. (2001). Mapping theories of developmental language impairment: Premises, predictions and evidence. *Language and Cognitive Processes*, 16(2-3), 113-142.

Cohen, A. (1958). Het Nederlandse dimunutiefsuffix; een morfonologische proeve (The Dutch diminutive suffix; a morphophonological model). *De Nieuwe Taalgids*, 51, 40-45.

Dahl, Ö. (2004). The growth and maintenance of linguistic complexity. Philadelphia, USA: John Benjamins BV.

Damhuis, R. (1992). Woordenlijst voor 4- tot 6-jarigen. Een streeflijst voor kleuters. Rotterdam: Projectbureau OVB.

De Bree, E., & Kerkhoff, A. (2010). Bempen or bemben: Differences between children at-risk of dyslexia and children with SLI on a morpho-phonological task. *Scientific Studies of Reading*, 14(1), 85-109.

De Bree, E., Van Der Ven, S., & Van Der Maas, H. (2017). The voice of Holland: Allograph production in written Dutch past tense inflection. *Language Learning and Development*, 13 (3), 215-240.

De Haas, Wim, & Trommelen, Mieke (1993). Morfologisch handboek van het Nederlands: Een overzicht van de woordvorming (Morphological manual of Dutch: A summary of word formation), Den Haag: SDU Uitgeverij.

Deacon, H. S., & Kirby, J. R. (2004). Morphological awareness: Just "more phonological"? The roles of morphological and phonological awareness in reading development. *Applied Psycholinguistics*, 25, 223-238.

Demuth, K., & Tomas, E. (2016). Understanding the contributions of prosodic phonology to morphological development: Implications for children with specific language impairment. *First Language*, 36(3), 265-278.

Den Os, E., & Harder, R. (1987). De verwerving van de regels voor meervouds- en verkleinwoordsvorming in het Nederlands (The acquisition of plural and diminutive rules in Dutch). *De Nieuwe Taalgids*, 80, 240-250.

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

Ernestus, M., & Baayen, H. (2006). The functionality of incomplete neutralization in Dutch: The case of past-tense formation. In L. Goldstein, D. Whalen & C. Best (Eds.), *Laboratory phonology* (8th ed., pp. 27-49). Berlin: Mouton de Gruyter.

Ewen, C. J. (1978). The phonology of the diminutive in Dutch. *Lingua*, 45, 141-173.

Fikkert, P., & Freitas, M. J. (2006). Allophony and allomorphy cue phonological acquisition: Evidence from the European Portugese vowel system. *Catalan Journal of Linguistics*, 5, 83-108.

Fowler, A. E., & Liberman, A. M. (1995). Morphological awareness as related to early reading and spelling ability. In L. B. Feldman (Ed.), Morphological aspects of language processing (pp. 157-188). Hillsdal, N.J: Erlbaum.

Gallagher, A., Frith, U., & Snowling, M. J. (2000). Precursors of literacy delay among children at genetic risk of dyslexia. *Journal of Child Psychology and Psychiatry*, 41(2), 203-213.

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

Gathercole, S. E., Willis, C. S., Baddeley, A., & Emslie, H. (1994). The children's test of nonword repetition: A test of phonological working memory. *Memory*, 2(2), 103-127.

Griffiths, Y. M., & Snowling, M. J. (2001). Auditory word identification and phonological skills in dyslexic and average readers. *Applied Psycholinguistics*, 22, 419-439.

Haverkamp-Lubers, R., & Kooij, J. (1971). Het verkleinwoord in het Nederlands (The diminutive in Dutch). Universiteit van Amsterdam: Publikaties van het instituut voor Algemene Taalwetenschap.

Huber, D. (2005). Some notes about the Dutch diminutive suffix. In N. Kula, & J. Van De Weijer (Eds.), Papers in government phonology. *Special issue of Leiden papers in linguistics* (pp. 23-49)

Hulme, C., & Snowling, M. J. (2009). Developmental disorders of language learning and cognition. West Sussex: Wiley-Blackwell Publishing.

Jarmulowicz, L. (2006). School-aged children's phonological production of derived English words. *Journal of Speech, Language and Hearing Research*, 49, 294-308.

Jarmulowicz, L., & Hay, S. E. (2009). Derivational morphophonology: Exploring errors in third graders' production. *Language, Speech, and Hearing Services in Schools*, 40, 299-311.

Jarmulowicz, L., Hay, S. E., Taran, V. L., & Ethington, C. A. (2008). Fitting derivational morphophonology into a developmental model of reading. *Reading Writing*, 21, 275-297.

Joanisse, M. F., Manis, F. R., Keating, P., & Seidenberg, M. S. (2000). Language deficits in dyslexic children: Speech perception, phonology and morphology. *Journal of Experimental Child Psychology*, 77, 30-60.

Jolly, H. R., & Plunkett, K. (2008). Inflectional bootstrapping in 2-year-olds. *Language and Speech*, 51(1&2), 45-59.

Kerkhoff, A. (2007). Acquisition of morpho-phonology: The Dutch voicing alternation (PhD). Universiteit Utrecht, Utrecht. Available from LOT Publications. (LOT Number: 164).

Kerkhoff, A., & De Bree, E. (2004). Acquisition of morpho-phonology in children with specific language impairment and typically developing children. In A. Kerkhoff, J. De Lange & O. S. Leicht (Eds.), Utrecht institute of linguistics OTS, year book 2004 (pp. 37-52)

Kernan, K. T., & Blount, B. G. (1966). The acquisition of Spanish grammar by Mexican children. *Anthropological Linguistics*, 8(9), 1-14.

Keuleers, E., & Brysbaert, M. (2010). Wuggy: A multilingual pseudoword generator. *Behavior Research Methods*, 42(3), 627-633.

Keuleers, E., Brysbaert, M., & New, B. (2010). SUBTLEX-NL: A new frequency measure for Dutch words based on film subtitles. *Behavior Research Methods*, 42(3), 643-650.

Kidd, E., & Kirjavainen, M. (2011). Investigating the contribution of procedural and declarative memory to the acquisition of past tense morphology: Evidence from Finnish. *Language and Cognitive Processes*, 26(4/5/6), 794-829.

Law, J. L., Wouters, J., & Ghesquière, P. (2015). Morphological awareness and its role in compensation in adults with dyslexia. *Dyslexia*, 21(3), 254-272.

Leikin, M., & Hagit, E. Z. (2006). Morphological processing in adult dyslexia. *Journal of Psycholinguistic Research*, 35, 471-490.

Linebarger, M. C., Schwartz, M. F., & Saffran, E. M. (1983). Sensitivity to grammatical structure in so-called agrammatic aphasics. *Cognition*, 13, 361-392.

Marchman, V. A. (1997). Children's productivity in the English past tense: The role of frequency, phonology and neighbourhood structure. *Cognitive Science*, 21(3), 283-304.

Marchman, V. A., & Bates, E. (1994). Continuity in lexical and morphological development: A test of the critical mass hypothesis. *Journal of Child Language*, 21, 339-366.

Marchman, V. A., Saccuman, C., & Wulfeck, B. (2004). Productive use of the English past tense in children with focal brain injury and specific language impairment. *Brain & Language*, 88, 202-214.

Marchman, V. A., Wulfeck, B., & Weismer, S. E. (1999). Morphological productivity in children with normal language and SLI: A study of the English past tense. *Journal of Speech, Language and Hearing Research*, 42, 206-219.

Marshall, C. R., & Van Der Lely, Heather K. J. (2006). A challenge to current models of past tense inflection: The impact of phonotactics. *Cognition*, 100, 302-320.

Marshall, C. R., Ramus, F., & Van Der Lely, H. K. J. (2010). Do children with dyslexia and/or specific language impairment compensate for place assimilation? Insights into phonological grammar and representations. *Cognitive Neuropsychology*, 27(7), 563-586.

Marynissen, A. (1998). Van (t)ke naar (t)je: De oorsprong en verspreiding van het Nederlandse diminutiefsuffix (t)je (From (t)ke to (t)je: The origin and spreading of the Dutch diminutive suffix (t)je). *Tijdschrift Voor Nederlandse Taal- En Letterkunde*, 114, 252-268.

