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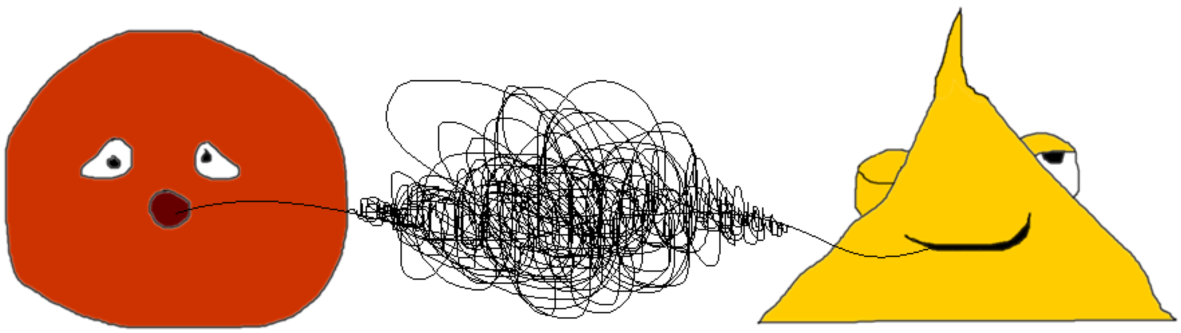

DEVELOPMENT OF METRICAL SEGMENTATION STRATEGIES IN 6- TO 14-YEAR-OLD CHILDREN

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Abstract

Both in infant and adult speech segmentation, stress cues seem to be the most reliable markers for word boundaries. Stress cues are highly language specific in the sense that metrical systems differ from language to language. English-speaking adults are believed to take each stressed syllable to mark the onset of a new word. This Metrical Segmentation Strategy (MSS) is proposed to be a universal segmentation strategy and therefore predicted to be applied by Dutch speakers as well (Cutler and Norris, 1988). However, recent research has indicated that Dutch listeners depend heavily on their native (penultimate) stress pattern when segmenting words from a speech stream (van Ommen, in prep.). This language-specific knowledge must be learned by infants in order to be able to segment words for word acquisition. Research has shown that at the age of 3, Dutch children have mastered generalizations for regular stress assignment, and by the age of 4 they have become more sensitive to less regular stress assignment (Nouveau, 1994). The development of such knowledge towards adult-like word segmentation is yet to be documented. Therefore, the research questions of this thesis are: How and to what extent do Dutch learning children apply their knowledge about the Dutch stress system during word segmentation? And how do those segmentation strategies develop during growth of knowledge about the stress system?

To answer these questions a word-spotting task was conducted with 131 Dutch children (66 male and 65 female), age ranging between 6- to 14- years. Participants were auditorily presented with two-syllable nonsense-words with opposite stress patterns (Sw or wS), associated with two pictures. These two words were affixed to different preceding nonsense syllable-strings that were manipulated for stress position (the prefixes), creating 6 different stress conditions. Participants were instructed to press a button as soon as they recognized either of the names, while their accuracy scores and response latencies were measured.

Results showed that children segment targets faster from a speech stream when their age increases. Certain stress patterns are of greater support to the child during segmentation than others and this function changes with age. Children between 6 and 8 segment native penultimate Sw targets significantly faster from a speech stream than the less native wS targets, while children older than 8 years no longer segment Sw targets faster than wS targets. The data showed that younger children are not facilitated by the stress pattern of the prefix during segmentation, but from the age of 10 onwards, a prefix with a native penultimate stress pattern (wSw) combined with a target with a native stress pattern (wSw-Sw) has a highly facilitating effect on segmentation of the target. All findings suggest a development towards application of language specific segmentation cues in Dutch learning children, where native stress patterns are highly facilitating for word segmentation in both younger and older children and the segmentation strategies for targets with non-native stress patterns develops with age.

1. Introduction

1.1 Speech segmentation

Whenever a speaker produces a multiword sentence, an acoustic signal is created. This signal does not contain segregated word-like units, but merely consists of a continuous concatenation of sounds (Adriaans, 2011). Unlike the white spaces in written text, which guide a reader in identifying individual words, speech does not contain consistent physical cues marking word boundaries (Cole and Jakimik, 1980). One could think of a spoken utterance as a single long word, containing no clearly delineated beginnings or endings: often the final sounds of one word blend with the initial sounds of the next word. In order to understand speech, the listener has to recognize word-like units in the continuous sound signal. Moreover, a single sound stream can have very different meanings based on the placement of the word boundaries: The phrase *How to wreck a nice beach* sounds similar to *How to recognize speech*, but implies something quite different (Faaborg et al., 2005).

Much research has been dedicated to discover the underlying mechanisms of word segmentation. Researchers have identified and studied the contributions of several segmentation cues ranging from universal to language specific cues. *Statistical cues* are believed to be the most universal segmentation cues. These cues consist of the statistical/distributional properties of the signal that can be seen as transitional probabilities between successive syllables being higher within words than across word boundaries (McClelland and Elman, 1986). Numerous studies over the past decade support the claim that humans are equipped with powerful statistical language learning mechanisms. Statistical learning can be captured as a strategy of tracking patterns of sounds in the input to detect linguistic units (Saffran, 2001a). An English speaker can infer from the input that the probability that the syllable *ny* will be followed by *sen* is much lower than the likelihood to encounter *fun* followed by *ny* or *sen* followed by *tence*. Based on this acquired knowledge a speaker can deduce the probability of *fun* and *ny* on the one hand, and *sen* and *tence* on the other hand, being constituents of a single unit, while the same deduction leads to the insertion of a word boundary between *ny* and *sen* (Saffran et al., 1996a).

Coarticulation cues are both universal and language specific. Speech sounds can be pronounced differently in distinctive contexts. The articulation of a sound is affected by the surrounding sounds. In the English words *key* and *coo*, the /k/ is produced differently. When pronouncing *coo*, the speaker rounds his/her lips during the pronunciation of /k/, preparing for the articulation of the following round vowel (Curtin et al., 2001). When hearing a rounded /k/ that is not preceded by a round vowel, a listener can infer that the round vowel is yet to come. The listener can then be certain that /k/ will not be followed by a word boundary.

Language specific cues can be found at several levels; the phonotactic, allophonic and prosodic level. *Phonotactic cues* include constraints on phoneme order. Phonemes can be sequenced differently within words than across word boundaries (Jusczyk, 1999). An English speaker can induce from the input that /ɵ/ is an acceptable phoneme in its native language, and that this phoneme is permitted at word beginnings. The speaker can infer that /ɵ/ can precede /r/ at word beginnings (in [th]*ree*), while a word-initial combination with /l/ or /m/ will result in a string that is unacceptable in English (Jusczyk et al., 1993). Such a string may occur elsewhere in the input, for instance in phases like *the fifth member*[1], but the listener will recognize the sequence [ɵm] as illegal and can therefore assume a word boundary.

Cues can occur at the *allophonic level*, where some phonemes are realized differently according to their position within words (Jusczyk, 1999). In English, for example, the acoustic characteristics of /t/ alter, depending on its location in the sequence. Appearing in a syllable-initial position /t/ is aspirated (in [t^h]*ea*) while it tends to be unaspirated when it occurs in a syllable-final position (in *ea*[t]) (Umeda and Coker, 1974). Listeners can associate the different occurrences of /t/ with their distinctive position within syllables and thereafter apply this information to infer word boundaries in fluent speech.

Furthermore, cues can occur at the *prosodic level*, such as regular stress in specific positions within words. Words in stress languages consist of sequences of metrically strong and weak syllables. In English, strong syllables (S) bear primary or secondary stress and contain full vowels, whereas weak syllables (w) are unstressed and contain short vowels. In the area of metrical segmentation, it has been shown that listeners use the rhythmic patterns of utterances to guide hypotheses about boundaries between word endings and word onsets. Is has been shown that English listeners are led to perceive a word boundary before a strong syllable (Cutler and Norris, 1988). This seems to be an effective strategy to segment English speech, since most words in the lexicon begin with a strong syllable (Cutler and Carter 1987).

Contrary to infants, adults have access to language specific cues, and have already built a lexicon to rely on for recognition of familiar words in the speech stream (Cutler and Norris, 1979; Cole and Jakimik, 1980). Newborn infants have yet to face the enormous task of acquiring words, since they are not born with a pre-existing lexicon. The continuous speech signal needs to be segmented into discrete words, and subsequently, when these units are identified, they have to be assigned meaning in order to be stored in a lexicon (Cunnilera et al., 2010b). For segmentation of the speech stream into separate

[1] Jusczyk et al. (1993) p. 403.

words, the infant has to start isolating language specific cues. In order to access those language specific cues, infants must have a system to extract cues from the sound pattern of their native language, which is proposed to track correlations between sound patterns and word boundaries (Pelucchi et al., 2009). It has been proposed that infants start segmenting the speech based on universal cues, and thereon built their knowledge about language specific cues (Matthys et al., 2005).

Much research has been dedicated to examine word segmentation by very young infants and adults. Based on those experiments, a consistent representation arises about the emergence of language specific cues in infants and the application in adulthood. However, the development from rudimentary application towards adult-like usage is yet to be documented. This thesis endeavors to contribute to this area of research by investigating the development of the application of language specific cues in word segmentation during childhood (6- to 14- years). Therefore, a review of several experiments on adult segmentation will be provided, followed by a section concerning infant learning of segmentation strategies. After sketching this general outline for speech segmentation, the subsequent sections will zoom in on highly language specific segmentation behavior in Dutch adults and children.

1.2 Adult segmentation strategies

Adults apply a wide range of segmentation strategies, including application of highly language specific cues, such as phonotactic, allophonic, coarticulation, metrical and lexical cues. Adults have access to such knowledge since they have had years of experience with the target language and have built a full-grown lexicon. Matthys et al. (2005) propose a ranking of segmentation strategies, consisting of three categories. Figure 1 displays the different tiers, the first being sentential context and lexical knowledge. When adults recognize a word, they have access to numerous additional details, including the word's meaning, grammatical role and connotations (Bortfeld et al., 2005). It has been shown that adults are capable of segmenting speech in a top-down fashion, applying stored knowledge of the phonological forms of pervious learned words to corresponding sequences in the speech stream for inferences about word boundaries (Cole and Jakimik,1980; Norris, 1994). Cutler and Norris (1979) propose a word identification competition between a phonemic route (bottom-up) and a lexical (top-down) route in which the phonological representation of a word is accessed from the lexicon.

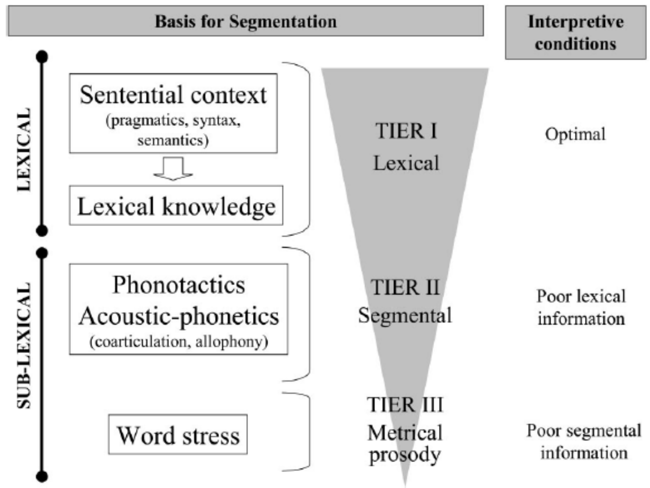

Figure 1; Hierarchy of strategies for speech segmentation, as proposed by Matthys et al. (2005), p. 488.

Matthys et al. (2005) showed by means of several experiments that in low quality speech, where lexical and semantic information were removed or neutralized, segmentation falls back on phonotactic, allophonic and coarticulation cues, represented by the second tier in Figure 1. These cues were preferred over stress, but when the signal was diminished even further, participants relied on metrical cues for segmentation. Therefore, the most basic strategy for word identification appears to rely on cues for word boundary placement provided by the dominant metrical pattern of the target language. To gain access to this knowledge, the listener must be able to identify the language-specific stress pattern, for the metrical systems in the world's languages differ considerably. Since adults have access to such knowledge, segmentation strategies based on the stress pattern of the native language seems to be a fruitful strategy for speech segmentation.

As noted in the previous section, it is suggested that English speaking adults take each stressed syllable (a strong syllable bearing primary stress and containing a full vowel), to mark the onset of a new word, whereas a weak syllable (an unstressed syllable containing only short vowels) are rarely taken to mark a word onset. This Metrical Segmentation Strategy (MSS) is proposed to be a universal strategy, but was first attested in English adults (Cutler and Norris, 1988). The authors presented a group of English speaking adults with a sequence of nonsense words and the participants were asked to press a button whenever they detected a real word in the sound stream and repeat out loud what they had conceived. The target items consisted of monosyllabic words (*mint*), embedded in either disyllabic words consisting of two strong syllables (henceforth SS) (*mintayve*) or disyllables containing a strong syllable followed by a weak syllable (henceforth Sw) (*mintesh*). The facility of detection of the word depends on the stress pattern of the combination of the syllables. The results showed that the target words were detected significantly faster when they were placed in a strong position followed by a weak syllable (*mintesh*) than in a strong position followed by another strong syllable (*mintayve*). This suggests that adult speech segmentation is driven by the detection of strong syllables, since detection of a strong syllable is delayed when it occurs in a combination of another strong syllable, but not when it is conjoined with a weak syllable.

Based on these findings, Cutler and Butterfield (1992) stated that an *initial segmentation process scans the input and places markers at the onset of each strong syllable*[2]. The authors examined a sample of spontaneous misunderstandings and assessed all present 'slips of the ear' on the positioning of the incorrect boundary insertions and deletions. Results showed that erroneous boundary insertions occur significantly more often before strong than before weak syllables, as can be seen in Table 1, whereas erroneous boundary deletions occur more often before weak than before strong syllables.

	Before a strong syllable		**Before a weak syllable**	
Boundary insertions	90	*analogy > and allergy*	45	*effective > effect of*
Boundary deletions	68	*is he really > Israeli*	107	*my gorge is > my gorgeous*

Table 1; Word boundary insertions and deletions before strong and weak syllables in spontaneous misunderstandings. Table adapted from Cutler and Butterfield (1992), p. 223.

To exclude the possibility of chance in finding these results in the sample, the authors ran a control experiment in which they presented a group of adults with unpredictable sequences of six syllables consisting of an alternating rhythm of strong (S) and weak (w) syllables. The rhythm was either SwSwSw (*Soon police were waiting*) or wSwSwS (*Conduct ascents uphill*). The utterances were presented at such reduced volume that which listeners could hear approximately 50% of the presented input. Subjects were asked to write down what they distinguished from the input. Analysis revealed that in the laboratory setting the subjects showed the same tendency to infer a word boundary before a strong syllable (see Table 2) and delete it before a weak syllable. These results signal that adults attest the patterns as predicted by MSS (Cutler and Butterfield, 1992).

	Before a strong syllable	**Before a weak syllable**
Boundary insertions	146	49
Boundary deletions	17	52

Table 2; Word boundary insertions and deletions before strong and weak syllables in faintly heard speech. Table adapted from Cutler and Butterfield (1992), p. 228.

Segmentation by means of the MSS seems a productive strategy, although an English listener who would solely be guided by the bottom-up generalization that 'English words begin with a strong syllable' (Cutler and Carter 1987; Cutler and Butterfield, 1992), would successfully segment regular

[2] Cutler and Butterfield (1992), p. 221.

words, such as *dónor* and *péncil*, with the predominant stress-initial (Sw) pattern, but would overlook words in the speech stream bearing irregular stress patterns-final (wS) patterns, such as *belóng* and *acróss* (Johnson and Jusczyk, 2001). Therefore, it has been suggested that the combined use of all language specific cues may provide sufficient information for successful segmentation, since none of these cues systematically signals boundaries between words and cohesion of successive sounds within words (Christiansen et al., 1998). However, none of these strategies are applicable by language learners who yet have to isolate segmentation cues from their target language, e.g., language learning infants and second language learners, who have only just started listening to their target language.

1.3 Infant learning of segmentation strategies

Given the complex nature of word boundary cues, word segmentation is an enormous task for infants. Infants must have a system to extract cues from the sound pattern of their native language; Matthys et al. (2005) propose an acquisition order in which infants start segmenting speech by means of stress cues before they become sensitive for phonotactic, allophonic and coarticulation cues, while segmentation based on lexical knowledge is last to emerge. This acquisition order seems reasonable, since research indicates that although adult-like segmentation based on language specific cues does not emerge before the child is 7 months old, it has long been preceded by the development of the infant's sensitivity to the prosodic structure of its native language. In the first days after birth, infants prefer to listen to speech rather than other auditory input (Colombo and Bundy, 1981). However, recent experiments have shown that infants' preference for speech sound is based on properties that are not unique to human speech. A group of neonates presented with nonsense speech, synthetic sounds and rhesus monkey vocalizations, displayed no preference for speech over rhesus vocalizations but showed a preference for both these sounds over synthetic sounds. At the age of 3 months, the infants preferred human speech to rhesus vocalizations (Vouloumanus et al., 2010).

Nevertheless, infants seem to be sensitive to the properties of their own native language at a very early stage. Nazzi et al. (1998) investigated the ability of newborns to discriminate between sets of sentences in different foreign languages and discovered that newborns use prosodic and rhythmic information from the input to classify speech into language categories, defined by global rhythmic properties. Similar results were thereafter found by Mehler et al. (1988), and Christophe and Morton (1998). 4-days-old English infants can discriminate their native language from a foreign language from a different rhythmic class, such as Japanese, suggesting that they are somehow able to encode linguistic stimuli and construct a representation of the input, more specifically, they are able to discover regularities in the speech. However, English neonates are unable to discriminate their own native language from a foreign language from the same rhythmic class: Dutch and English (Christophe and Morton, 1998; Nazzi et al., 1998). These findings suggest the rhythmic information infants initially rely upon is class-specific and not language-specific. At 5-months-old, English learning infants achieved competences to discriminate Dutch from English, indicating that 5 months of exposure to speech is sufficient to form a more language-specific representation.

Since infants are sensitive to the rhythmic structure of their native language, it seems a good starting point to break into speech segmentation. In order to build a lexicon, infants must form an association between a sequence of sounds with an object or concept (Cutler, 1994). To do so, the infant needs to be able to segment a word-like unit from the stream of speech sounds, since there is no evidence from any culture of a greater incidence of isolated words in speech to children than in other forms of speech (Cutler, 1994). An infant encounters about 90–95% of the words embedded in fluent speech (van de Weijer, 1998). As a result, infants must be able to segment fluent speech before they start building a lexicon.

It has been hypothesized that infants are able to use statistical properties of the input language to discover word boundaries, and after 6- to 7- months of exposure to their native language, infants' knowledge of the generalizations in the patterns of stressed and unstressed syllables of their native language grows, and their capability to apply those metrical patterns as a cue for segmenting word-like units from speech increases rapidly. According to Jusczyk and Aslin (1995) infants do not yet have the ability to distinguish familiar words in a speech stream at 6 months of age. Even at 6.5-months-old, infants still tend to weigh statistical cues more heavily than stress cues and therefore do not yet rely on language specific information to recognize words (Thiessen and Saffran, 2003). 7.5-month-old infants still display a tendency to use distributional cues (Jusczyk et al., 1999) but also demonstrate sufficient processing capacity for segmenting trisyllabic words, which they segment on the basis of stress (Houston et al., 2004). At 8 months, the infants' learning mechanism tunes increasingly towards the native language (Saffran, 2001a). This is reflected by the finding that they start to rely more heavily on the speech cues, such as coarticulation and stress, to indicate word onsets than on statistical cues relating to the transitional probabilities of successive syllables (Johnson and Jusczyk, 2001). These results are confirmed by Thiessen and Saffran (2003), who found that it is not until they are 9-months-old that infants learn to employ language specific information and start gradually abandoning their initial strategy to rely on statistical information during segmentation. An obvious inference is that this gradual shift from dependency on purely statistical cues towards a reliance on language particular cues during the segmentation of a sound stream is due to the increasing exposure of the native language.

Compatible results are found in a study which indicated that the development of abilities of speech segmentation takes place between 7.5 months and 10.5 months; 10.5-month-old infants turned out to be more successful in locating word boundaries based on an increased sensitivity to language specific cues, than a group of 7.5-month-old infants. Jusczyk et al. (1999) familiarized twenty-four 7.5-month-old infants with a pair of Sw disyllabic target words (*kingdom*) and subsequently presented them with passages containing the familiarized targets (*your kingdom is in a faraway place*). The results indicate that 7.5-month-old infants familiarized with isolated versions of Sw target words are able to detect these same words when they occurred in the test passages. In a second experiment a group of infants was subjected to the same experiment, but with a reversion of the test material: familiarization to the target words occurred in the context of fluent speech passages, and repetitions of target words produced in isolation were presented during the test phase. This experiment showed that 7.5-month-olds recognize disyllabic words in isolation after previously encountering the targets in sentential contexts and therefore proved that the infants were able to segment an unfamiliar word from a speech stream. That the infants were not merely focusing on the strong syllable, but parsed both syllables of the word, followed from an additional test in which the infants were familiarized with monosyllabic words in passages (*the prince will tell a joke to the king*) and then tested on isolated versions of disyllabic words that included the monosyllables targets as a strong syllable (*kingdom*). The infants did not display any notable interest in the monosyllabic target, and thus failed at segmenting a portion of these Sw disyllabic words while succeeding in segmenting the whole Sw combination.

Mirroring the previous experiments, a group of 7.5-month-old infants were familiarized with pairs of wS words (*guitar*) and thereafter presented with passages that contained the target (*the man put away his old guitar*). The results displayed that the infants did not appear to detect the target words when they occurred in sentential context. After manipulation of the input in such a way that the wS target always preceded the same unstressed word (*your guitar is really a fine instrument*), the infants parsed the strong syllable of the target and the following unstressed syllable as an Sw unit (e.g., *taris*). The authors concluded that at 7.5 months, infants identify strong syllables as onsets in fluent speech, but they are also sensitive to the distribution of syllables within the speech stream. When two syllables consistently co-occur, they are perceived as two parts of a single unit. Subsequent experiments with 10.5-month-old infants, subjected to the same experiments, showed that infants at this age are perfectly capable of segmenting wS words from fluent speech, even in contexts with potentially misleading distributional cues. This supports the view that the ability of English learners to segment wS words from fluent speech develops between 7.5 and 10.5 months. This ability to segment words with less regular stress patterns is essential for the acquisition of words with patterns that are less common in the input but are grammatical in the native language (e.g., *todáy, awáke*).

No research has been conducted to reveal the development of segmentation abilities of infants after the age of 10.5 months, and hence some general developmental data will be taken into account. On a developmental point of view, speech- language development accelerates form the first year on and at the age of 3, children are believed to have almost fully mastered the sound system of their native language and their knowledge matures during the period between roughly 3 and 7 years. This growth is based on the combination of an increase in linguistic knowledge that is acquired by the child and the growth and maturing of speech motor control (Goorhuis-Brouwer and Schaerlaekens, 2000). The child's development in production grows in tandem with, and is often preceded by, an increase of perception. This process can be illustrated by the ability of understanding two-word sentences at the age of 1- 1,5 years old followed by the emergence of two-word sentences in the production of the child at the age of 2- 2,5 as can be seen in Table 3.

Age (years)	Minimal speech potential
1,0 – 1,5	Understands two-word commands. Points out. Much and varied babbling, accompanied by understandable utterances.
1,5 – 2,0	Acquired five to ten words.
2,0 – 2,5	Understands three- word sentences. Two- word utterances with incomplete word construction.
2,5 – 3,0	Three- word utterances with incomplete word construction.
3,0 – 3,5	Three- to five- word utterances. About 50% of the utterances are intelligible.

Table 3; Language acquisition (Goorhuis-Brouwer, 2007).

At the age of 10- to12-months, infants start producing their first identifiable words (Elbers, 1982). The perception of the first words has long preceded this stage: Infants recognize the sound patterns of their own names as early as 4.5 months, and by 6 months, they are able to distinguish their names in running speech (Mandel et al., 1995). This brings us back to the development of segmentation abilities. Research indicates that infants, like adults, can employ familiar words to guide them in segmenting words in the speech stream. It is hypothesized that infants do not yet associate any semantic information with those learned phonological forms (Jusczyk, 1993), thus familiar sound sequences are sufficient to lead infants to infer word boundaries. Bortfeld et al. (2005) tested whether 6-month-old infants are able to utilize recognition of their own names to isolate and segment novel words that follow in the speech sequence. The group of infants was familiarized with sentences containing the infant's first name (e.g., *Maggie*) followed by another novel word (*the girl rode Maggie's bike*) and sentences in which the target was preceded by an unfamiliar name with the same number of syllable's and the same stress pattern (*Hannah's cup was bright and shiny*). After familiarization the infants were presented with the isolated novel words. Results displayed that the 6-

month-old infants succeeded in segmenting the novel word preceded by their own name, but did not recognize the target when it was preceded by an unfamiliar name. The authors repeated the experiment with *mommy* (familiar) or *Lola* (unfamiliar) preceding the target instead of the infant's own name and found the same results, but when *mommy* was replaced with *Tommy*, the infants failed to segment both the targets following *Lola* and the targets following *Tommy*. Even though *Tommy* sounds very similar to *mommy*, it does not guide the infant in segmenting the sound stream. These results indicate that infants as young as 6 months employ knowledge of familiar words for top-down segmentation of speech (Bortfeld et al. 2005). These results are confirmed by Shi and Lepage (2008), who showed that French learning 8-month-old infants were able to employ frequent function morphemes, such as *des*, 'of', and *mes,* 'my', to segment speech. This research supports the hypothesis that infants are able to commence building their lexicon based on only a few segmented words.

After producing their first word at the beginning of their first year, infants acquire new words at a slow pace (see also Table 3) but at the age of 1,5-year-old, most infants shift to a much faster rate of acquisition and at 2 years, they can produce 200 to 500 words (Bloom, 1973). Fernald et al. (1998) were the first to systematically examine receptive skills in early acquisition and found a corresponding increase of perceptual abilities during this period of rapid expansion of productive vocabulary. Their results demonstrate that both the speed and the accuracy of speech processing increase steadily over the second year and are thereafter rapidly progressing towards adult-like performance. Since segmentation of running speech is essential for building a lexicon, young infants must develop their segmentation skills at the same pace of progressing in perception and production skills.

Summarizing we can say that after birth, infants display a preference for speech and have some abilities to distinguish their native language from other languages. This ability increases at a fast pace and at the age of 7 months, infants start segmenting speech by means of stress cues before they become sensitive for phonotactic, allophonic and coarticulation cues, while segmentation based on lexical knowledge is last to emerge. This development continues until segmentation skills are fully adult-like. Adults apply all language specific cues (phonotactic, allophonic, coarticulation and stress cues) during bottom-up segmentation of speech, and lexical and semantic cues during top-down segmentation. Adults prefer segmentation based on lexical and semantic information, but when the quality of the speech signal decreases, segmentation falls back on phonotactic, allophonic and coarticulation cues. If the quality of the signal diminishes even further, adults will rely on stress for segmentation.

Both in infant and adult speech segmentation, stress cues seem to be the most basic markers for word boundaries. Stress cues are highly language specific in the sense that metrical systems differ from language to language. A survey of stress patterns in about 400 languages resulted in the following statistics (Hyman, 1977):

Dominant stress pattern	Number of languages	Example
Initial	114	Hungarian
Penultimate	77	Polish
Final	97	Turkish
No dominant stress placement	113	Russian

Table 4; Cross-linguistic stress patterns (Hyman 1977).

Table 4 displays the number of languages favoring a specific stress pattern. Initial (Sww[3]), penultimate (wSw) and final (wwS) stress placement can be found in languages with fixed stress as well as in languages that show a majority of words with stress on that specific position. Languages without a dominant stress position are mainly found to have a free stress system. An example of a language with a fixed stress system can be found in Polish, where stress always falls on the penultimate syllable. This in contrast to Russian, where stress is free to vary in position as a property both of individual words and of grammatical categories, such as case, number, person and gender (Baerman, 1999).