Matthews, D. E., & Theakston, A. L. (2006). Errors of omission in English-speaking children's production of plurals and the past tense: The effects of frequency, phonology and competition. *Cognitive Science*, 30, 1027-1052.

Mealings, K. T., Cox, F., & Demuth, K. (2013). Acoustic investigations into the later acquisition of syllabic -es plurals. *Journal of Speech, Language and Hearing Research*, 56, 1260-1271.

Melby-Lervag, M., Halaas Lyster, S., & Hulme, C. (2012). Phonological skills and their role in learning to read: A meta-analytical review. *Psychological Bulletin*, 138(2), 322-352.

Mennen, I., Levelt, C., & Gerrits, E. (2006). Acquisition of Dutch phonology: An overview. In J. M. Scobbie, I. Mennen & J. Watson (Eds.), QMUC speech science research centre working Paper WP10 (pp. 1-15)

Nakagawa, S., & Schielzeth, H. (2013). A general and simple method for obtaining R^2 from generalized linear mixed-effects models. *Methods in Ecology and Evolution*, 4, 133-142.

Nicoladis, E., & Paradis, J. (2012). Acquiring regular and irregular past tense morpehemes in English and French: Evidence from bilingual children. *Language Learning*, 62(1), 170-197.

Norton, E. S., & Wolf, M. (2012). Rapid automatized naming (RAN) and reading fluency: Implications for understanding and treatment of reading disabilities. *Annual Review of Psychology*, 63, 427-452.

Oetting, J. B., & Horohov, J. E. (1997). Past-tense marking by children with and without specific language impairment. *Journal of Speech, Language and Hearing Research*, 40, 62-74.

Oostdijk, N. (2000). The spoken Dutch corpus. Outline and first evaluation. In M. Gravilidou, G. Caravannis, S. Markantonatou, S. Piperidis & G. Stainhaouer (Eds.), Proceedings of the second international conference on language resources and evaluation (LREC) (pp. 887-894)

Paradis, J. (2010). Bilingual children's acquisition of English verb morphology: Effects of language exposure, structure complexity, and task type. *Language Learning*, 60(3), 651-680.

Paradis, J., Tremblay, A., & Crago, M. (2014). French-English bilingual children's sensitivity to child-level and language-level input factors in morphosyntactic acquisition. In T. Grüter, & J. Paradis (Eds.), Input and experience in bilingual development (first ed., pp. 161-180) John Benjamins B.V.

Paradis, J., Tulpar, Y., & Arppe, A. (2016). Chinese L1 children's English L2 verb morphology over time: Individual variation in long-term outcomes. *Journal of Child Language*, 43, 553-580.

Peelaerts, C. (2008). Van kleine boot tot scheepje: Experimenteel onderzoek naar de diminutiefvorming bij Vlaamse kinderen (from "kleine boot tot scheepje": Experimental research on diminutive production in Flemish children). Unpublished manuscript.

Pennington, B. F., Cardoso-Martinis, C., Green, P. A., & Lefly, D. L. (2001). Comparing the phonological and double deficit hypothesis for developmental dyslexia. *Reading and Writing: An Interdisciplinary Journal*, 14, 707-755.

Peterson, R. L., & Pennington, B. F. (2012). Developmental dyslexia. *The Lancet*, 379, 1997-2007.

Peterson, R. L., & Pennington, B. F. (2015). Developmental dyslexia. *Annual Review of Clinical Psycholinguistics*, 11, 283-307.

Pierrehumbert, J. B. (2003). Phonetic diversity, statistical learning and acquisition of phonology. *Language and Speech*, 46(2-3), 115-154.

Protocol dyslexie diagnostiek en behandeling 2.0, ProtocolU.S.C. (2013).

Ramus, F., Marshall, C. R., Rosen, S., & Van Der Lely, H. K. J. (2013). Phonological deficits in specific language impairment and developmental dyslexia: Towards a mulidimensional model. *Brain*, 136, 630-645.

Raven, J., Raven, J. C., & Court, J. H. (2003). Manual for Raven's progressive matrices and vocabulary scales. San Antonia: Harcourt Assessment.

Rice, M. L., Wexler, K., & Redmond, S. M. (1999). Grammaticality judgements of an extended optional infinitive grammar: Evidence from English-speaking children with specific language impairment. *Journal of Speech, Language and Hearing Research*, 42, 943-961.

Rispens, J. (2004). Syntactic and phonological processing in developmental dyslexia (PhD). Rijksuniversiteit van Groningen, Groningen (Groningen Dissertations in Linguistics 48).

Rispens, J. E., & Baker, A. (2012). Nonword repetition: The relative contributions of phonological short-term memory and phonological representations in children with language and reading impairment. *Journal of Speech, Language and Hearing Research*, 55, 683-694.

Rispens, J. E., & De Bree, E. H. (2014). Past tense productivity in Dutch children with and without SLI: The role of morphophonology and frequency. *Journal of Child Language*, 41(1), 200-225.

Rispens, J. E., Baker, A., & Duinmeijer, I. (2015). Word recognition and nonword repetition in children with language disorders: The effects of neighborhood density, lexical frequency and phonotactic probability. *Journal of Speech, Language and Hearing Research*, 58, 78-92.

Rispens, J. E., Been, P. H., & Zwarts, F. (2006). Brain responses to subject-verb agreement violations in spoken language in developmental dyslexia: An ERP study. *Dyslexia*, 12, 134-149.

Rispens, J. E., Roeleven, S., & Koster, C. (2004). Sensitivity to subject-verb agreement in spoken language in children with developmental dyslexia. *Journal of Neurolinguistics*, 17, 333-347.

Robertson, E. K., Joanisse, M. F., Desroches, A. S., & Terry, A. (2012). Past-tense morphology and phonological deficits in children with dyslexia and children with language impairment. *Journal of Learning Disabilities*, 20(10), 1-11.

Royle, P., & Stine, I. (2013). The French noun phrase in preschool children with SLI: Morphosyntactic error analyses. *Journal of Child Language*, 40, 945-970.

RStudio Team. (2015). RStudio: Integrated development for R. RStudio. Boston, MA: RStudio, Inc. doi:http://www.rstudio.com/

Scarborough, H. S. (1990). Very early language deficits in dyslexic children. *Child Development*, 61(6), 1728-1743.

Schlichting, L. (2005). Peabody picture vocabulary test-III-NL. Amsterdam: Harcourt test Publishers.

Semel, E., Wiig, E. H., & Secord, W. A. (2010). Clinical evaluation of language fundamentals, Dutch version (W. Kort, E. Compaan, M. Schittekatte & P. Dekker Trans.). (3rd ed.). Amsterdam: Pearson Assessment and Information B.V.

Shankweiler, D., Crain, S., Katz, L., Fowler, A. E., Liberman, A. M., Brady, S. A., . . . Shaywitz, B. A. (1995). Cognitive profiles of reading disabled children: Comparison of language skills in phonology, morphology, and syntax. *Psychological Science*, 6(3), 149-156.

Shetter, W. Z. (1959). The Dutch diminutive. *The Journal of English and Germanic Philology*, 58(1), 75-90.

Snow, C. E., Smith, N. S. H., & Hoefnagel-Höhle, M. (1979). The acquisition of some Dutch morphological rules. *Journal of Child Language*, 7, 539-553.

Snowling, M. J. (2008). Specific disorders and broader phenotypes: The case of dyslexia. *The Quarterly Journal of Experimental Psychology*, 61(1), 142-156.

Snowling, M. J. (2013). Early identification and interventions for dyslexia: A contemporary view. *Journal of Research in Special Educational Needs*, 13(1), 7-14.

Song, J. Y., Sundara, M., & Demuth, K. (2009). Phonological constraints on children's production of English third person singular -s. *Journal of Speech, Language and Hearing Research*, 52, 623-642.

Swingley, D., & Aslin, R. N. (2000). Spoken word recognition and lexical representation in very young children. *Cognition*, 76(2), 147-167.

Tabachnick, B. G., & Fidell, L. S. (2013). Using multivariate statistics (6th ed.) Pearson.

Tomas, E., Demuth, K., & Petocz, P. (2017). The role of frequency and predictability in learning morphophonological alternations: Implications for children with SLI. *Journal of Speech, Language and Hearing Research*, 60, 1316-1329.

Tomas, E., Demuth, K., Smith-Lock, K. M., & Petocz, P. (2015). Phonological and morphophonological effects on grammatical development in children with specific language impairment. *International Journal of Language and Communication Disorders*, 50(4), 516-528.

Tomas, E., Van De Vijver, R., Demuth, K., & Petocz, P. (2017). Acquisition of nominal morphophonological alternations in Russian. *First Language*, 37(5), 453-474.

Tomasello, M. (2003). Constructing a language: A usage-based theory of language acquisition (1st ed.). Cambridge, Massachusets: Harvard University Press.

Tomasello, M., & Slobin, D. I. (Eds.). (2005). Beyond nature-nurture (1st ed.). Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc.

Trommelen, M. (1984). The syllable in Dutch. Dordrecht: Foris Publications.

Van Alphen, P., De Bree, E. H., Gerrits, E., De Jong, J., Wilsenach, C., & Wijnen, F. (2004). Early language development in children with a genetic risk of dyslexia. *Dyslexia*, 10(4), 265-288.

Van Den Bos, K. P., Spelberg, L. H. C., Scheepstra, A. J. M., & De Vries, J. R. (1994). KLEPEL (two minute pseudo word reading task). Amsterdam: Pearson.

Van der Hulst, H. (2008). The Dutch diminutive. *Lingua*, 118, 1288-1306.

Van Kempen, J., & Wijnen, F. (2000). Grammaticale ontwikkeling. In S. Gillis, & A. Schaerlakens (Eds.), Kindertaalverwerving: Een handboek voor het Nederlands (1st ed., pp. 225-286) Martinus Nijhof Uitgevers.

Van Voorst, J. (1983). A metrical treatment of schwa-epenthesis in Dutch. *Cahiers Linguistique D'Ottowa*, 10, 75-102.

Windsor, J. (1994). Children's comprehension and production of derivational suffixes. *Journal of Speech and Hearing Research*, 37, 408-417.

Wolf, M., & Bowers, P. G. (2000). Naming-speed processes and developmental reading disabilities: An introduction to the special issue on the double-deficit hypothesis. *Journal of Learning Disabilities*, 33, 321-324.

Wolf, M., Bowers, P. G., & Biddle, K. (2000). Naming-speed processes, timing, and reading: A conceptual review. *Journal of Learning Disabilities*, 33(4), 387-407.

Zamuner, T. S., Kerkhoff, A., & Fikkert, P. (2006). Acquisition of voicing neutralization and alternations in Dutch. *Proceedings of the Annual Boston University Conference on Language Development*, 2, 701-712.

Zamuner, T. S., Kerkhoff, A., & Fikkert, P. (2012). Phonotactics and morphophonology in early child language: Evidence from Dutch. *Applied Psycholinguistics*, 33, 481-499.

Appendix

A. Test items

Table A1.
Items real diminutive

Item	Target diminutive	Non-target form judgement	Lexical freq noun	Lexical freq dim	Phonotactic freq stem
Bol	Boll-etje	Bol-tje	9.81	0.75	-1.2505
Snor	Snorr-etje	Snor-tje	9.95	0.55	-1.2925
Vlam	Vlamm-etje	Vlam-pje	7.94	0.37	-1.4301
Schoen	Schoen-tje	Schoen-etje	13.45	0.48	-1.0530
Schaal	Schaal-tje	Schaal-etje	9.74	0.59	-1.1450
Ballon	Ballonn-etje	Ballon-tje	5.28	0.07	-1.1274
Klem	Klemm-etje	Klem-pje	10.47	not found	-1.3897
Zaal	Zaal-tje	Zaal-etje	15.41	0.25	-1.3097
Boer	Boer-tje	Boer-etje	14.77	0.8	-1.2614
Teen	Teen-tje	Teen-etje	7.39	2.17	-1.0876
Worm	Worm-pje	Worm-tje	9.1	0.09	-1.2351
Zalm	Zalm-pje	Zalm-tje	5.28	0.05	-1.4150
Riem	Riem-pje	Riem-etje	14.16	0.05	-1.4831
Bezem	Bezem-pje	Bezem-tje	3.8	not found	-1.2213
Pruim	Pruim-pje	Pruim-etje	1.12	0.11	-1.3773
Helm	Helm-pje	Helm-tje	11.09	0.09	-1.1348
Scherm	Scherm-pje	Scherm-tje	13.68	0.18	-1.3767
Kraam	Kraam-pje	Kraam-etje	1.14	0.14	-1.3156
Raam	Raam-pje	Raam-etje	70.84	2.24	-1.4117
Duim	Duim-pje	Duim-etje	10.79	0.8	-1.3293
Kring	Kring-etje	Krin-kje	3.48	0.32	-1.1535
Verwarming	Verwarmin-kje	Verwarming-etje	4.96	not found	-1.3794
Leerling	Leerling-etje	Leerlin-kje	12.99	not found	-1.2024
Woning	Wonin-kje	Woning-etje	13.38	0.02	-1.1337
Wandeling	Wandeling-etje	Wandelin-kje	8.46	1.65	-0.8940
Wang	Wang-etje	Wan-kje	8.46	1.65	-0.8940
Tekening	Tekening-etje	Tekenin-kje	8.92	0.18	-1.1777
Botsing	Botsin-kje	Botsing-etje	3.32	0.02	-1.2706
Pudding	Puddin-kje	Pudding-etje	4.94	0.02	-1.4538

Ontploffing	Ontploffin-kje	Ontploffing-etje	4.46	not found	-1.3551
Wieg	Wieg-je	Wieg-tje	4.12	0.46	-1.4665
Vos	Vos-je	Vos-tje	7.59	0.14	-1.3122
Koek	Koek-je	Koek-tje	3.27	8.12	-1.3868
Schep	Schep-je	Schep-tje	4.26	0.59	-1.3108
Knoop	Knoop-je	Knoop-tje	9.51	0.55	-1.5531
Dwerg	Dwerg-je	Dwerg-tje	8.99	0.16	1.3557
Stok	Stok-je	Stok-tje	14.48	3.06	-1.1726
Zeep	Zeep-je	Zeep-tje	14.22	0.14	-1.4798
Schaap	Schaap-je	Schaap-tje	6.54	0.18	-1.2989
Vaas	Vaas-je	Vaas-tje	4.57	0.05	-1.4899

Table A2.
Items nonce diminutive

Item	**Target diminutive**	**Non-target form judgement**	**Phonotactic freq stem**
Keen	Keen-tje	Keen-etje	-1.4192
Loen	Loen-tje	Loen-etje	-1.3104
Vom	Vomm-etje	Vom-pje	-1.1536
Gol	Goll-etje	Gol-tje	-1.3139
Raal	Raal-tje	Raal-etje	-1.3448
Poer	Poer-tje	Poer-etje	-1.4971
Neel	Neel-tje	Neel-etje	-1.0242
Zam	Zamm-etje	Zam-pje	-1.3768
Hil	Hill-etje	Hil-tje	-1.3759
Nan	Nann-etje	Nan-tje	-1.0250
Zuim	Zuim-pje	Zuim-tje	-1.5922
Liem	Liem-pje	Liem-tje	-1.4119
Reem	Reem-pje	Reem-tje	-1.4225
Zaam	Zaam-pje	Zaam-tje	-1.3766
Doom	Doom-pje	Doom-tje	-1.1681
Leem	Leem-pje	Leem-etje	-1.3130
Koem	Koem-pje	Koem-etje	-1.5470
Tuim	Tuim-pje	Tuim-etje	-1.4590
Buim	Buim-pje	Buim-etje	-1.3652
Gaam	Gaam-pje	Gaam-etje	-1.1975
Ming	Ming-etje	Min-kje	-1.0038
Tukking	Tukkin-kje	Tukking-etje	-1.2364
Loving	Lovin-kje	Loving-etje	-1.2347
Ting	Ting-etje	Tin-kje	-1.1347
Ning	Ning-etje	Nin-kje	-1.0935