This survey indicates that languages with penultimate or final stress (e.g., closest to word-final position) occur more often than languages with stress at word beginnings. Most of the segmentation experiments reported in the previous sections have been conducted on speakers of English, a language with a predominant initial stress pattern. This word-initial stress pattern makes English highly suitable for segmentation by means of the MSS. Therefore, it might be interesting to compare these finding to similar data from languages with a (close to) word-final stress pattern, such as Dutch. Even though Dutch has formally predominant penultimate stress (Kager, 1989), statistically it is a hybrid between initial and penultimate stress (Vroomen and de Gelder, 1995) due to a very high rate of exceptions. This raises the question whether speakers of Dutch apply the MSS during segmentation, or whether the MSS is language specific (for English). To answer these questions, the following section will describe the distribution of stress patterns in Dutch.

[3] The trisyllabic example is chosen for convenience. Stress patterns apply to words with all numbers of syllables, apart from monosyllabic lexical words which are bound to be stressed.

1.4 The Dutch stress system

The Dutch stress system resembles that of English to a considerable degree, since both languages have variable lexical stress, with a strong statistical tendency for stress to fall word-initially (Cutler and Norris, 1988; Vroomen et al., 1998). In English weak syllables are usually reduced, in Dutch however, weak syllables generally contain unreduced vowels. The phonemic structure of a syllable determines the metrical strength of a syllable, based on the phoneme identity of the vowel and the number of consonants in the coda (Kager, 1989). Unstressed vowels may be reduced, although vowel reduction is much more infrequent than in English (Kager, 1989; Trommelen and Zonneveld, 1999). The English weak-strong contrast has more distinctive acoustic correlates than the Dutch difference between weak and strong syllables (Quené and Koster, 1998).

Quené (1992a) examined the frequency of occurrence of all possible combinations of strong (S) and weak (w) syllables resulting in legal Dutch words as found in a lexical database for Dutch (CELEX, 1990), containing both derived and underived words. As can be seen in Table 5, only 9.9% of the Dutch word tokens begin with a weak syllable, such as *tomáat*, 'tomato', or *kolóm,* 'column', when taking monosyllabic words into account (Quené, 1992a).

Nr. of syllables	Stress pattern	Number of types	Number of tokens
1	S	4713	24269023
2	Sw	11658	4753446
	wS	3372	1481539
3	Sww	5083	710826
	wSw	5582	1003460
	wwS	1849	257398
4	Swww	1008	80600
	wSww	1583	118438
	wwSw	3155	229714
	wwwS	853	55342
5	Swwww	108	5146
	wSwww	110	5777
	wwSww	680	40557
	wwwSw	1292	55133
	wwwwS	504	18065
Other		41	669
Total S-		22570 (54,3%)	29819041 (90,1%)
Total w-		19021 (45,7%)	3266092 (9,9%)

Table 5; Numbers of lexical types and tokens derived from the CELEX database, broken down by number of syllables and stress pattern. Table adapted from Quené (1992a).

The outcomes displayed in Table 5 are compatible with the findings of Vroomen and de Gelder (1995), stating that 87.7% of Dutch lexical words starts with a strong syllable in initial position. However, a second glance at Table 5 suggests another interpretation of the data. Monosyllabic words are bound to consist of a strong syllable which makes it unclear whether the stress pattern reflects dominant initial, penultimate or final stress. When excluding monosyllabic words from the analysis, the occurrence of initial stress in multisyllabic words shifts, as can be seen in Table 6. These data display a very different picture of the assignment of initial stress; in multisyllabic words, initial strong and weak syllables are almost evenly distributed.

Stress pattern	Number of types	Number of tokens
Total S-	17857 (48.4%)	5550018 (62.9)
Total w-	19021 (51.6%)	3266092 (37.1%)

Table 6; Numbers of lexical types and tokens of multisyllabic Dutch words derived from the CELEX database. Table adapted from Quené (1992a).

Moreover, when monosyllabic words are not taken into account, the proportion of words with penultimate stress convincingly exceeds the number of words with different stress patterns:

Stress pattern	Number of types	Number of tokens
Total -Sw	21687 (58.8%)	6027177 (68.4%)
Total other	15191 (41.2%)	2788933 (31.6%)

Table 7; Numbers of lexical types and tokens of multisyllabic Dutch words derived from the CELEX database. Table adapted from Quené (1992a).

This medley of stress positions on word level suggests a complex system of rules regarding stress placement in Dutch. Dutch occupies an intermediate position between fixed stress and free stress systems. Dutch stress assignment is, on the one hand, largely predictable since it always occurs in the final three syllables of underived words[4]. This results in three potential stress patterns: final, penultimate and antepenultimate, since main stress in morphologically underived words is prohibited further to the left. On the other hand, the distribution of main stress is determined by several subtle rules that depend on the syllable structure of the final syllables, in a quantity sensitive fashion (Kager, 1989). Syllables can be ranked by means of weight; heavy syllables will attract the quantity sensitive Dutch stress. Table 8 displays the hierarchy of syllable weight, where weight increases downward.

Nr.	Syllable type	Example
1	V	ə
2	V_iV_i	a:
3	VC, V_iV_j	ɑn, ɑu
4	VCC, VVC	ɔnt, e:n

Table 8; hierarchy of Dutch syllable types, adapted from Kager (1989), p. 257 and p. 262).

[4] Although Table 5 contains stress patterns of the type Swww, Swwww and wSwww (Quené, 1992a), such stress patterns are probably merely found in derived words containing stress-attracting prefixes.

The lightest syllable type (1), consisting of a short vowel (V), hardly ever occurs overtly in the output, since Dutch has a lengthening rule for prevocalic and final syllable vowels, with the exception of the schwa occurring frequently at word endings. The most general distributions of main stress in underived Dutch words by means of syllable weight can be captured by the following generalizations (Kager, 1989):

- The first rule being that, when the final syllable of the word ends with a vowel (-V), stress falls on the penultimate syllable: *pánda, '*panda'.
- When the final syllable ends with a consonant (-VC), the stress may either be penultimate in words where the penultimate syllable is of the shape consonant-vowel (X-VC-VC): *eléktron,* 'electron', or antepenultimate when the penultimate syllable ends in a vowel (X-CV-VC): *ánanas*, 'pineapple'.
- Furthermore, when the final syllable contains a long vowel followed by one consonant, or a short vowel followed by one or several consonants, the syllable is considered as superheavy, either -VVC: *magnéet*, 'magnet', –VCC: *alért*, 'alert', or -VVCC: *jalóers,* 'jealous', and will attract the main stress.

However, a variety of exceptions is present in the output:[5] According to the first generalization, words ending in an open syllable receive penultimate main stress, regardless of the structure of the penultimate syllable. The exceptions of this generalization are words with an open final syllable receiving either antepenultimate stress: *Cánada*, 'Canada', and *bróccoli*, 'broccoli', or final stress: *menú*, 'menu', and *chocolá*, 'chocolate' (Visch and Kager, 1984). Furthermore, words ending in a closed syllable receive either penultimate stress in case of a closed penultimate syllable or antepenultimate stress when the penultimate syllable is open. Again, several exceptions occur: Some words ending in closed syllables receive final stress while the penultimate syllable is closed: *balkón*, 'balcony', or penultimate stress when the penultimate syllable is open: *Celébes*, 'Celebes', or final stress when the penultimate syllable is open: *kolóm*, 'column' (Visch and Kager 1984).

As a result, Dutch listeners are confronted with polysyllabic words where stress placement varies between three different positions, e.g. *pínda*, 'peanut', *ánanas*, 'pineapple', and *magnéet*, 'magnet'. This raises the question whether the MSS is a reasonable strategy for word segmentation in Dutch. The following section discusses whether Dutch adults apply the MSS during word segmentation, or rather rely on language specific cues.

1.5 Universal and language-specific segmentation strategies

[5] It goes beyond the scope of this analysis to review appearances of superheavy syllables. For a complete assessment of the behavior of superheavies, see Kager (1989).

At first glance did the data found by Quené (1992a) suggest that application of the MSS in Dutch is reasonable on statistical grounds. Vroomen and de Gelder (1995) conducted an experiment to explore adult segmentation by means of the MSS. A group of Dutch adults was asked to detect strong (e.g., *melk*, ‘milk’) syllables embedded in disyllabic nonsense strings. The second syllable was either weak (*melkem*) or strong (*melkeum* and *melkaam*). Results showed that the combination of the target with a weak syllable had a much larger facilitating effect on the detection of *melk*, than placement of the target before a strong syllable. Vroomen et al. (1998) imitated the experiment of Cutler and Butterfield (1992), modified for Dutch listeners. A group of adults listened to barely audible sentences and were found to insert erroneous word boundaries before strong syllables: *beroemd gedicht* > *beroemdste vis*, ‘famous poem’ > ‘most-famous fish’, and delete them before weak syllables, such as: *intern besluit* > *de kerker sluit*, ‘internal conclusion’ > ‘the jail closes’. These demonstrations of adult employment of the Metrical Segmentation Strategy mirror the evidence of application of the MSS in English.

However, the revised statistics in Table 6 and 7 demand reconsideration of the initial generalization of the MSS. If native speakers of Dutch segment words beginning with a strong syllable by means of the MSS, they must either adopt separate segmentation strategies for the recognition of words with different stress patterns, or apply a totally different strategy than the MSS. Beside the evidence found by Vroomen and de Gelder (1995) and Vroomen et al. (1998), suggesting application of the MSS by Dutch adults, there is evidence against application of the MSS which can be found in the different manifestation of stress in Dutch compared to English. The MSS relies on vowel reduction for recognition of the difference between weak and strong syllables (Fear et al., 1995), while a variety of Dutch weak syllables contain unreduced vowels (Kager, 1989).

Quené en Koster (1998) conducted a word spotting experiment to assess the role of vowel quality in word segmentation by Dutch adults. All subjects were auditorily presented with a set of target words, allocated to five different conditions. Targets contained a phonologically short vowel (e.g., *flits*, ‘flash’). CV sequences where attached to the words, in order to compose disyllabic non-words. The CV syllables contained either a schwa (*flitsef*), a short vowel (*flitsif*) or a long vowel (*flitsief*). The fourth and fifth condition were created by placing stress either on the initial (*flítsif*) or the final syllable (*flitsíf*) on some of the targets. Subjects were asked to press a button when they heard the beginning of a Dutch word in the stream of nonsense syllables. Results showed that none of the vowel contrasts had any effect on the recognition of words. In contrast, the placement of stress strongly affected the detectability of the target word. It seems therefore that Dutch adults rely on acoustic side effects of stress instead of vowel reduction when segmenting a word from the speech stream.

Additional evidence against application of the MSS Dutch adults was found in a cross-linguistic experiment by van Ommen (in prep.). A group of Dutch, Turkish, Hungarian and Polish speaking adults were tested on the facilitating role of stress cues for word segmentation. All subjects were presented with sentences in which the stress conditions varied (see Table 9) during a word-spotting task.

Nr	Condition	Prefix	Target
1	Final-final	wwS	wS
2	Final-initial	wwS	Sw
3	Penultimate-final	wSw	wS
4	Penultimate-initial	wSw	Sw
5	Initial-final	Sww	wS
6	Initial-initial	Sww	Sw

Table 9; overview of the different stress conditions (van Ommen and Kager, 2012)

Subjects were presented with two words that were associated with two pictures. One of the pictures was connected with an Sw target, the other with a wS target, in order to measure the supporting role of regressive cues. Regressive cues were hypothesized to play a role when only the Sw pattern of the target facilitates segmentation; the stressed first syllable would guide the listener to place a word boundary before the target and thereby segment the target faster from the speech steam. After familiarization subjects were asked to detect the targets, which were preceded by nonsense strings (prefixes in Table 9). Stress placement in the prefixes was applied to assess the role of progressive cues, where the stress pattern of the preceding context facilitates segmentation. A prefix with word-final stress (wwS) was hypothesized to lead the listener to infer a word boundary after the stressed final syllable and thereby anticipate segmentation of the target. Subjects were asked to press a button when they recognized one of the targets in the speech stream, while response latencies were measured from onset of the target.

Canonical stress patterns differ among the investigated languages; Turkish has a stress-final (-wS) pattern, while Dutch and Polish have penultimate stress (-Sw) and in Hungarian stress falls word-initial (Sw-). Therefore, nativeness of the stress conditions was coded in such a way that 0 indicates a non-native stress pattern, and 1 denotes a pattern that is natural in the language (see Table 10).

Nativeness Context	Nativeness Target	Hungarian	Polish	Turkish	Dutch
0	0	wwS-wS	wwS-wS	wSw-Sw	wwS-wS
0	0	wSw-wS	Sww-wS	Sww-Sw	Sww-wS
0	1	wwS-Sw	wSw-Sw	wSw-wS	wwS-Sw
0	1	wSw-Sw	Sww-Sw	Sww-wS	Sww-Sw
1	0	Sww-wS	wSw-wS	wwS-Sw	wSw-wS
1	1	Sww-Sw	wSw-Sw	wwS-wS	wSw-Sw

Table 10; Nativeness of stress conditions, where 0= non-native, 1 = native (van Ommen, in prep., p. 18).

This experiment makes it possible to test the universality of the application of stress cues against the language specificity. If the Metrical Segmentation Strategy (Cutler and Norris, 1988) is a universal segmentation strategy, it would be expected that Turkish listeners would display smaller latencies on non-native Sw targets than on wS targets bearing their native stress pattern. It was furthermore hypothesized that conditions in which two neighbouring stressed syllables occur (for example wwS-Sw) this so called 'clash' would facilitate boundary detection for all subjects, since two adjacent stressed syllables can never be part of the same word. Clash was therefore hypothesized to be a universal facilitating cue. Contrary to conditions in which the boundary must be placed between two unstressed syllables (for example Sww-wS), i.e., 'lapse', which was predicted to delay target detection in all language groups, resulting in longer latencies. If listeners are facilitated during word segmentation by the canonical stress pattern of their native language only, conditions scoring a 1 on nativeness (see Table 10) are expected to result in smaller latencies than conditions scoring a 0. Conditions in which both target and prefix score a 1 are expected to result in the smallest latencies.

Overall the results display a significant effect of initial stress on the target, but no significant effect of final stress on the prefix suggesting no effect of progressive cues. No universal facilitating effect of stress clash or lapse was found. This seems to be evidence in favor of the universality of the MSS. However, looking closer at the different language groups, it was found that for all languages facilitating effects of native stress patterns were found in both the prefix and the target. Per language, the Turkish group displayed a significant effect of native stress (wwS) on the prefix and a trend toward a significant effect on the target (wS). The Dutch group showed a significant effect of native stress (wSw) on the prefix and a trend for native stress on the target (Sw) and the interaction between target and prefix. The Hungarian and the Polish groups revealed a significant effect of native stress on the prefix only. For each language, a facilitating effect of native stress on segmentation was found, while universal stress cues were not systematically applied for boundary inference. Initial stress seemed facilitating for boundary placement, but this was an effect found in all language groups together. Facilitating effects of wS patterns in the Turkish group were overruled by the three other language groups who were all expected to display a facilitating effect of Sw patterns, reflecting either preference for initial or penultimate stress. Consequently word segmentation in adults seems to rely on native stress patterns, and may therefore be designated as a language-specific process.