Moging	Mogin-kje	Moging-etje	-1.2360
Boning	Bonin-kje	Boning-etje	-1.2236
Witting	Wittin-kje	Witting-etje	-1.1556
Sing	Sing-etje	Sin-kje	-1.0372
Jing	Jing-etje	Jin-kje	-1.1287
Lop	Lop-je	Lop-tje	-1.2792
Voes	Voes-je	Voes-tje	-1.3823
Poek	Poek-je	Poek-tje	-1.4294
Mip	Mip-je	Mip-tje	-1.3787
Tiek	Tiek-je	Tiek-tje	-1.1908
Foop	Foop-je	Foop-tje	-1.0836
Koep	Koep-je	Koep-tje	-1.5289
Moek	Moek-je	Moek-tje	-1.0179
Woeg	Woeg-je	Woeg-tje	-1.5053
Ries	Ries-je	Ries-tje	-1.3314

Table A3.
Items real past tense

Item	**Target past tense**	**Non-target form judgement**	**Lexical freq verb**	**Lexical freq past tense**	**phonotactic freq stem**
Aaien	Aai-de	Aai-te	2.1	0.25	-1.2231
Boren	Boor-de	Boor-te	5.37	0.66	-1.0392
Tillen	Til-de	Til-te	5.15	1.44	-0.9698
Kammen	Kam-de	Kam-te	2.63	0.48	-1.0902
Kauwen	Kauw-de	Kauw-te	4.69	0.41	-1.2711
Bellen	Bel-de	Bel-te	228.77	78.71	-0.9148
Duwen	Duw-de	Duw-te	22.36	7.45	-1.1408
Gooien	Gooi-de	Gooi-te	49.62	20.47	-1.1151
Delen	Deel-de	Deel-te	68.92	3.45	-0.9387
Horen	Hoor-de	Hoor-te	352.28	182.05	-0.9426
Kussen	Kus-te	Kus-de	45.62	9.24	-0.9855
Maken	Maak-te	Maak-de	957.27	130.12	-0.9603
Pakken	Pak-te	Pak-de	140.18	22.8	-1.1553
Likken	Lik-te	Lik-de	7.5	1.49	-1.0443
Bakken	Bak-te	Bak-de	11.85	1.14	-1.1150
Vissen	Vis-te	Vis-de	40.27	0.78	-1.1139
Werken	Werk-te	Werk-de	306.82	81.75	-1.0111

Dansen	Dans-te	Dans-de	102.91	5.35	-0.8773
Piepen	Piep-te	Piep-de	1.85	0.37	-1.2874
Dekken	Dek-te	Dek-de	10.54	0.73	-1.0470

Table A4.
Items nonce past tense

Item	**Target past tense**	**Non-target form judgement**	**Phonotactic freq stem**
Pirren	Pir-de	Pir-te	-1.4466
Lummen	Lum-de	Lum-te	-1.2691
Ronen	Roon-de	Roon-te	-1.2264
Monen	Moon-de	Moon-te	-1.1815
Zaren	Zaar-de	Zaar-te	-1.0797
Homen	Hoom-de	Hoom-te	-1.0111
Danen	Daan-de	Daan-te	-1.0092
Wommen	Wom-de	Wom-te	-0.9409
Norren	Nor-de	Nor-te	-1.0400
Luunen	Luun-de	Luun-te	-1.4192
Nikken	Nik-te	Nik-de	-1.0352
Doepen	Doep-te	Doep-de	-1.0687
Dappen	Dap-te	Dap-de	-0.9692
Guipen	Guip-te	Guip-de	-1.4757
Rakken	Rak-te	Rak-de	-1.2324
Lapen	Laap-te	Laap-de	-1.2672
Wauken	Wauk-te	Wauk-de	-1.3998
Vuppen	Vup-te	Vup-de	-1.3899
Naupen	Naup-te	Naup-de	-1.2942
Gikken	Gik-te	Gik-de	-1.0047

B. Chapter 4: Final most explanatory models linear mixed effects analysis

Table B1.

Optimal models predicting performance on the production task for the real and nonce past tense and diminutive

Production				
Predictor variable	Estimate (β)	SE (β)	Z	*P*
Diminutive real				
Intercept	2.97	0.38	7.725	< .001
Age	0.01	0.016	0.703	0.48
Raven	0.15	0.40	0.364	0.72
Phonological awareness	0.94	0.41	2.255	0.02
Diminutive nonce				
Intercept	1.65	0.28	5.958	< .001
Age	0.02	0.01	1.442	0.15
Raven	0.33	0.29	1.137	0.26
NWR	0.58	0.25	2.335	0.02
Past tense real				
Intercept	2.00	0.39	5.037	< .001
Age	-0.03	0.03	-1.109	.27
Raven	0.45	0.75	0.591	.55
Phonological awareness	2.09	0.78	2.695	.007
PPVT	1.93	0.89	2.165	.03
Past tense nonce				
Intercept	-2.49	1.25	-2.00	.05
Age	0.05	0.02	2.53	.01
Raven	-0.04	0.59	-0.06	.95
Digit span	0.37	0.11	3.25	.001

Table B2.

Optimal models predicting performance on the judgement task for the real and nonce past tense and diminutive

	Judgement			
Predictor variable	Estimate (β)	SE (β)	t	*P*
Diminutive real				
Intercept	0.64	0.06	10.81	< .001
Age	0.001	0.001	1.16	0.25
Raven	0.05	0.03	1.80	0.07
Digit span	0.02	0.005	3.24	0.001
Diminutive nonce				
Intercept	0.69	0.01	51.66	<.001
Age	0.004	0.001	4.00	<.001
Raven	0.06	0.03	2.29	.002
Past tense real				
Intercept	0.48	0.08	6.38	<.001
Age	0.003	0.001	2.57	.01
Raven	0.06	0.04	1.67	.09
Digit span total	0.02	0.007	2.60	.009
Past tense nonce				
Intercept	0.627	0.018	34.25	< .001
Age	0.002	0.0013	1.84	0.065
Raven	0.016	0.039	0.42	0.68
Phonological awareness	0.091	0.045	2.01	0.04

C. Chapter 5: Final most explanatory models linear mixed effects analysis

Table C1.
Optimal models predicting performance on the production task with the real and nonce diminutive

Production				
Predictor variable	Estimate (β)	SE (β)	Z	*P*
Diminutive real (/-ətjə/)				
Intercept	2.74	0.28	9.85	< .001
Age	0.02	0.01	2.00	.05
Raven	0.55	0.28	2.01	.05
Allomorph (/-ətjə/ vs others)	-2.52	0.48	-5.27	< .001
Age * Allomorph	-0.02	0.008	-2.31	.02
Diminutive nonce (/-ətjə/)				
Intercept	1.51	0.20	7.57	< .001
Age	0.01	0.006	2.40	.02
Raven	0.43	0.18	2.43	.02
Allomorph (/-ətjə/ vs others)	-3.08	0.38	-8.12	< .001
Age * Allomorph	-0.04	0.008	-4.97	< .001
Diminutive real (/-kjə/)				
Intercept	2.38	0.28	8.45	< .001
Age	0.01	0.009	1.56	.1
Raven	0.54	0.28	1.96	.05
Allomorph (/-kjə/ vs others)	-2.37	0.70	-3.39	< .001
Age * Allomorph	-0.01	0.01	-1.43	.2
Diminutive nonce (/-kjə/)				
Intercept	0.90	0.26	3.40	< .001
Age	0.003	0.006	0.53	.6
Raven	0.41	0.17	2.36	.02
Allomorph (/-kjə/ vs others)	-1.28	0.72	-1.78	.08
Age * Allomorph	0.003	0.009	0.36	.7

D. Chapter 6: Final most explanatory models linear mixed effects analysis

Table D1.
Optimal models predicting differences in performance between the groups on the phonological and background tasks