The results found by van Ommen display that the Dutch listeners depended more (both in context, target and the interaction between context and target) on their native stress pattern when segmenting words for a speech stream, than the other language groups. If native stress cues are thus important for word segmentation by Dutch adults, it is interesting to explore the maturation of knowledge of the

Dutch stress system and the development in application of this knowledge for word segmentation. Newborns rely on universal cues for isolation of language specific cues and during maturation learn to apply their language specific cues for word segmentation. When infants have developed adult-like segmentation strategies with age, they eventually fully rely on language specific cues. This development is highly underexposed in the literature about metrical segmentation and will therefore be further explored in the next sections.

1.6 The development of knowledge of the Dutch stress system

In an experiment that tested the degree in which 3- and 4-year-old Dutch children have mastered the Dutch stress system, Nouveau (1994) divided words in different classes of stress loci, ranging from regular to very irregular (see Table 11). The children were tested during an elicitation experiment about whether the degree of irregularity of the test words would affect the number of erroneous stress placements during production, and whether errors would result in more regular stress patterns.

Final syllable	A	B	C
open (-V)	Aréna	Cánada	Chocolá
closed (-VC)	Celébes	Klarinét	

Table 11: Division of Dutch words into three different categories: (A) regular cases (B) exceptional words and (C) very irregular cases. Table adapted from Zonneveld and Nouveau (2004) p. 372.

Results showed that children in both groups were more accurate in repeating words with regular than in irregular stress and that errors resulted in stress patterns with the same amount of irregularity or less irregularity than the stress pattern of the target word, but never more. Subsequently 20 3-year-olds and 20 4-year-olds were tested during an imitation experiment where targets consisted of nonsense words with contrasting stress positions. The second experiment was based on the same hypothesis as the first: the ease of production would depend on stress type, and errors would lead to more regular forms. The nonsense words were designed to have a close resemblance to existing words and were pretested on Dutch adults. The group of adults was presented with the words in written form while the stress pattern remained undetermined. The adult subjects were asked to read them out loud, and thereby established the stress pattern. The regular stress pattern of individual words was then determined by the responses of the adult group (group A, in Table 12), and all deviations were marked as exceptional (group B), or very irregular (group C).

Final syllable	A	B	C
open (-V)	Fenímo	Fénimo	Fenimó
closed (-VC)	Jákot	Jakót	

Table 12: Grouping of nonsense words as applied during the second test, categorized by: (A) regular, (B) exceptional, and (C) very irregular. Table adapted from Nouveau (1994) p. 372.

The children were auditorily presented with the nonsense words and were asked to repeat them. The results revealed that there is a very significant relationship between the degree of irregularity of the stress pattern and the error rate, where items from category (A) were easier to imitate than items from category (B), while words from category (B) evoked less stress misplacements than words belonging to category (C), as can been seen in Table 13. These results indicate that children have already mastered most generalizations of the stress system of their native language by the age of 3, and slowly develop this knowledge with age, since the group of 4-year-olds showed a slightly higher accuracy.

Target	Percentage of errors	
	3- year olds	4- year olds
Jákot (A)	15%	-
Fenímo (A)	10%	25%
Jakót (B)	30%	5%
Fénimo (B)	30%	10%
Fenimó (C)	40%	30%

Table 13: Error rates for both groups of subjects, for two test items bearing different stress patterns.

Overall, the group of 4-year-olds was more accurate in imitating items from category A and B, with exception of the high error rate found in repetitions of *fenímo*. This latter finding will be explained on the following page. The increase of accuracy indicates that the knowledge of the stress system gradually expands, but is not yet complete by the age of 4 (Zonneveld and Nouveau, 2004), as can be seen in Figure 2. During the pretest, the group of adults unanimously preferred *jákot* over *jakót*, and this tendency is evidently present in both groups. Figure 2 shows furthermore that the group of 4-year-olds is far more accurate in producing the regular stress pattern than the group of 3-year-olds, depicting an overall maturation of the stress system.

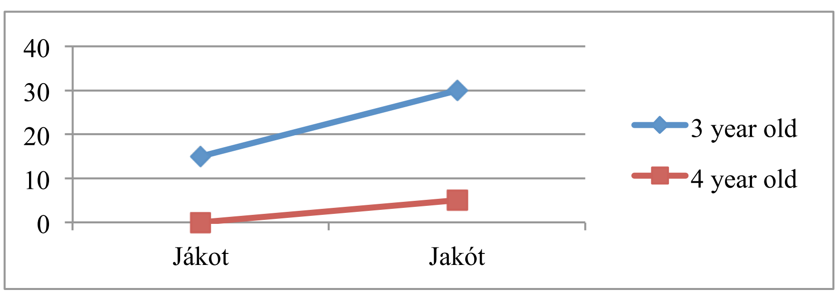

Figure 2; Visual representation of the differences in error rates (in percentages) between 3-year old and 4-year-old children for a CV-CVC sequence with two different stress patterns. Adapted from Nouveau (1994) p. 229.

More interesting though, is the increase of facility to produce stress patterns associated with category (B). The decrease of erroneous productions of words with an exceptional stress pattern between the 3th and the 4th year is larger than the decrease of errors made during production of regular (type (A)) stress patterns. This indicates a fine-tuning towards minor generalizations which are responsible for the assignment of divergent, though legal, stress patterns. It is important to note that at the age of 4, this growth towards the adult stress system is not yet fully completed; the group of 4-year olds still made errors in 5% of the productions of irregular stress patterns.

Figure 3 displays the error patterns in production of *fenimo*. The preferred stress pattern was expected to be wSw conform the Dutch penultimate stress placement. During the pretest, the group of adults preferred Sww (75%) over wSw (5%) and wwS (20%), probably due to similarities to frequent words like *ánimo*, 'zest', *dóminee*, 'vicar', and *Áfrika*, 'Africa'. Generally, when the final syllable does not attract stress (either –V or –VC) and the penultimate syllable contains an /i/, stress will be placed on the antepenultimate syllable (Neyt and Zonneveld, 1982).

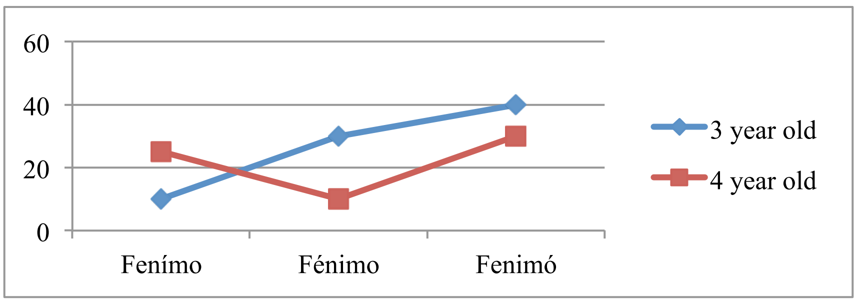

Figure 3; Visual representation of the differences in error rates (in percentages) between 3-year old and 4- year old children for a CVCVCV sequence with three different stress patterns. Adapted from Nouveau (1994) p. 227.

This pattern is reflected in the productions of the 4-year old children, which displayed a very low error rate (10%), compared to errors in the canonical penultimate wSw (25%) and the very irregular wwS (30%) pattern. Contrary to the adults and the 4-year olds, the group of 3-year olds display the expected preference; a low error rate in the production of wSw (10%), a lower accuracy (30%) in production of items belonging to category (B) and a highly inaccurate performance on very irregular stress patterns (40%). This suggests that at the age of 3, children have mastered generalizations for weight sensitive stress application and overgeneralize this knowledge at the cost of less regular stress assignment, such as the inferring role of /i/ in the placement of penultimate stress. By the age of 4, children have become more sensitive to irregular stress assignment and perform adult-like when comparing the structure nonsense words with existing words to determine stress placement. This indicates that knowledge of the native penultimate stress pattern is almost fully internalized at the age of 4. However, the question whether young children can apply this knowledge for speech segmentation remains yet to be answered.

1.7 Research question and hypothesis

Summarizing the previous sections we have seen that 7.5-month-old English learning infants are able to segment disyllabic Sw words from sentential contexts, but are not able to segment wS words from a speech stream until the age of 10.5 months. This consecutive development seems effective since most English words begin with a strong syllable and English-speaking adults are believed to take each stressed syllable to mark the onset of a new word. This Metrical Segmentation Strategy (MSS) is proposed to be a universal segmentation strategy and therefore applied by Dutch speakers as well. This seems reasonable since at first glance, the majority of Dutch lexical words start with a strong syllable. But when discarding monosyllabic words, penultimate stress exceeds every other stress pattern in Dutch multisyllabic words. Several experiments indicate that Dutch adult listeners do not rely on the MSS for word segmentation. This is not surprising, since the MSS is an inadequate strategy for segmentation of words with penultimate stress consisting of more than 2 syllables. Recently it was shown that Dutch listeners heavily depend on their native stress pattern when segmenting words from a speech stream, which suggests a language- specific segmentation strategy in Dutch adult listeners. This language-specific knowledge about the native stress system must be learned by infants in order to be able to segment words for word acquisition. Research has indicated that at the age of 3, Dutch children have mastered generalizations for weight sensitive stress application and overgeneralize this knowledge to less regular stress assignment, and by the age of 4 they have already become more sensitive to irregular stress assignment. It is clear that children will eventually arrive at a stage in which their knowledge about the Dutch stress system is completely adult-like. This development towards adult-like word segmentation is yet to be documented. Therefore, the research questions of this thesis are:

- How and to what extent do Dutch learning children apply their knowledge about the Dutch stress system during word segmentation?
- And how do those segmentation strategies develop during growth of knowledge about the stress system?

No research has, to my knowledge, been conducted thus far to answer these questions. The experiment of van Ommen (in prep.) will be conducted with Dutch primary-school children, to investigate the development of language specific segmentation strategies as found in the group of Dutch adults. The following effects are hypothesized to be of influence on the data:

Effect of prefix and target:

1. When conjoined with a target, the prefix with penultimate stress (wSw) will evoke smaller latencies than strings with a less regular Dutch stress pattern (Sww and wwS) conjoined with the same target
2. Similar to the results of van Ommen, latencies in the wSw-Sw condition are expected to remain smallest at any age.

Effect of target:

3. The target bearing penultimate stress (Sw) will evoke smaller latencies than a target bearing a non-native stress-final pattern (wS) regardless of the prefix.

Effect of prefix:

4. Regardless of the target, the prefix with penultimate stress (wSw) will evoke faster latencies than prefixes with a less regular Dutch stress pattern (Sww and wwS).

Effect maturation of metrical segmentation strategies:

5. Latencies of all conditions will decrease with age.
6. The preference for items containing the Sw target will be larger in younger children than in older children.
7. Latencies of the conditions containing the Sw target will decrease slower than latencies in all conditions containing the wS target, reducing the initial large difference between the targets.
8. The preference for items containing the wSw prefix will be larger in younger children than in older children.
9. The latencies of the conditions with the wSw- prefix will decrease slower than latencies in conditions containing the other two prefixes, reducing the initial large difference between the conditions with the prefixes.

This hypothesized development is displayed in Table 14:

Age ↓	wSw-Sw >>>>>> Sww-Sw, wwS-Sw >> wSw-wS >> Sww-wS, wwS-wS
	wSw-Sw >> Sww-Sw, wwS-Sw, wSw-wS, Sww-wS, wwS-wS

Table 14; Hypothesized hierarchy of conditions, arranged by hypothesized segmentation rate of the target.

To test these hypothesized answers to the research question, an experiment was designed and conducted with 6- to 14- year-old Dutch children.

2. Methods

2.1 Word spotting task

Most experiments on word segmentation have been conducted by means of a word-spotting task. During a word-spotting task, listeners are auditorily presented with a list of nonsense syllable sequences, in some of which familiar words are embedded (McQueen et al., 1994). The listeners' task is to detect those embedded word and press a button, while their response latencies and accuracy scores are measured. Therefore the word-spotting task is an excellent method to study competences of continuous speech segmentation, since it requires listeners to segment words out of a syllable string (Cutler and Norris, 1988). Van Ommen (2012) based the design of her segmentation task on the target-detection task Kabak et al. (2010) where participants were presented with a visual target, followed by an auditory nonsense string. The task was to determine whether the auditory string contained the visual stimulus. Van Ommen replaced the orthographic target by an auditory version. During a training phase, participants were auditorily presented with the two nonsense-words. These words were associated with two pictures and always presented simultaneously with the related word to enforce a lexical entry. These two words were then affixed to different preceding contexts, composed of nonsense syllables and manipulated for stress position (henceforth prefixes), creating different conditions for systematic testing. Both the effect of the target (regressive cues) and the preceding sequence (progressive cues) on response latencies of the subjects were examined. This adapted design was further modified to make it suitable for children a pre-tested during a pilot.

2.2 Participants

Participants were 131 children (66 male and 65 female), age ranging between 73- to 159- months old (mean: 110.87) from two different primary schools: Jan van Rijckenborgh School, Heiloo (69 children), and Jan van Rijckenborgh School, Hilversum (62 children), both in the Netherlands. All parents were informed two weeks before the first experiment commenced, by means of a section in the school newsletter (as can be found in Appendix 1, on page 55). None of the parents objected, hence all children were asked to participate voluntarily. After the task, each participant was questioned according to a questionnaire (as can be found in Appendix 2, on page 56), to establish the native language(s), handedness and whether the participant had speech, reading or hearing disorders.

16 children were left-handed, while 115 children were right-handed. 26 children were bilingual, Dutch always being one of their native languages: 8 children spoke English as a second (native) language, 4 French, 4 Spanish, 3 German, 2 Greek, 1 Norwegian, 1 Moroccan, 1 Bulgarian, 1 Hungarian, and 1 Russian. 2 children were trilingual: 1 spoke, apart from Dutch, both English and Greek and 1 spoke

both Moroccan and Flemish. 14 children were reported having a speech or reading disorder: 13 were either diagnosed with dyslexia or suspected to be dyslexic, and 1 child had a history of articulation disorders. Analysis demonstrated that neither bi- or multilingual children, nor children with speech or writing disorders needed to be excluded from the data set.

The task comprised a training phase and a test phase. The training phase consisted of a word-picture matching task, where subjects were presented with 10 items. Overall subjects were highly accurate in matching the correct name with the belonging picture. Subjects were excluded on the basis of the following criteria: the first exclusion criterion was an accuracy rate of less than 70% in the target-to-picture matching task, resulting in the exclusion of 4 participants:

Error rate:	Participants:
5 (excluded)	1
4 (excluded)	3
3	2
2	12
1	30
0	83
Total included:	127

Table 15; Summary of the error rates during the training phase.

Furthermore, 5 subjects were excluded for displaying a false alarm rate (a response to a filler without target) of more than 20% during the test phase, resulting in a group of 122 children (15 left-handed and 107 right-handed children).

2.3 Materials

Items were adopted from van Ommen (2012) and consisted of five-syllabic nonsense strings, composed of a prefix followed by a target. Each prefix consisted of three CV syllables. Table 7 shows two examples: /badusu/ and /felisi/. Targets were either /darnam/ or /mernel/, both of type CVCCVC. Combination of prefix and target resulted in a CVCVCV-CVCCVC string, e.g.; /badusudarnam/ or /felisimernel/. Main stress was assigned to one of the syllables of the prefix, and to one of the syllables of the target, suggesting two word-like units. This resulted in six different conditions, since the prefix provided three possible stress positions, and the target could receive stress on two different locations:

Nr	Condition	Prefix	Target	Example
1	Final-final	wwS	wS	badusudarnam, felisimernel
2	Final-initial	wwS	Sw	badusudarnam, felisimernel
3	Penultimate-final	wSw	wS	badusudarnam, felisimernel
4	Penultimate-initial	wSw	Sw	badusudarnam, felisimernel
5	Initial-final	Sww	wS	badusudarnam, felisimernel
6	Initial-initial	Sww	Sw	badusudarnam, felisimernel

Table 16; overview of the different test conditions.

All items were phonotactically legal in Dutch and were controlled for overall syllable frequency and for frequency in stressed and unstressed position. Furthermore, possible interfering segmentation cues, such as positional frequency of syllables were avoided and closed syllables did not occur in the prefix. After recording, items were manipulated to create a different stress pattern for each condition, while keeping all other phonetic factors constant across conditions.

Targets differed in type of vowels; /darnam/ contained only back vowels, while the vowels in /mernel/ are all pronounced in the front of the mouth. Both targets were embedded in 20 segmentally different prefixes, producing 40 different experimental items. Each item was recorded with all six different stress patterns, which generated 240 different items. Items were divided over 4 lists. List 1 and 2 contained items in which the targets /darnám/ and /mérnel/ were embedded, while list 3 and 4 included /dárnam/ and /mernél/ (see Appendix 5 on page 60 for all items, categorized per list). Items were characterized as follows:

Stress pattern		Code	Example	Code	Example
A	wwSwS	Front 1A	bidiFImerNEL	Back 1A	baduSUdarNAM
B	wSwwS	Front 1B	biDIfimerNEL	Back 1B	baDUsudarNAM
C	SwwwS	Front 1C	BIdifimerNEL	Back 1C	BAdusudarNAM
D	wwSSw	Front 1D	bifiDIMERnel	Back 1D	baduSUDARnam
E	wSwSw	Front 1E	biFIdiMERnel	Back 1E	baDUsuDARnam
F	SwwSw	Front 1F	BIfidiMERnel	Back 1F	BAdusuDARnam

Table 17; categorization of experimental items.

Items were divided over lists in such a way that, according to Table 17:

- list 1 contained F1a (Front 1a), F1c and F1b, B1e (Back 1e), B2d, B2F etc.
- list 2 contained F1b, F2a, F2c, B1d, B1f, B2e, etc.
- list 3 contained F1d, F1f and F2e, B1b, B2a, B2c, etc.
- list 4 contained F1e, F2d, F2f, B1a, B1c, B2b, etc.

Thus, not all lists contained all items, but frequency of conditions per list was controlled for. Fillers were constructed to avoid a bias for position of the target in the string as well as a bias for a positive response: fillers either contained a target in antepenultimate position (filler 1), a target in penultimate position (filler 2) or no target at all (filler 3). Filler 1 and 2 were paired with the test items in such a way that the stress patterns in the targets were equal. Each list was constructed of 60 test items, 20 filler 1 items, 20 filler 2 items and 80 filler 3 items, thus 180 items in total.

Van Ommen (2012) recorded all items as a single unit to avoid phonetic segmentation cues between prefix and target. Each item was spoken by a female native speaker of Spanish, once with stress on the first, and once with stress on the second syllable of the target, the prefix was always recorded without stress. All items were pronounced in a carrier sentence, with phrase accent on the embedded target. Thereafter, conditions with different stress patterns were created through resynthesis, while all other phonetic factors were kept constant across conditions. Phonetic adjustment was applied by means of the program Praat (Boersma and Weenink, 2011); the length of the three vowels of the prefix was controlled for by standardizing the duration. Then the stressed syllable was lengthened by a ratio of 1.5. The pitch of the prefix was made flat and the stressed syllable received a boost of 8 semitones, with the peak after the first quarter of the overall duration of the vowel. Then the overall amplitude of stressed syllable was increased with 8 dB. Five native speakers of Dutch judged the acceptability of the stress patterns, by indicating which syllable was stressed and whether the language sounded like 1) their own language, 2) another language, or 3) a computer language. 4 listeners judged the language to sound like a foreign language, 1 listener identified it as a computer language.

2.4 Procedure

The experiment was conducted in a quiet room. Both at the school in Heiloo and the school in Hilversum a secluded office was allocated as test room. Participants were randomly invited to participate and were received individually for testing. Participants were seated behind a desk on which a laptop and a button box were placed and received a Sony MRD-V50 headphone. The experiment was designed in ZEP (Veenker, 2011) and ran in real-time Linux. Setup was positioned in such a way that the researcher was seated outside the gaze of the participant, but was able to monitor performance and progress (see Figure 4).

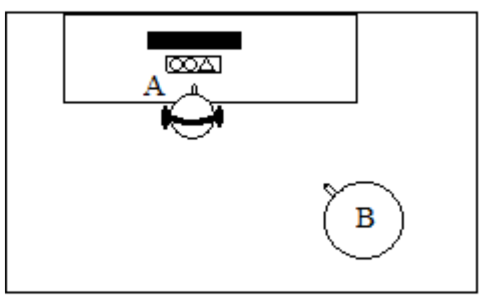

Figure 4; Experimental setup and position of participants (A) and researcher (B).

After initiation of the test a recording was played, welcoming the participants and explaining that they participated in a game and thereafter providing further instructions (see Appendix 3 on page 57 for the complete instructions). Then, two creatures were visually introduced during two short animations, while their names were auditorily presented with four different tokens of the name belonging to the creature. A circular red creature was introduced as /darnam/ and a yellow triangular creature was presented as /mernel/.

Introduction was followed by an instruction where participants were asked to look at the button box. The box contained 3 buttons, each marked with a sticker; the button on the left was marked with the picture of *Darnam*, the middle button was marked with a red circle and the right-most button represented *Mernel*. During a training phase participants were presented with one of the two names and were asked to indicate the corresponding creature by pressing the correct button. Participants received auditory feedback on their response. The introduction and training phase were designed to enforce a lexical entry of the non-word to function as a target during the subsequent segmentation task.

Figure 5; Visual representations of Darnam (left) and Mernel (right).

The segmentation task was preceded by a practice phase in which participants were explained that they would listen to an alien language in which the names of the two creatures were hidden. They were instructed to press the middle button as soon as they recognized either of the names. It was emphasized that participants pressed immediately when they identified one of the names, since response latencies were measured from target onset. Items were preceded by a fixation cross, followed by the auditory presentation of the item. After responding by pressing a button, the creatures appeared on the screen and participants were provided with feedback. In case of a false alarm (e.g., the participant responded to an item in which no target was imbedded) a large red cross would appear on the screen and the participant was told that there was no need to press any button. When participants responded correctly to an item containing a target, they were praised and asked to choose the right creature and press the corresponding button. The practice phase consisted of twelve items, of which 50% contained a target. Before commencing on the test phase, participants received a sticker card (see Appendix 4, on page 59) and were explained that they would play the game 4 times and would be rewarded with a sticker after each game. After completion of the sticker card, they would receive a treat. During the test phase participants no longer received any feedback, except for the red cross in case of a false alarm. This negative feedback was retained through all phases of the experiment in order to prevent of a response bias. Each block of the test phase contained 45 items, randomly selected from a list of 180 items, and presented with an inter stimuli interval of 2 seconds.

3. Results

3.1 Analysis

Statistical analysis of the results was performed by means of IBM SPSS 20. The overall accuracy rate across participants ranged from 84.8% correct responses for filler 1, to 94.6% for items without a target (see Table 18). 5 subjects were excluded based on their number of incorrect responses of more than 1 standard deviation below the mean for items containing no target. Test items evoked an accuracy of 92.9%.

Item	Mean	Standard deviation
Overall	91.9%	0.273
No target (filler 3)	94.6%	0.226
Target (filler 1, 2 and test)	89.8%	0.303
Test	92.1%	0.270
Filler 1	84.8%	0.359
Filler 2	87.7%	0.328

Table 18; Accuracy rates across participants, categorized per type of item.

Reaction times for correct responses were log-normalized and analyzed using Mixed Linear Modelling. This method of data analysis has the advantage of performing a full analysis with multiple random factors simultaneously (Quené and van den Bergh, 2008). In order to create a model that best explained the variation in the data, first a model was built explaining variation of the log-transformed latencies only. Thereafter, all possible factors were added one by one to examine their possible explanatory values. Each subsequent model was compared to the former models to see whether the added factor significantly contributed to the model. Factors that were not significant were removed if they did not result in significant interactions. Factors that had explanatory value on the variation in the data were:

- the stress conditions,
- age in months,
- the interaction between stress condition and age,
- the creature,
- and the sequence of presenting the items.

These factors were adopted in the model as fixed factors. Crossed random factors, allowing for random intercepts and slopes (Quené and van den Bergh, 2008) were subjects and items.

When the latencies of both the left-handed and right-handed children were treated as a single group during analysis, it became clear that handedness had a very large effect on the data. The interaction between the factors condition, age and handedness was very significant (F=2.767, p=0.017), which gave rise to analyze both groups separately. Left-handed children (15) display a very deviant pattern compared to the group of right-handed children (107). Therefore, the results of the two groups will be discussed independently.

3.2 Model 1: Effect of prefix and target combined

The first model investigates the effect of the individual stress conditions, which means that the effects of the prefix and the target of a stress condition are combined. The group of right-handed children displayed a very significant effect of both the age (F=6.227, p=0.014), the stress conditions (F=3.842, p=0.002) and the interaction between age and stress conditions (F=2.663, p=0.21). This effect remained significant after application of the Bonferroni-correction. Figure 6 visualizes the decrease of latencies with the increase of age, categorized per stress condition:

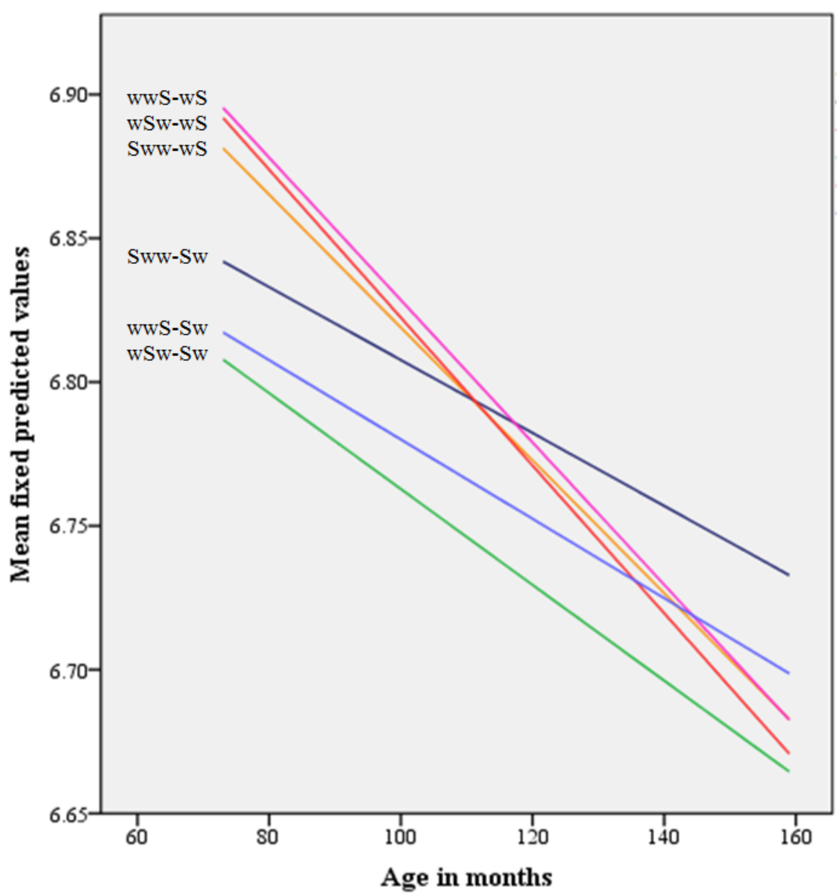

Figure 6; The decrease of mean latencies over time, categorized per stress condition, as displayed by the group of (107) right-handed children.

Table 19 displays to what extend the latencies for the individual conditions differ from each other. Significant differences between conditions are displayed in bold:

	Sww-wS	Sww-Sw	wSw-wS	wSw-Sw	wwS-wS	wwS-Sw
Sww-wS	-	**.017**	.668	.196	.837	*.092*
Sww-Sw	**.017**	-	**.005**	.263	**.009**	.462
wSw-wS	.668	**.005**	-	*.086*	.823	**.035**
wSw-Sw	.196	.263	*.086*	-	.134	.697
wwS-wS	.837	**.009**	.823	.134	-	*.058*
wwS-Sw	*.092*	.462	**.035**	.697	*.058*	-

Table 19; P-values for the differences in latencies found in individual conditions. Significant differences are displayed in bold, trends are displayed in italic.