Phonological and background tasks				
Predictor variable	Estimate (β)	SE (β)	t	*P*
Real word reading				
Intercept (RD children)	30.51	4.2	7.18	< .001
RD vs RA	-1.76	5.5	-0.32	.75
RD vs CA	20.77	5.6	3.73	< .001
Pseudo word reading				
Intercept (RD children)	22.41	4.6	4.88	< .001
RD vs RA	4.00	6.0	0.67	.51
RD vs CA	29.16	6.1	4.82	< .001
RAVEN				
Intercept (RD children)	36.51	1.8	20.23	< .001
RD vs RA	-11.39	2.4	-4.73	< .001
RD vs CA	-3.07	2.4	-1.26	.21
PPVT				
Intercept (RD children)	109.53	3.1	35.62	< .001
RD vs RA	-9.65	4.0	-2.41	.02
RD vs CA	-2.41	4.0	-0.60	.55
RAN time				
Intercept (RD children)	124.47	10.2	12.19	< .001
RD vs RA	-19.40	13.4	-1.45	.15
RD vs CA	-31.39	13.6	-2.31	.02
NWR				
Intercept (RD children)	0.91	0.01	84.51	< .001
RD vs RA	-0.04	0.02	-2.35	.02
RD vs CA	-0.001	0.02	-0.06	.95
Digit span				
Intercept (RD children)	10.95	0.7	16.27	< .001
RD vs RA	-0.08	0.9	-0.09	.93
RD vs CA	0.58	0.9	0.65	.52

Table D2.
Optimal models predicting differences in performance between the groups on the production task

	Production			
Predictor variable	Estimate (β)	SE (β)	Z	*P*
Diminutive real				
Intercept (RD children)	4.51	0.761	5.930	< .001
RD vs RA	-0.62	0.619	-1.009	.313
RD vs CA	-0.55	0.619	-0.882	.378
Diminutive nonce				
Intercept (RD children)	1.66	0.30	5.591	< .001
RD vs RA	0.003	0.28	0.012	.990
RD vs CA	0.36	0.28	1.285	.199
Past tense real				
Intercept (RD children)	2.78	0.56	4.963	< .001
RD vs RA	-0.53	0.67	-0.790	.429
RD vs CA	-0.14	0.67	-0.213	.831
Past tense nonce				
Intercept (RD children)	1.99	0.36	5.473	< .001
RD vs RA	-0.75	0.48	-1.569	.117
RD vs CA	-0.25	0.48	-0.508	.612

Table D3.

Optimal models predicting differences in performance between the groups on the judgement task

	Judgement			
Predictor variable	Estimate (β)	SE (β)	t	*P*
Diminutive real				
Intercept (RD children)	0.87	0.03	30.81	< .001
RD vs RA	-0.10	0.04	-2.48	.01
RD vs CA	0.03	0.04	0.63	.53
Diminutive nonce				
Intercept (RD children)	0.75	0.03	26.28	< .001
RD vs RA	-0.15	0.04	-3.80	< .001
RD vs CA	0.03	0.04	0.64	.53
Past tense real				
Intercept (RD children)	0.69	0.04	16.67	< .001
RD vs RA	-0.08	0.06	-1.42	.16
RD vs CA	0.10	0.06	1.73	.08
Past tense Nonce				
Intercept (RD children)	0.64	0.04	16.00	< .001
RD vs RA	-0.04	0.06	-0.76	.45
RD vs CA	0.09	0.06	1.62	.11

Summary

VARIABILITY IN THE ACQUISITION OF ALLOMORPHS: THE DUTCH DIMINUTIVE AND PAST TENSE

What factors influence the acquisition of allomorphs? This dissertation presents findings from four studies in which the productivity and development of the Dutch past tense and diminutive allomorphs have been investigated. Adults, typically developing children, and children with reading difficulties were tested on a Wug-type production task and a grammaticality judgement task with both real and nonce nouns and verbs.

Many allomorphs are phonological variant forms of morphemes. The selection of the appropriate allomorph can depend on the phonological characteristics and structures of the stem. Such forms are based on the phonological and/or phonotactic constraints of the language, i.e., restrictions on the permitted combinations of phonemes in a language. The main issue dealt with in this dissertation builds on findings from earlier studies that have shown that some allomorphs are acquired more slowly than others. For example, the three allomorphic forms of the English regular past tense, /-d/ as in *'lived'*, /-t/ as in *'helped'*, and /-Id/ as in *'waited'*, show variability in production accuracies in children. The syllabic /-Id/ allomorph is produced less accurately and is acquired later than the other two allomorphs. Many other examples of a protracted acquisition of some allomorphs compared to others have been found, not only in English but also in other languages. Studies have found coda complexity, articulatory difficulties, perceptual saliency, phonetic substance, local phonetic dependencies, stress, and syllabicity to influence the production and perception of allomorphs. An important notion throughout this dissertation is therefore that the complexity of the phonological structure and characteristics of the stem that an

allomorph attaches to appears to influence allomorphic productivity and development. The extent to which that is indeed the case was further investigated. Since morphological inflections and derivations entail a phonological component, it might be argued that phonological skills positively influence children's sensitivity to allomorphy. Children's phonological processing skills in relation to their ability to use the appropriate allomorph was therefore also assessed.

Many previous studies have in addition indicated that frequency effects need to be taken into account when investigating linguistic development. It has repeatedly been found that children acquire more frequent language structures before less frequent structures across phonology, morphology, syntax, and semantics. As such, it is expected that the ease with which children acquire morphophonological patterns and allomorphs will vary according to the relative frequency of these patterns. Effects of phonotactic and type frequency were therefore also studied. Related to these effects of frequency, associations between the size of children's lexicons and their sensitivity to allomorphy was in addition investigated. The learning of lexical items triggers the organization of the lexicon in such a way as to allow the abstraction of general patterns and productive usage. The larger the child's lexicon, the more instances of a morphophonological pattern the child will have encountered and the more accurately the child will be able to choose the appropriate allomorph.

In this dissertation children's linguistic skills (phonological processing; vocabulary size) and item specific characteristics (phonological characteristics of the stem; type frequency of the allomorphs; phonotactic frequency of the stem+allomorph combinations) were thus investigated in relation to children's accuracy scores on a Wug-type production task and a grammaticality judgement task. The Dutch past tense, /-də/ and /-tə/, and the

Dutch diminutive, /-jə/, /-tjə/, /-ətjə/, /-pjə/, and /-kjə/, were studied. More details on the rationale of this dissertation can be found in the introduction of the dissertation (*Chapter 1*).

Since the separate studies in *Chapters 3 to 6* have a comparable background and make use of similar methodologies, these aspects were discussed in *Chapter 2*. The Dutch past tense and diminutive is described, and the test materials and stimuli used in the different studies are presented. The production and grammaticality judgement tasks were constructed with both real and nonce verbs and nouns. Adults (*Chapter 3*), typically developing children (*Chapters 4 and 5*), and children with reading difficulties (*Chapter 6*) were tested.

Although the main topic of this dissertation is the acquisition of allomorphs, it is necessary to be aware of what the outcome of this development will be. Based on its linguistic description (presented in *Chapter 2*), the Dutch diminutive is a complex morphophonological phenomenon with five allomorphs based on different phonological characteristics of the stem. Especially the phonological characteristics of the stems that give rise to the allomorph /-ətjə/ appear to be complex. Although relatively many theoretical papers exist on the formation of the Dutch diminutive, its actual productivity is unclear. The productivity of the Dutch diminutive system in adults was therefore investigated (*Chapter 3*). The results indicated that the diminutive allomorphs /-jə/, /-tjə/, /-pjə/, and /-kjə/ are fully productive in adults, but that the allomorph /-ətjə/ is not. Adults seemed to store the real stem+/-ətjə/ combinations in their lexicon. However, the morphophonological pattern was not always generalized to nonce nouns. Instead, the adults applied place assimilation with the final phoneme of the noun and judged both the target (stem+/-ətjə/), but also non-target stem+allomorph combinations based on

this place assimilation, as correct. In the following studies testing children's abilities to produce and judge the diminutive allomorphs, we took this finding into account.

Chapter 4 focussed on children's linguistic skills (phonological processing and vocabulary size) in relation to their production and perception accuracies of allomorphs. Associations between five- to ten-year old children's phonological processing skills, as measured with an NWR, phonological awareness, and digit span task, vocabulary size, measured with the PPVT, and ability to produce and judge stem+allomorph combinations, were investigated. Since /-ətjə/ had been found to be less productive than the other allomorphs in adults (*Chapter 3)* and we wanted to be able to extend our findings to allomorphic forms in general, this allomorph was excluded from the analyses of the production task. In addition, instead of looking at the accuracies of the separate allomorphs (as was done in *Chapters 3 and 5*), in this study we looked at production and judgement accuracies of the past tense and diminutive allomorphs taken together. Children's phonological processing skills were found to be significantly associated with production and judgement accuracies of the past tense and diminutive. Although vocabulary size was significantly correlated with performance on the production and judgement tasks for both the past tense and diminutive and was significant in some of the suboptimal models, it was only significantly associated in the optimal model predicting production accuracies of the real past tense items. The size of children's (receptive) lexicon had a smaller effect on children's accuracy scores than their phonological awareness and phonological working memory skills. The results of this study suggest a relation between phonological processing, the lexicon, and the production and perception of allomorphs in primary school age children. However, the findings also indicated that allomorphic production and judgement accuracies

are more strongly associated with phonological processing skills than vocabulary size.

The study presented in *Chapter 5* focussed on item specific characteristics in relation to production accuracies of the Dutch diminutive. This was a study that looked at productivity of the Dutch diminutive in the same children as tested in *Chapter 4*. Which stem- and allomorph-specific factors contribute to the protracted acquisition of some allomorphs, their non-target productions, and whether these factors change during development was investigated. The effects of the complexity of the phonological characteristics of the stem, and type and phonotactic frequencies of the allomorphs were studied. Although previous studies have indicated that phonological characteristics and frequency of stems, allomorphs, and stem+allomorph combinations are important, the relation between these item specific characteristics is unclear. The Dutch diminutive allomorphs have varying type frequencies and their use is determined by different phonological characteristics of the noun stems. This made it possible to investigate this relation. The complexity of the phonological characteristics of stems and type frequency of the allomorphs were shown to be important in the acquisition of the Dutch diminutive. However, complexity seemed to have a larger influence on diminutive production accuracies than frequency (note that no effect of phonotactic frequency was found). These findings show that the number of times children encounter an allomorph has an effect. However, children need to be aware of the phonological characteristics of the stems and, based on this, be able to generalize over multiple items. Overall, the findings underline the findings of *Chapter 4* that showed the importance of phonological skills in allomorphic development.

Finally, in *Chapter 6* the relations between phonological and morphological skills in children with reading difficulties were investigated. More specifically, children with poor decoding skills were included as earlier studies have found that these children have impairments in their phonological processing. Again, both the past tense and diminutive were tested with a production (not taking /-ətjə/ into account) and grammaticality judgement task. The findings indicated that the group of children with reading impairments had difficulties with automatic lexical retrieval only and had no further language or phonological difficulties. In addition, they did not show any difficulties with the tasks testing the Dutch past tense and diminutive. The absence of allomorphic difficulties is in line with the hypothesis that there is a group of children with reading difficulties who do not display broader language difficulties. This is also in line with other studies that showed that only children with especially poor phonological abilities have problems with inflectional morphology, while children with good phonological skills do not. The results underline the findings from the study presented in *Chapter 4* that showed significant associations between phonological skills and the ability to use and judge the appropriate allomorph, as significant correlations between phonological processing skills and sensitivity to allomorphy were found in children with reading difficulties as well. Again, the results from this study are in line with the other findings of this dissertation in that they point towards both phonological skills and phonological characteristics of the stems having a substantial influence on the development of the allomorphic patterns tested.

The results of the studies conducted in this dissertation indicate that associations between linguistic skills, item specific characteristics, and sensitivity to allomorphy in primary school-age children exist. Phonological processing skills and complexity of the phonological characteristics of the

stem were found to have a larger influence on production and judgement accuracies than frequency and vocabulary size. Nevertheless, acquiring the allomorphs is impossible without enough input. The more instances there are available, the faster the child will acquire the patterns that govern the allomorph. Familiarity with the phonological characteristics of the stems that give rise to the allomorphs and enough instances of stem+allomorph combinations in the lexicon are necessary. However, the variation found in the acquisition of allomorphs, it is suggested, follows mainly from differences in children's phonological processing skills and variations in complexity of the phonological characteristics of the stems (see also *Chapter 7*). The better the phonological skills of the children, the more they will be aware of the phonological characteristics of the stems and the related morphophonological patterns, and the more accurately they will be able to generalize over these. The more complex the phonological characteristics, the harder it is for children to generalize over the morphophonological patterns. In sum, the results from this dissertation indicate that although frequency and vocabulary size are related to children's acquisition of allomorphs, phonological processing skills and the complexity of the phonological stem characteristics appear to be more direct causes of children's protracted acquisition of some allomorphs compared to others.

Samenvatting

VARIABILITEIT IN DE VERWERVING VAN ALLOMORFEN: HET NEDERLANDSE DIMINUTIEF EN DE VERLEDEN TIJD

Welke factoren hebben invloed op de verwerving van allomorfen? In dit proefschrift worden vier studies gepresenteerd waarin de productiviteit en verwerving van de Nederlandse diminutief- en verleden tijd-allomorfen zijn onderzocht. Zowel volwassenen als kinderen met en zonder leesproblemen zijn getest op hun productie- en beoordelingsvaardigheden met zowel echte als verzonnen zelfstandig naamwoorden en werkwoorden.

Allomorfen zijn fonologische varianten van het morfeem. De keuze voor de geschikte allomorf kan afhangen van de fonologische karakteristieken van de stam waaraan het morfeem wordt toegevoegd. Deze vormen zijn gebaseerd op de fonologische en/of fonotactische restricties van de taal (restricties op de toegestane combinaties van fonemen in een taal). De verschillende studies in dit proefschrift zijn gebaseerd op eerder onderzoek dat heeft aangetoond dat sommige allomorfen langzamer worden verworven dan andere. Het is bijvoorbeeld aangetoond dat wanneer kinderen de Engelse regelmatige verleden tijd moeten vormen zij verschillen laten zien in productievaardigheden afhankelijk van welk allomorf, /-d/ als in *'lived'*, /-t/ als in *'helped'*, en /-Id/ als in *'waited'*, er wordt verwacht. Het blijkt dat de syllabische /-Id/ allomorf minder accuraat wordt geproduceerd dan de andere twee allomorfen. Menig ander voorbeeld van een latere verwerving van sommige allomorfen in vergelijking tot andere allomorfen is gevonden in niet alleen het Engels, maar ook in andere talen. Verschillende studies hebben gevonden dat de complexiteit van de coda, articulatiemoeilijkheden, fonetische kwaliteit, fonetische afhankelijkheid, klemtoonplaatsing en syllabiciteit invloed hebben op de productie en perceptie van allomorfen. Een belangrijk inzicht voor dit proefschrift is derhalve dat de complexiteit van de

fonologische structuur en karakteristieken van de stam waaraan een allomorf wordt toegevoegd van invloed lijken te zijn op de productiviteit en verwerving van allomorfen. In hoeverre dit daadwerkelijk het geval is, wordt verder onderzocht in dit proefschrift. Omdat morfologische vervoegingen en derivaties dus een fonologische component bevatten, zou het daarnaast ook zo kunnen zijn dat de fonologische vaardigheden van kinderen de verwerving van allomorfen positief beïnvloeden. Fonologische vaardigheden ten opzichte van het gebruik van de geschikte allomorf zijn daarom ook onderzocht.