This table shows that significant differences are mainly found between conditions containing targets with an opposite stress pattern:

- Sww-wS decreases significantly faster than Sww-Sw,
- Sww-Sw decreases significantly slower than Sww-wS, wSw-wS and wwS-wS,
- wSw-wS decreases significantly faster than Sww-Sw and wwS-Sw,
- wwS-wS decreases significantly faster than Sww-Sw,
- wwS-Sw decreases significantly slower than wSw-wS.

Two trends toward a significant difference can be found in:

- wSw-wS decreases faster than wSw-Sw,
- wwS-wS decreases faster than wwS-Sw,
- Sww-wS decreases faster than wwS-Sw.

It is clear that in all conditions displaying a (trend toward) a significant difference with another condition, the target of the two differing conditions bears the opposite stress pattern. Latencies in conditions containing an Sw target all decreases at a slower pace than latencies of wS conditions. The prefix of the differing conditions does not seem to contribute to significant distinct latencies, since no explicit pattern can be found between the prefixes of the differing categories. Prefixes are either equal between differing categories, or vary uninterpretable. The findings displayed in Table 19 point toward a large effect of the stress pattern of the target. The effects of the prefix and the target separately will be examined in the following sections.

The results of the group of left-handed children were very different. Overall the group of left-handed children displays larger latencies than the group of right-handed children. Analysis showed that neither the type of stress condition, nor the increase of age of the participants had a significant effect on the data. Overall the interaction between condition and age was highly insignificant, and the sole significant part-effect can be found in condition Sww-wS compared to condition Sww-Sw and wSw-wS. Latencies in condition Sww-Sw and wSw-Sw decrease over time, while latencies in condition Sww-wS increase, which is evident in Figure 7, where the growth of latencies over time in condition Sww-wS is visualized:

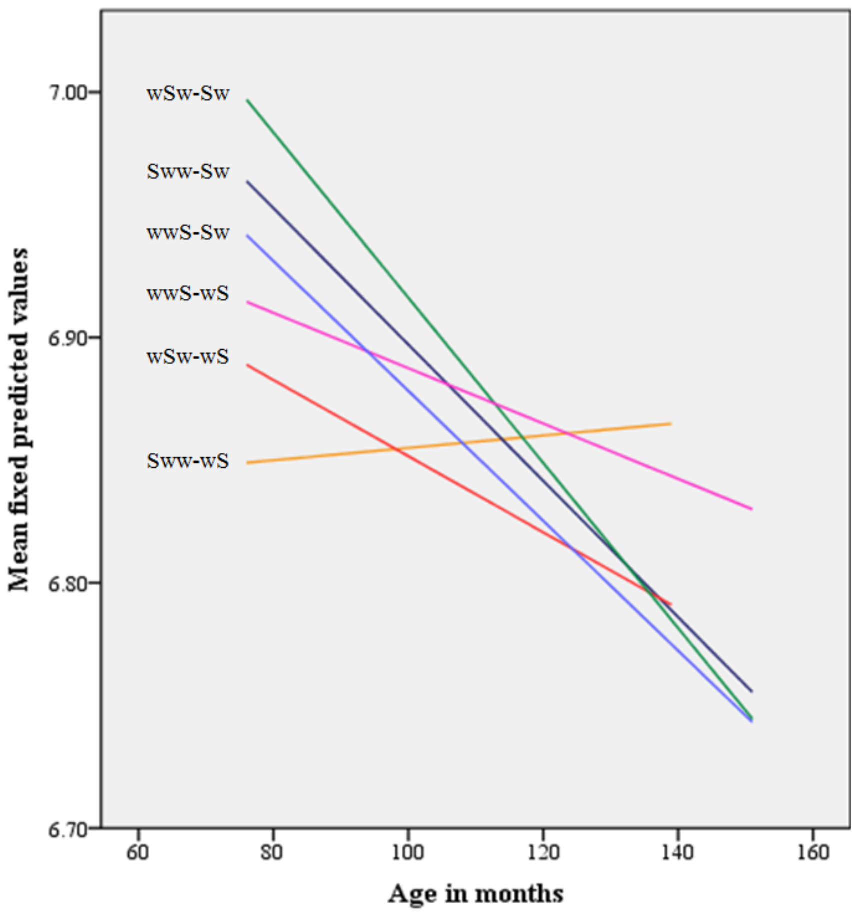

Figure 7; The behavior of mean latencies over time, categorized per stress condition, as displayed by the group of (15) left-handed children.

Figure 7 shows larger latencies in the stress conditions with a native target at younger age, than in conditions with a non-native target. Contrary to the results of the right-handed children, the decrease of latencies in stress conditions with a native target is much larger (however not significant) with age, than the decrease of latencies of conditions with a non-native targets.

3.3 Model 2: Effect of the target

In the second model the facilitating effects on the latencies of a native and non-native stress pattern in the target, Sw or wS, are compared. For the right-handed subjects the effect between different stress patterns on the target was highly significant (F=10.501, p=0.001), as was the effect of age (F=6.239, p=0.14) and the interaction between the type of target and age (F=11.826, p=0.001). For the left-handed group, only a significant effect was found for the interaction between age and type of target (F=6.632, p=0.01), while the factors age and type of target were highly insignificant. Figure 8 displays the interesting difference between the two subject groups:

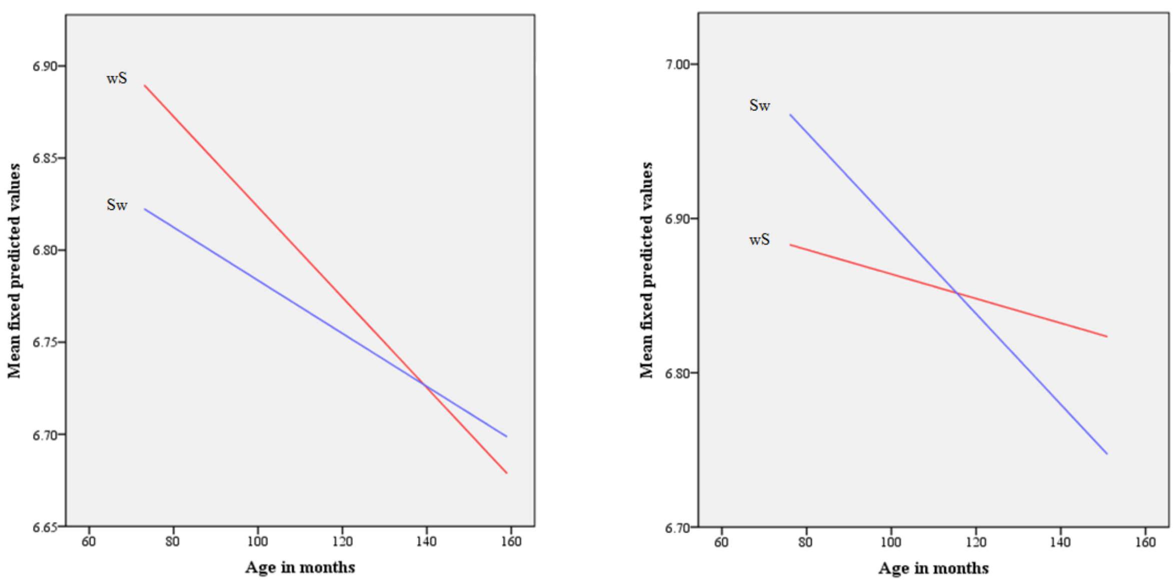

Figure 8; The decrease of mean latencies over time, categorized per type of target, as displayed by the group of right-handed (left) children and the group of left-handed children (right).

The facilitating effect of the stress pattern on the target seems to contribute to latencies in opposite directions in the two groups. The right-handed subjects benefit more from a native stress pattern at a younger age, while this preference diminishes over time relative to the facilitating effect of the non-native wS pattern. The group of left-handed children seems to benefit more from a non-native stress pattern on the target during word segmentation, than from a native Sw pattern at young age. This facilitating effect of the wS stress pattern moderates at a high rate; around the age of 10 years (120 months), the facilitating effect of an Sw-target is more prominent during segmentation.

3.4 Model 3: Effect of the prefix

The last model explores the facilitating effect of the prefix, comparing the three different conditions Sww, wSw, and wwS. The group of right-handed subjects displayed only a significant effect for age (F=6.083, p=0.015), while the effects of the stress conditions and the interaction between age and stress conditions on the latencies were insignificant. The group of left-handed subjects displayed no significant effect of any of the three factors. However, the different behavior of the two groups is remarkable. Figure 9 visualizes the decrease of latencies with the increase of age, categorized per stress condition, for the right-handed subjects (left) and the left-handed subjects (right):

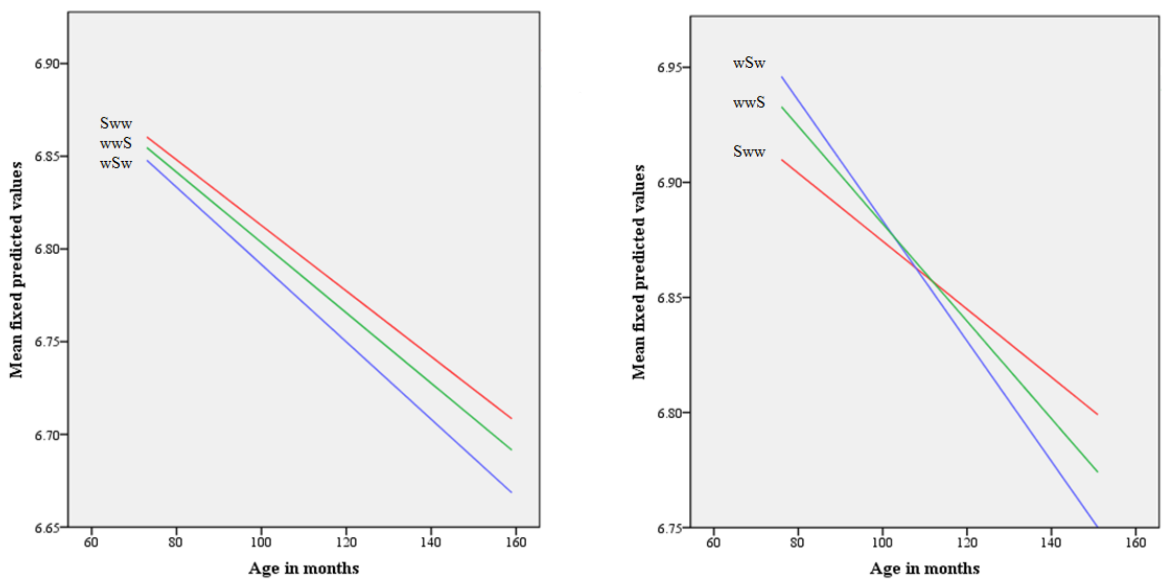

Figure 9; The decrease of mean latencies over time, categorized per prefix, as displayed by the group of right-handed (left) children and the group of left-handed children (right).

Figure 9 shows that in the group of right-handed children the facilitating effect of the native wSw prefix is slightly higher than the two prefixes with less native stress patterns, but the decrease of latencies with the increase of age is relatively uniform for all conditions. The group of left-handed subjects displays a larger facilitating effect from the prefixes with a non-native stress pattern at younger age, with a much larger decrease of latencies with age in the native wSw condition compared to the two other prefixes, while latencies in the wwS and wSw conditions decrease relatively faster than the Sww condition.

3.5 Effect of the condition without age

To assess the shift of the hierarchy between the conditions with age, latencies of right-handed subjects were compared per age group. The model contained the following fixed factors: the stress conditions, the creature and the sequence of presenting the items. As in the previous models, crossed random factors were subjects and items. For each age group a separate analysis was conducted:

- Group 1: 73-95 months (6-8- years),
- Group 2: 96-119 months (8-10- years),
- Group 3: 120-143 months (10-12- years),
- Group 4: 144- 159 months (12-14 years).

The analysis revealed that the group of 6- to 8-year-old subjects displays a highly significant facilitating effect caused by a penultimate stress pattern on the target:

	Sww-wS	Sww-Sw	wSw-wS	wSw-Sw	wwS-wS	wwS-Sw
Sww-wS	-	**.035**	.222	**.000**	.322	**.006**
Sww-Sw	**.035**	-	**.001**	*.069*	**.002**	.518
wSw-wS	.222	**.001**	-	**.000**	.809	**.000**
wSw-Sw	**.000**	*.069*	**.000**	-	**.000**	.240
wwS-wS	.322	**.002**	.809	**.000**	-	**.000**
wwS-Sw	**.006**	.518	**.000**	.240	**.000**	-

Table 20; P-values for the difference in latencies found in individual conditions for the age group 6- to 8-years. Significant differences are displayed in bold, trends are displayed in italic.

Table 20 shows that at the age of 6- to 8- years, children segment all targets with an Sw stress pattern significantly faster than targets with a wS stress pattern. Furthermore, an interesting trend is found towards faster segmentation of targets in condition wSw-Sw than condition Sww-Sw. Contrary to the group of youngest subjects, 8- to 10-year-old subjects display no significant effect in any of the conditions, apart from a continuation of the trend toward significant faster segmentation of the target in condition wSw-Sw than in condition wwS-wS:

	Sww-wS	Sww-Sw	wSw-wS	wSw-Sw	wwS-wS	wwS-Sw
Sww-wS	-	.481	.532	.130	.881	.514
Sww-Sw	.481	-	.940	.410	.396	.961
wSw-wS	.532	.940	-	.380	.441	.978
wSw-Sw	.130	.410	.380	-	*.098*	.385
wwS-wS	.881	.396	.441	*.098*	-	.425
wwS-Sw	.514	.961	.978	.385	.425	-

Table 21; P-values for the difference in latencies found in individual conditions for the age group 8- to 10-years. Trends toward significant differences are displayed italic.

The third group displayed a shift in hierarchy of latencies in the conditions, as can be seen in Table 22. Latencies in condition Sww-Sw are slower than in most other conditions. Apart from condition wwS-wS, in which subjects did not display (a trend towards) significant faster segmentation, 10- to 12-year-old subjects segment targets either significant slower in the condition where both prefix and target bear initial stress, or display a trend towards significant delayed segmentation.

	Sww-wS	Sww-Sw	wSw-wS	wSw-Sw	wwS-wS	wwS-Sw
Sww-wS	-	*.093*	.395	.157	.823	.681
Sww-Sw	*.093*	-	**.011**	**.002**	.147	**.033**
wSw-wS	.395	**.011**	-	.574	.283	.653
wSw-Sw	.157	**.002**	.574	-	.102	.305
wwS-wS	.823	.147	.283	.102	-	.524
wwS-Sw	.681	**.033**	.653	.305	.524	-

Table 22; P-values for the difference in latencies found in individual conditions for the age group 10-to 12-years. Significant differences are displayed in bold, trends are displayed in italic.

The oldest group of subjects showed that Sw targets were segmented fastest when they were preceded by a prefix bearing penultimate stress:

	Sww-wS	Sww-Sw	wSw-wS	wSw-Sw	wwS-wS	wwS-Sw
Sww-wS	-	.885	.418	*.053*	.366	.890
Sww-Sw	.885	-	.505	**.037**	.449	.776
wSw-wS	.418	.505	-	**.006**	.929	.337
wSw-Sw	*.053*	**.037**	**.006**	-	**.005**	*.067*
wwS-wS	.366	.449	.929	**.005**	-	.292
wwS-Sw	.890	.776	.337	*.067*	.292	-

Table 23; P-values for the difference in latencies found in individual conditions for the age group 12- to 14-years. Significant differences are displayed in bold, trends are displayed in italic.

The condition with canonical penultimate stress on both the prefix and the target evokes the smallest latencies. The results from the previous tables are summarized in Table 24:

Age groups		**Hierarchy:**
Group 1	Significant:	Sww-Sw, wSw-Sw, wwS-Sw >> Sww-wS, wSw-wS, wwS-wS
	Trend:	wSw-Sw >> Sww-Sw
Group 2	Significant:	-
	Trend:	wSw-Sw >> Sww-Sw
Group 3	Significant:	wSw-wS, wSw-Sw, wwS-Sw >> Sww-Sw
	Trend:	Sww-wS >> Sww-Sw
Group 4	Significant	wSw-Sw >> Sww-Sw, wSw-wS, wwS-wS
	Trend	wSw-Sw >> Sww-wS, wwS-Sw

Table 24; (trends towards) significant hierarchies between conditions per age group, arranged by latencies of segmentation of the target.

Group 1 displays a large facilitating effect of penultimate stress on the target during segmentation. Group 2 and 3 show a development towards a disfavor for the condition with initial stress on both the prefix and the target. The oldest group eventually displays a facilitating effect of penultimate stress on both the target and the prefix, while latencies in all other condition do not differ significantly.

3.6 Effect of the creature

An unexpected effect of the type of creature was found. Both left-handed and right-handed children preferred *Darnam* over *Mernel*, regardless of the stress pattern; both groups responded significantly faster to *Darnam* than to *Mernel* in either of the stress conditions (Sw or wS). This preference is displayed in Table 25:

Handedness	Darnam	Mernel
Right	*6.729*	6.809
Left	6.846	*6.907*

Table 25; Log-normalized latencies of the left-handed and right-handed children, evoked by Darnam and Mernel, regardless of the stress pattern.

A significant effect of the interaction between handedness and creature type was found (F=4.989, p=0.026). The left handed children are overall slower than the right handed children and the difference between the latencies of the two groups is significant (p=0.026). Left handed children responded significantly slower to *Mernel* than right-handed children responded to *Darnam* (see the italic values in Table 25).

4. Discussion

In Section 4.1 to 4.6 the results of the group of right-handed children will be discussed. Section 4.6 discusses the results found in the left-handed group and Section 4.7 reviews the unexpected effect of the type of creature as found in both groups.

4.1 Effect of prefix and target combined

The hypothesis about the combined effect of prefix and target was that (1) when conjoined with a target, the wSw prefix would evoke smaller latencies than the two other prefixes combined with the same target, and that (2) the wSw-Sw condition would evoke the smallest latencies at any age. When the prefix with penultimate stress is conjoined with the stress-final target (wS), no notable difference in latencies was found compared to the Sww-wS and wwS-wS conditions, neither through analysis nor is it visually implied in any of the figures. In the condition where the penultimate stress pattern is placed both on the prefix and on the target (wSw-Sw) it is clear that both younger and older children are facilitated during segmentation, since this condition evokes the smallest latencies in children of all ages. However, when looking at the results of the age groups separate, this effect is neither significant in the group of 6- to 8-year-old children, nor in the group of 8- to 10-year-old children. In the group of 10- to 12-year-old children a trend towards a significant facilitating effect of the condition with penultimate stress on both target and prefix was found, and this trend develops until it is significantly present in the groups of 12- to 14 year-old children. Therefore, from the age of 10, right-handed children demonstrated a development towards the language-specific segmentation strategies as displayed by the group of Dutch adults in the experiment of van Ommen (in prep.) who showed dependence on the penultimate stress pattern of the prefix and a tendency toward reliance on the native pattern of the target for segmentation.

4.2 Effect of the target

The results of the model in which target and prefix were combined already predicted a large effect of the stress pattern of the target, which is confirmed by the very significant overall difference between segmentation of Sw and wS targets. When looking at the age groups separately, it is evident that this significant finding is mainly caused by the latencies of the group of 6- to 8-year-olds. This group displays a highly significant preference for Sw targets over wS targets, but this preference decreases very fast with age and is no longer visible in the group of 8- to 10-year-olds. This development shows that the hypothesis (3) that both younger and older children will display smaller latencies during the detection of Sw targets than wS targets can only be confirmed for the group of youngest children.

4.3 Effect of the prefix

It was hypothesized (4) that the prefix carrying the penultimate stress pattern (wSw) would facilitate segmentation, compared to the two other prefixes. The current experiment showed that the interaction of age and prefix did not result in a significant effect. However, looking at the age groups separately the lack of overall facilitating effect of the prefix can be explained by the lack of effect of the wSw prefix in the younger age groups. Children between 6- to 10-years-old display no significant effect of the prefix with penultimate stress, while in the group of 10- to 12-year-olds the wSw prefix significantly facilitated segmentation of both the Sw and the wS target. In the group of 12- to 14-year-olds this effect was only found when the prefix was conjoined with the Sw target. A possible explanation of the appearance and disappearance of the facilitating effect of the wSw-wS condition is that children discover the application of the native stress pattern of the prefix for word segmentation between the age of 8 and 10 years and focus on this novel ability, resulting in a faster segmentation of any target following the wSw prefix. When the novelty of this knowledge declines, the focus on Sw targets in the sound stream renews, as is reflected by the behavior of 12- to 14-year-olds.

The observation that children between 8- to 14-years-old display a (trend towards a) significant smaller facilitating effect of the Sww prefix on segmentation than the two other prefixes is very interesting, since it goes against the prediction of the MSS. If subjects would have marked the strong syllable as the beginning of a word, they would have displayed a preference of the Sww prefix over the wSw and wwS prefix. The preference found in the responses points towards segmentation based on language specific stress cues. A possible explanation is that the Sww prefix evoked larger latencies due to 'lapse', where segmentation is delayed because the boundary must be placed between two unstressed syllables. Lapse could only occur in the condition where the Sww prefix precedes the wS target. This is clearly not the case, since the Sw target was not segmented faster than the wS target when conjoined with the Sww prefix. In the group of 10- to 12-year-olds the opposite trend was found towards significant faster latencies in condition Sww-wS than in condition Sww-Sw. Therefore, large latencies for detection of a target that is preceded by the Sww prefix must be the result of a negative effect of the stress pattern of the prefix. The opposite effect where boundary placement is facilitated by two adjacent strong syllables does not appear either, since the condition wwS-Sw does not evoke smaller latencies than the native condition. These findings show that Dutch children develop towards a stage in which they draw information from the context of the target word for segmentation when this context carries the native penultimate stress pattern.

4.4 Effect of maturation of metrical segmentation strategies

The hypothesis (5) that latencies of all conditions decrease with age can immediately be confirmed. Latencies in all conditions significantly diminish as children grow older. The development of segmentation skills was hypothesized to evoke a hierarchy of conditions based on the response rate per condition, as was displayed in Table 14 on page 24. This table displays the proposed hierarchy at the age of 6 years (upper row) and the expected hierarchy at 14 years of age (lower row).

Hypothesized	
Age ↓	wSw-Sw >>>>>> Sww-Sw, wwS-Sw >> wSw-wS >> Sww-wS, wwS-wS
	wSw-Sw >> Sww-Sw, wwS-Sw, wSw-wS, Sww-wS, wwS-wS

Table 14; Hypothesized hierarchy of conditions at 6-years-old and at 14-years-old, arranged by hypothesized segmentation rate of the target. Table 14 is repeated for convenience.

Overall it was expected that younger children would respond faster in conditions with an Sw target than in conditions with a wS target (6) and that this difference would diminish with age. The results displayed that younger children segment Sw targets significantly faster from the speech stream than wS targets. This can be explained by a shorter exposure to the Dutch stress system, since Dutch 3- and 4-year-old children display a greater difficulty with the production of irregular stress patterns (Nouveau, 1994). It is reasonable to assume that children apply this insufficient knowledge about irregular stress during word segmentation at the age of 6. This difficulty with less regular stress patterns was hypothesized to decrease with age, as a trade-off effect of the increase of the growth of knowledge about less regular Dutch stress patterns. This hypothesis (7) is confirmed by the initial head start of segmentation of the Sw target that is outpaced by the segmentation wS target as the children are older (see Table 2).

Results	
	wSw-Sw, wwS-Sw, Sww-Sw >> wSw-wS, Sww-wS, wwS-wS
Age ↓	-
	wSw-Sw, wwS-Sw, wSw-wS, Sww-wS >> Sww-Sw
	wSw-Sw >> wwS-Sw, wSw-wS, Sww-wS, wwS-wS, Sww-Sw

Table 26; Actual hierarchy of conditions at 6- to 8-years-old, at 10- to 12-years-old and at 12- to 14-years-old, arranged by latencies of segmentation of the target.

Between 8- and 10-years-old none of the conditions evoke significantly differing latencies. This reflects a developmental stage in which the children do no longer prefer Sw targets, but have not yet developed novel segmentation strategies. Between 10- and 12-years-old children showed improved segmentation skills for wS targets. Latencies in all conditions converged, except in the condition where both target and prefix carry initial stress (Sww-Sw). This latter stress pattern evoked significant larger reaction times than the other conditions. Latencies in condition wwS-wS did not differ from any of the other conditions and is therefore excluded from the hierarchy in the middle row (see Table 26). This effect is no longer present in the group of 12- to 14-year-olds where the hierarchy is rearranged in such a way that only the condition with target and prefix bearing the canonical Dutch stress pattern (wSw-Sw) evokes significant smaller latencies than all other conditions. This final stage resembles the results found by van Ommen, where Dutch adults are facilitated during segmentation when target and prefix bear penultimate stress, in such a way that we may conclude that at 12- to 14-year-old, Dutch right-handed children seem to have mastered adult-like segmentation strategies.

It was hypothesized that (8) in younger children the wSw prefix would enhance segmentation of the target. This could not be confirmed, since none of the prefixes resulted in significant facilitation for segmentation in the groups of 6- to 8-year-olds and 8- to 10-year-olds. Unexpectedly, this facilitating effect was present in both the group of 10- to 12-year-olds and the group of 12- to 14-year-olds. These results display an opposite development as predicted in hypothesis 8. The subsequent prediction was that in all age groups only the wSw-Sw condition was expected to evoke smaller latencies than all other conditions. The decrease of latencies in this condition was expected be slower than in all other conditions, resulting in smaller differences between the wSw-Sw condition and the other conditions in older than in younger children (9). This hypothesis must be rejected, since only condition wSw-wS displays a trend towards a faster decreasing rate compared to condition wSw-Sw, which must be caused by the target. The significant faster decrease of latencies in condition wSw-wS compared to conditions Sww-Sw and wwS-Sw, cannot be explained by the facilitating effect of the prefix, since both Sww-wS and wwS-Sw display the same effect:

Significant slower decreasing rate:

- Sww-wS, wSw-wS, wwS-wS >> Sww-Sw
- wSw-wS >> wwS-Sw

Trend towards significant slower decreasing rates:

- wSw-wS >> wSw-Sw
- wwS-wS >> wwS-Sw

These developments merely display that after a longer exposure time to the target language, children display a decrease of latencies in conditions with a less-native target, reflected in the significant faster decrease of latencies in conditions with wS targets, relative to the decrease of latencies in conditions with an Sw target.

The hierarchy shift that occurs with the increase of age, displayed a different relation between stress pattern and maturation of segmentation strategies than anticipated (see Table 26). Between the age of 6- to 8-years-old, children displayed a significant facilitating effect of the Sw stress pattern on the target compared to the wS stress pattern. As the children become older, the large difference between the latencies for the Sw target and the wS target disappears, due to a faster decrease of latencies in conditions with a wS target. Though the prefix seems to contribute very little to segmentation rates in the younger age groups, the wSw-Sw condition pattern evokes smallest latencies. When the children become older, the facilitating effect of the wSw prefix grows until it reaches an adult-like state in the group of 12- to 14-year-olds.

These findings do not directly give rise to assume application of the MSS by Dutch children. Targets beginning with a strong syllable are overall segmented faster than targets with a weak syllable in initial position. This fining is compatible with the prediction of the MSS, but this preference can also be explained by the penultimate canonical stress pattern of Dutch. This latter explanation is supported by the finding that all children respond slowest in the Sww-Sw condition compared to the other two conditions containing an Sw target, and older children eventually display significantly largest latencies in the Sww-Sw condition. If the MSS was indeed a universal segmentation strategy, Dutch children would be expected to segment words with initial stress faster than words with any other stress pattern. Other universal cues, such as lapse and clash (see van Ommen, in prep.) do not seem to play a prominent role in word segmentation either. Neither facilitates condition wwS-Sw segmentation, nor delays condition Sww-wS detection of the target. Instead, the results of this experiment strongly suggest word segmentation on the basis of stress cues that are highly language specific.