Een aantal eerdere studies heeft bovendien aangetoond dat frequentie-effecten moeten worden meegenomen wanneer de taalontwikkeling wordt onderzocht. Het is herhaaldelijk gevonden, zowel binnen de fonologische, morfologische, syntactische als de semantische ontwikkeling, dat kinderen de meer frequente taalstructuren eerder verwerven dan de minder frequente structuren. Zodoende is het dus te verwachten dat de verwerving van morfofonologische patronen en allomorfen afhangt van de relatieve frequentie van deze patronen. De effecten van fonotactische-frequentie en type-frequentie zijn daarom ook onderzocht. De grootte van het vocabulaire van kinderen en de invloed op de verwerving van allomorfen is gerelateerd aan deze frequentie-effecten. De relatie tussen woordenschat en verwerving van allomorfen is daarom ook onderzocht. Het leren van lexicale items beïnvloedt de organisatie van het lexicon zodanig dat algemene patronen geabstraheerd en productief kunnen worden. Dit is gebaseerd op het idee dat hoe groter het kind zijn lexicon, hoe vaker het kind een morfofonologisch patroon is tegengekomen, en hoe beter het kind zal weten welk allomorf geschikt is.

In dit proefschrift zijn bij kinderen van de basisschoolleeftijd zowel linguïstische vaardigheden (fonologische verwerking en grootte van het lexicon) als item-specifieke karakteristieken (fonologische karakteristieken

van de stam, type-frequentie van de allomorfen en fonotactische-frequentie van de stam+allomorf combinaties) onderzocht in relatie tot scores op een productie- en beoordelingstaak. De Nederlandse verleden tijd-allomorfen, /-də/, /-tə/, en de Nederlandse diminutief-allomorfen, /-jə/, /-tjə, /-ətjə/, /-pjə/, en /-kjə/, zijn in deze twee taken getest. Verdere details met betrekking tot de rationaal van dit proefschrift zijn te vinden in de inleiding (*Hoofdstuk 1*).

Omdat de verschillende studies in *Hoofdstuk 3 – 6* een vergelijkbare achtergond hebben en gebruik maken van dezelfde methodologie, zijn deze beschreven in *Hoofdstuk 2*. Het vervoegen van de Nederlandse verleden tijd en het diminutief is beschreven, als ook de stimuli en materialen die in de verschillende studies zijn gebruikt. In de productie- en beoordelingstaak zijn zowel bestaande als verzonnen woorden gebruikt. Volwassenen (*Hoofdstuk 3*), typisch ontwikkelende kinderen (*Hoofdstuk 4 en 5*), en kinderen met leesproblemen (*Hoofdstuk 6*) zijn getest.

Het hoofddoel van dit proefschrift is het bestuderen van de ontwikkeling en verwerving van allomorfen. Desalniettemin is het belangrijk om bewust te zijn van wat de uitkomst van deze ontwikkeling zal zijn. Afgaande op de linguïstische beschrijving van het Nederlandse diminutief (zie *Hoofdstuk 2*), is deze een complex morfofonologisch fenomeen met vijf allomorfen die afhangen van verschillende fonologische karakteristieken van de stam. Vooral de fonologische karakteristieken die aanleiding geven tot het gebruik van de allomorf /-ətjə/ lijken vrij complex te zijn. Hoewel er een aantal theoretische studies bestaat die de vorming van het Nederlandse diminutief beschrijven, is de productiviteit van het diminutief relatief onbekend. De productiviteit van het diminutief in volwassenen is daarom eerst onderzocht (*Hoofdstuk 3*). De resultaten laten zien dat de vier

allomorfen /-jə/, /-tjə/, /-pjə/, en /-kjə/ volledig productief zijn in volwassenen. Daarentegen lijkt de allomorf /-ətjə/ niet volledig productief te zijn. De volwassenen lijken de bestaande stam+/-ətjə/ combinaties op te slaan in hun lexicon en scoren op plafondniveau. Echter, de morfofonologische patronen worden niet altijd gegeneraliseerd naar de verzonnen zelfstandig naamwoorden. In plaats daarvan gebruikten de volwassenen plaatsassimilatie met de laatste foneem van de stam en beoordeelden zij zowel de target als niet-target stam+/-ətjə/ combinaties als correct. Deze bevindingen zijn meegenomen in de hieropvolgende studies waarin de verwerving van allomorfen in kinderen zijn getest.

In *Hoofdstuk 4* is de relatie tussen linguïstische vaardigheden (fonologische verwerking en grootte van het vocabulaire) en de testscores op de productie en beoordelingstaak in vijf- tot tienjarige typisch ontwikkelende kinderen geanalyseerd. De samenhang tussen de fonologische vaardigheden, gemeten met nonword repetitie, fonologisch bewustzijn, en digit span taken, en woordenschat, gemeten met de PPVT, en het vermogen om stam+allomorf combinaties te produceren en beoordelen, is onderzocht. Omdat de allomorf /-ətjə/ minder productief is in volwassenen dan de andere allomorfen (*Hoofdstuk 3*), en de bevindingen zouden moeten gelden voor de verwerving van allomorfen in het algemeen, is er besloten om dit allomorf uit te sluiten van de analyse voor de productietaak. Verder is er in deze studie naar de allomorfen in hun geheel gekeken, in tegenstelling tot wat is gedaan in *Hoofdstuk 3* en *5* waar de verschillende allomorfen apart zijn geanalyseerd. De resultaten van deze studie tonen aan dat de fonologische vaardigheden van kinderen significant gerelateerd zijn aan de scores op de productie- en beoordelingstaak die de Nederlandse diminutief- en verleden tijd-allomorfen testen. Ondanks dat de scores op de woordenschattaak significant correleerden met de scores op de productie- en beoordelingstaak voor zowel

de verleden tijd als diminutief, en significant waren in sommige suboptimale modellen, waren deze scores alleen significant gerelateerd in het optimale model dat de productiescores voor de bestaande verleden tijd voorspelt. De grootte van de (receptieve) woordenschat van kinderen lijkt dus een kleiner effect te hebben op de allomorf productie- en beoordelingsvermogens van kinderen dan fonologisch bewustzijn en fonologisch werkgeheugen. De resultaten van deze studie suggereren een relatie tussen fonologisch verwerken, het lexicon, en productie- en beoordelingsscores van allomorfen in basisschoolkinderen. Desalniettemin laten de resultaten ook zien dat deze scores sterker zijn geassocieerd met fonologische vaardigheden dan met de grootte van het lexicon.

De studie in *Hoofdstuk 5* behandelt de item-specifieke karakteristieken van de stam en de allomorf in relatie tot de scores op de productietaak in dezelfde kinderen die ook in *Hoofdstuk 4* zijn getest. Meer in het bijzonder is de productiviteit van het Nederlandse diminutief de focus van deze studie. Welke stam- en allomorf-specifieke factoren een bijdrage hebben aan de latere verwerving van sommige allomorfen ten opzichte van andere allomorfen, de niet-target producties, en of deze factoren gedurende de ontwikkeling veranderen, is onderzocht. Hoewel eerdere studies hebben aangetoond dat de fonologische karakteristieken en frequenties van de stammen, allomorfen, en stam+allomorf combinaties van invloed zijn, is de samenhang tussen deze factoren onduidelijk. De Nederlandse diminutief-allomorfen hebben variërende type-frequenties en het gebruik van deze allomorfen hangt af van de specifieke fonologische karakteristieken van de stam. Dit maakt het mogelijk om de relatie tussen de verschillende factoren te onderzoeken. De complexiteit van de fonologische karakteristieken van de stam en type-frequentie van de allomorfen bleek van invloed te zijn op de

verwerving van het Nederlandse diminutief. Echter, complexiteit bleek van groter belang te zijn dan type-frequentie (een effect van fonotactische-frequentie is niet gevonden in deze studie). De resultaten laten dus zien dat het aantal keer dat een kind een allomorf tegenkomt een effect heeft, maar dat kinderen zich vooral bewust moeten zijn van de fonologische karakteristieken van de stam, en, hierop gebaseerd, in staat moeten zijn om te generaliseren over meerdere items. De bevindingen van deze studie komen dus in grote lijnen overeen met de resultaten van *Hoofdstuk 4* die het belang van fonologische vaardigheden in de verwerving van allomorfen aantonen.

Tenslotte zijn in *Hoofdstuk 6* de relaties tussen fonologische en morfologische vaardigheden onderzocht in kinderen met leesproblemen. Meer concreet zijn kinderen met decodeerproblemen onderzocht omdat eerdere studies hebben aangetoond dat deze kinderen fonologische verwerkingsproblemen laten zien. Zoals ook in de eerdere studies in dit proefschrift zijn de verleden tijd en diminutief allomorfen getest met een productie- (zonder /-ətjə/) en beoordelingstaak. De resultaten laten zien dat de kinderen met leesproblemen moeilijkheden hebben met snel geautomatiseerd benoemen (RAN-taak, de vaardigheid om vertrouwde symbolen, zoals driehoeken, vierkanten, en kleuren, zo snel mogelijk te benoemen), maar geen verdere taal- of fonologische problemen hebben. Daarnaast laten zij ook geen problemen met de productie- en beoordelingstaak zien. Deze bevinding dat de kinderen met leesproblemen geen problemen laten zien met de taken die allomorfie testen komt overeen met de hypothese dat er ook kinderen met leesproblemen zijn die geen verdere taalproblemen laten zien. De resultaten komen bovendien ook overeen met eerdere studies die hebben laten zien dat alleen kinderen met voornamelijk zwakke fonologische vaardigheden moeilijkheden laten zien met morfologie. Dit in contrast tot kinderen met sterke fonologische

vaardigheden die geen morfologische problemen laten zien. De resultaten komen verder overeen met de bevindingen in *Hoofdstuk 4* waar significante associaties tussen fonologische vaardigheden en scores op de productie- en beoordelingstaak zijn gevonden. Ook in deze studie zijn er significante correlaties tussen de scores op de productie- en beoordelingstaak die allomorfie testen en de fonologische vaardigheden van kinderen met leesproblemen gevonden. Daarmee zijn de resultaten van deze studie dus in overeenstemming met de resultaten van de andere studies in dit proefschrift: zowel fonologische vaardigheden als de fonologische karakteristieken van de stam lijken een substantieel effect te hebben op de verwerving van de allomorfische patronen getest in dit proefschrift.

De bevindingen van de studies gepresenteerd in dit proefschrift laten zien dat linguïstische vaardigheden, item-specifieke karakteristieken, en de verwerving van allomorfie geassocieerd zijn in kinderen van de basisschoolleeftijd. De resultaten laten zien dat fonologische vaardigheden en complexiteit van de fonologische karakteristieken van de stam van groter belang lijken te zijn dan de grootte van het vocabulaire en frequentie. Desalniettemin is het onmogelijk om de allomorfen te verwerven zonder genoeg input. Hoe meer exemplaren er beschikbaar zijn, des te eerder zal het kind de patronen verwerven die de keuze voor het juiste allomorf bepalen. Bekendheid met de fonologische karakteristieken van de stam en genoeg exemplaren van de stam+allomorf in het lexicon zijn noodzakelijk. Niettemin lijkt de variatie in de verwerving van allomorfen voornamelijk veroorzaakt te worden door verschillen in fonologische vaardigheden van kinderen en variaties in de complexiteit van de fonologische karakteristieken van de stam (zie ook *Hoofdstuk 7*). Hoe beter de fonologische vaardigheden van kinderen, hoe meer ze zich bewust zullen zijn van de verschillende fonologische

karakteristieken en de gerelateerde morfofonologische patronen, en des te accurater zullen zij deze patronen kunnen generaliseren. Hoe complexer de fonologische karakteristieken, hoe moeilijker het zal zijn voor de kinderen om over de verschillende morfofonologische patronen te generaliseren. Samenvattend laten de resultaten in dit proefschrift dus zien dat de grootte van het lexicon en type-frequentie van het allomorf van invloed zijn op de verwerving van allomorfen, maar dat fonologische vaardigheden en de complexiteit van de fonologische karakteristieken van de stam directer gerelateerd zijn aan de verschillen in de verwerving van allomorfen.

Rövid összefoglaló

VARIÁCIÓK AZ ALLOMORFOK (KÉPZÖK) KIVÁLASZTÁSÁBAN: A HOLLAND KICSINYÍTÉS ÉS MÚLT IDÖ

Milyen tényezők befolyásolják az allomorfok képzését? Az allomorfok többsége a morfémák fonológiai változatai és a fõnév vagy az ige fonológiai jellemzőitől függ kiválasztásuk. Korábbi kutatások találtak variációkat az allomorfok kiválasztásában, de különböző magyarázatokat adtak erre. Azonban eddig még hiányzott egy olyan több oldalu tanulmány, amely összekapcsolja a különbözö magyarázatokat és tisztázza a magyarázatok közötti eltéréseket. Ez a négy tanulmány vizsgálja a holland múlt idö és a kicsinyitő képzők kialakitási és kiválasztási folyamatát felnőtteknél, különlegesen fejlődő gyermekeknél és olvasási nehézségekkel küzdő gyermekeknél. A tanulmányok vizsgálják az összefüggéseket a gyermekek fonológiai jellemzők összetettségére való fogékonysága, a gyermekek fonológiai feldolgozási készségei az (ős +) allomorf formák és fonotaktikus frekvenciák tekintetében, valamint a gyermekek szókincsének mérete között.

A frekvencia típusa és a szókincs mérete természetesen szerepet játszik abban az értelemben, hogy a gyermekeknek elegendő inputra van szükségük ahhoz, hogy alkalmazni tudják a morfofonológiai mintákat a törzs fonológiai jellemzői alapján. A gyermekeknek azonban képesnek kell lenniük ezeknek a fonológiai jellemzőknek az alkalmazására, ahhoz, hogy a különböző morfofonológiai mintákat általánosítani tudják. A gyermekek fonológiai feldolgozási készségei és a fonológiai törzsek jellemzőinek bonyolultsága azonban erőteljesebb befolyást gyakorolnak, és ezért az egyes allomorfok hosszabban tartó megtanulásának közvetlen okai lehetnek. Minél jobb a gyermek fonológiai feldolgozási készsége és minél kevésbé összetettek a

fonológiai jellemzők, annál jobban képesek a gyermekek a fonológiai mintákat elkülöníteni és a megfelelő allomorfot kiválasztani.

About the author

Tiffany Alma Boersma was born on 23 December 1990 in Amsterdam. After obtaining her secondary school diploma in 2009 at the *Vossius Gymnasium* in Amsterdam, she started her studies at *University College Utrecht* obtaining her Bachelor's degree in Liberal Arts and Sciences with an interdisciplinary major in Neuroscience and Linguistics in 2012. In 2011 Tiffany studied at the *University of Leipzig* and in her final year she was part of the Sirius Programme for excellent students established by the Dutch government in 2008. During her secondary school and Bachelor years, Tiffany was an avid athlete performing at the national level. During her Bachelor's, Tiffany developed a particular interest in child language development. She wrote her Bachelor thesis on pronominal reference in Dutch-Russian bilingual children and worked as a research assistant at both *Utrecht University* and the baby lab at the *University of Leiden*.

In 2012, Tiffany started the MRes Speech, Language, and Cognition at the *Division of Psychology and Language Sciences* at *University College London*. Here she developed a particular interest in child language pathologies and wrote her Master thesis on reading and language development in children with low IQ. She also worked as a research assistant in the *Nuffield early language intervention programme* and volunteered at *Team Up*, an organisation that provides free tutoring to secondary school students from lower socioeconomic backgrounds.

In September 2013, Tiffany started her PhD at the *University of Amsterdam* on variability in the acquisition of allomorphs under the supervision of Judith Rispens, Anne Baker, and Fred Weerman. She collected a large data set and looked at several factors that possibly influence sensitivity to allomorphy. She presented her work at several international conferences such as the *European Conference on Child Language Disorders (EUCLDIS)* in Budapest, Hungary (May 2016) and the *Symposium on Research in Child Language Disorders (SRCLD)* in Madison, Wisconsin (June 2016). During her PhD, Tiffany taught language and speech development classes and gave several guest lectures. She helped organise the LOT winter school (2015) and the Anéla Juniorendag in 2015, 2016, and 2017. She has been the treasurer of *Het WAP* since 2015 and has been an active member of this organisation since 2014. She also worked as a volunteer at the *Voorleesexpress*.