4.5 Effect of age

In the group of right-handed subjects, a very significant relation between the increase of age and the decrease of latencies per condition was found. As hypothesized, children at the age of 6 (72 months) display significantly larger latencies in all conditions, than older children. At 6 years of age latencies range from 6.80-6.90 and decrease to 6.66-6.74 at the age of 14. A part of this development is due to the significant effect of age on the task. Between 6 and 14 years both cognitive control and executive functions develop towards an adult-like performance. Davidson et al. (2006) describe mature cognition as characterized by abilities to:

(a) hold information in mind, including complicated representational structures, to mentally manipulate that information, and to act on the basis of it, (b) act on the basis of choice rather than impulse, exercising self-control (or self-regulation) by resisting inappropriate behaviors and responding appropriately, and (c) quickly and flexibly adapt behavior to changing situations. [6]

Davidson et al. (2006) tested 325 participants between 4 to 13 years old on the development of cognitive control and executive functions during a battery of memory, inhibition, and task switching experiments. In one of the tests participants were presented with two abstract shapes on a screen. They were taught a rule for each stimulus (*press this button when you see this shape*) during a short practice block. During the test the children were presented with the abstract shapes and asked to perform the appropriate action. Results showed age-related improvements in performance on percentage of correct responses (accuracy), speed (reaction time), and percentage of appropriate responses (inappropriate responses occur when a participant failed to wait for the stimulus). This development shows that children are expected to become “better” at the task, due to maturation of cognitive control and executive functions.

This maturation is of influence on the behavior of the children in the current experiment, as can be inferred from the significant effect of age on the latencies. The older the child, the higher the accuracy and the smaller the reaction time during the task. However, the significant effect of the stress conditions suggests that the stress pattern on the items is of equal important influence on the latencies. The highly significant interaction between age and condition shows that not only the maturation of cognitive control and executive functions is of influence on the decrease of the latencies, but that certain conditions are of greater support to the child during segmentation than others and that this function changes with age.

[6] Davidson et al. (2006) p. 2037.

4.6 Effect of handedness

The different behavior between the group of right-handed children and the group of left-handed children immediately strikes the eye. Handedness describes a characteristic form of specialization whereby a person prefers to use one hand for clearly identified activities, such as writing (Minderovic, 1998). For exclusion of confounding influences on the data all sorts of factors were analyzed. Factors such as gender, bi- and multilingualism, speech and/or reading disorders, the difference between lists, the difference between schools had no influence on the behavior of the subjects. Handedness surprisingly showed a highly significant interaction with the stress conditions and the age of the subjects. Handedness was evaluated as a possible factor because left-handed individuals are believed to have a higher incidence of atypical language representation in the brain (Szaflarkski et al., 2006). Pujol et al. (1999) found that approximately 95% of normal right-handed subjects display left-hemispheric dominance for language, while Knecht et al. (2000) found that right-hemispheric language dominance increased in a linear relation with the degree of left-handedness, accumulating from 4% in strong right-handers to 15% in ambidextrous individuals and 27% in strong left-handers. It is reasonable to assume that several of the left-handed subjects who participated in this experiment would display atypical lateralization of languages processes. However, no data are available to support such claim. Moreover, the relationship between handedness and language competence remains highly debated. Several experiments showed that strongly lateralized subjects perform better at language tasks compared to non-lateralized subjects; however, other experiments found opposite results (see Mellet et al., 2014 for an extensive overview). Even though some experiments suggest an advantage from right-handedness in phonological processing (De Agostini and Dellatolas, 2001), a connection between right-hemispheric dominance for language processing and metrical segmentation competences has never been explored. Therefore, no inferences can be made from this account.

Another direction to look for an explanation for the behavior of the group left-handers might be the distribution of the buttons on the button box. *Darnam* was always placed at the left of the middle button, *Mernel* at the right:

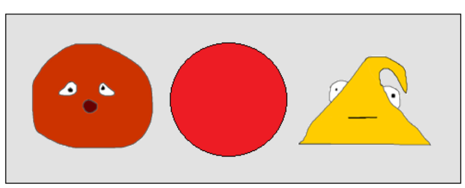

Figure 10: Design of the button box.

Klöppel et al. (2007) investigated the control of hand movements in right- and left- handed subjects, during button presses. To examine differences between left and right-handers during presses using right or left index fingers alone and bimanual button presses, a visually cued choice reaction time task was conducted. Each trial started with a visual command to press one of the two buttons with the left, right or both index fingers as quickly as possible. Results revealed that for left-handed responses, left-handers have shorter latencies than right-handed subjects, while on right-handed responses no differences in mean latencies for right-handed and left-handed subjects was found. Overall difference was found between bimanual button presses relative to left sided button presses:

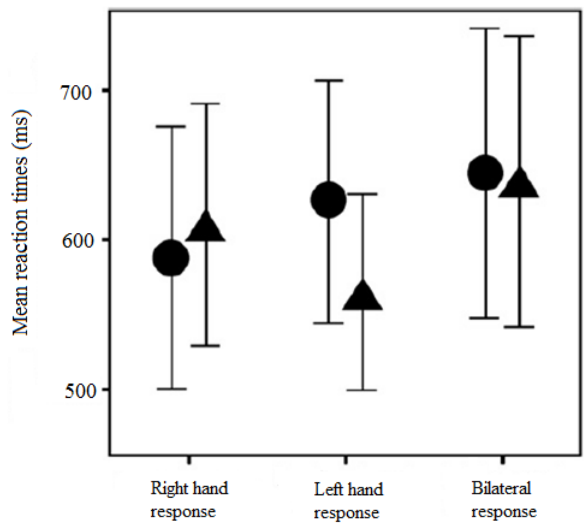

Figure 11; Mean reaction times of right-handers (circles) and left-handers (triangles) during visually cued button presses. Error bars represent ±1 SD. Figure adapted from Klöppel et al. 2007, p. 277

In the current experiment participants were instructed to press the middle button (see Figure 10) when they recognized either *Mernel* or *Darnam*, and subsequently press the button with the corresponding picture. Participants were explicitly instructed to keep a finger on the middle button when listening to the stimuli. Almost all participants automatically held the index fingers of both hands ready. This instruction evoked response to *Darnam* with either a first button press with the left index finger, followed by a second button press with the left index finger, or a first button press with the right index finger, followed by a second button press with the left index finger. In case of *Mernel*, the sequence was either a first button press with the right index finger, followed by a second button press with the right index finger, or a first button press with the left index finger, followed by a second button press with the right index finger (see Figure 12). Crossed button presses (right-left for *Mernel* and left-right for *Darnam*) would be highly implausible, since the instructions emphasized responding as quickly as possible when a target was perceived.

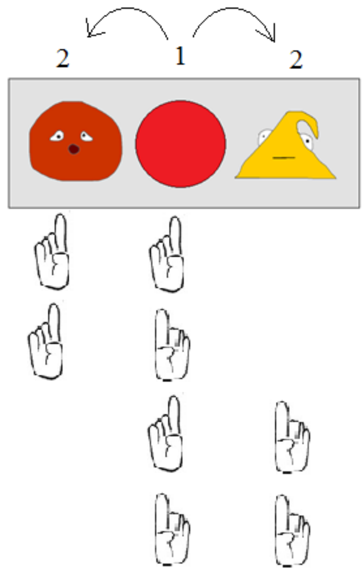

Figure 12; Possible sequences of button presses evoked by the instructions.

Based on the previous account, it would be expected that left-handed children display smaller latencies to *Darnam* when applying the left-left pattern, in contrast to using the right-left pattern. This facilitating effect does not apply for *Mernel*, since left-handed subjects are not expected to display faster latencies for the left-right or right-right pattern. Right-handed subjects do not benefit from this facilitating effect in any of the conditions since Klöppel (2007) found that right-handers are not significantly faster in responding with their right index finger than left-handed subjects.

However, this was not the case since both left-handed and right-handed children responded faster to *Darnam* than to *Mernel*, regardless of the stress pattern. Right-handed children responded even faster to *Darnam* than the group of left-handers. The explanation of the divergence of the response patterns of the group of left-handed children must be sought elsewhere. Since the group of left-handed subjects consisted of only 15 children, a substantial explanation can only be obtained by conducting the experiment with the same number of participants as were included in the right-handed group. Such experiment can elucidate whether left-handed children indeed display a different pattern in development of metrical segmentation strategies. The results of the group of left-handed children will therefore be interpreted as deviating from the group of right-handed children and uninterpretable until further research investigates a larger group of left-handed children on the development of segmentation strategies.

4.7 Effect of the creature

The unexpected facilitating effect of the *Darnam* cannot be due to the stress pattern, since half of the subjects were presented with *Dárnam* and the other half with *Darnám*. Neither is the placement of the pictures on the button-box expected to be of influences, as explained in the previous section. A third possible explanation can be found in the color and shape of the middle button. This button was round and red, which coincided with the circular, red appearance of *Darnam*. All subjects were instructed to press the red button when they perceived one of the targets, and subsequently hit the button with the right picture. It is presumable that the resemblance functioned as a prime and led subjects to respond faster to *Darnam* than to *Mernel*. Future studies should rule out this possible confounding factor by selecting a different shape and color for the middle button.

5. Conclusions

The questions how and to what extent Dutch children apply knowledge of the Dutch stress system during word segmentation and how segmentation strategies mature during growth of this knowledge, can be answered. Overall, children become faster at segmenting targets from a speech stream when they are older. This effect cannot solely be explained by maturation of cognitive control and executive functions, since a similar highly significant effect of the stress conditions was found and a significant interaction between the two effects, proving that certain conditions are of greater support to the child during segmentation than others and that this function changes with age.

Results have shown that younger right-handed children are faster at segmenting words out of a speech stream that bear their native penultimate stress pattern. After a longer exposure time to the Dutch stress pattern, latencies of the less regular stress patterns decrease with age, as a trade-off effect of the increase of the growth of knowledge about less regular Dutch stress patterns. When age increases, the differences in segmentation speed between targets with native and non-native stress diminishes and children do no longer display a significant preference for strong-weak stress patterns on the target during word segmentation.

The data showed that there is no significant effect of any of the prefixes on segmentation of the target in 6- to 10-year-old children. However, after the age of 10, segmentation strategies focus on the native penultimate stress pattern on both the target and the prefix. This displays a development from an initial facilitating effect of the native stress pattern on the target regardless of the prefix, towards a facilitating effect of the native stress pattern on the target only when it is conjoined with a prefix that carries the native stress pattern as well. This development contradicts the prediction of the MSS that strong syllables in the speech stream will be marked as word beginnings. Neither was any evidence found for a facilitating effect of ‘clash’, nor did conditions containing a ‘lapse’ delay segmentation of the target. All three findings suggest application of language specific segmentation cues in Dutch learning children

The results of the small group of left-handed children displayed a very different development in segmentation abilities than the right-handed children. No explanation for their deviant behavior was found and since the group of left-handers included only 15 subjects, further research will have to decide whether left-handed children demonstrate a different developmental pattern of segmentation strategies.

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Appendices

1. Explanatory letter, as communicated to all parents of both schools

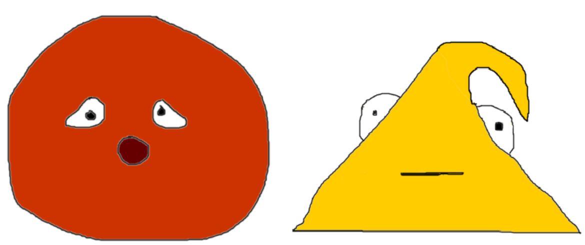
Beste ouder,

Mijn naam is Maud Verlinde, oud-leerling van de JvR school Heiloo en inmiddels bijna afgestudeerd op het gebied van Taalwetenschap. Tijdens mijn studie heb ik mij gespecialiseerd in het onderzoek naar de taalontwikkeling van kleuter tot volwassen spreker. Tijdens de gehele basisschoolperiode maakt een kind verbazingwekkend veel, en grote stappen in de taalontwikkeling door; de woordenschat groeit enorm en de grammatica ontwikkelt zich steeds verder. Ook neemt de vaardigheid in het communiceren met anderen snel toe.

Maar hoe leert een kind nieuwe woorden van anderen? Hoe weet een jong kind wat een woord is wanneer het dat woord nooit heeft geleerd, of zelfs nog nooit eerder heeft gehoord? In tegenstelling tot de kleine witruimtes tussen woorden in geschreven tekst, zijn er in gesproken tekst vrijwel geen aanwijzingen die aangeven waar het ene woord eindigt en het volgende woord begint. Een volwassen spreker heeft nauwelijks moeite om het onbekende woord uit de volgende zin te vissen: "vereerdlaagdrempeligsudaruportier". Voor een kind dat de woorden "vereerd", "laagdrempelig", en "portier" nog niet kent, zijn de woorden "ligsudar" en "ruportier" net zo aannemelijk als elke andere combinatie van de klanken.

De manier waarop woorden worden uitgesproken geeft hier gelukkig wat houvast; de nadruk op sommige lettergrepen kan helpen bij de beslissing of een klankenreeks een woord kan zijn of niet: "lígsudar" klinkt veel meer als een Nederlands woord dan "ligsudár". Als volwassen sprekers van het Nederlands merken we meteen dat het eerste woord Nederlandser klinkt dan het tweede, dat eerder Spaans aan doet. Kinderen voelen dit ook haarfijn aan; het is inmiddels uit vele onderzoeken gebleken dat heel jonge kinderen (al vanaf 7 maanden), woorden als "lígsudar" prefereren boven woorden als "ligsudár", omdat zij al kunnen horen welk van deze twee woorden het klemtoonpatroon van hun moedertaal draagt. Dit geeft aan dat het klemtoonpatroon van de moedertaal al heel vroeg een rol speelt in de taalontwikkeling.

Maar welke rol speelt dit bij het detecteren van onbekende woorden? Met mijn afstudeeronderzoek wil ik onderzoeken hoe groot de rol van klemtoon is bij het opdelen van spraak in woorden, en of deze rol gelijk blijft over de jaren. Het is goed mogelijk dat deze rol verandert; het kind krijgt immers steeds meer ervaring met de taal en de woorden om hem/haar heen. Dit wil ik graag testen aan de hand van een spel, waarin deze twee buitenaardse wezentjes de hoofdrol spelen:



Na de kerstvakantie zal ik een aantal dagen op school aanwezig zijn om het experimentje bij alle kinderen van groep 3 t/m 8 af te nemen. Mocht u nog vragen, bezwaren of opmerkingen hebben, kunt u gerust contact opnemen via: maudverlinde@gmail.com of 06-45038262.

2. Questionnaire

Vind het wezen in het woord. Versie 4-12 jaar

Lijst:	Nr:

Naam:
Geboortedatum: Leeftijd (in maanden):

Vragen voor kind:
1. Vond je het spel *makkelijk/moeilijk*?

2. Vond je het *makkelijk/moeiljk* om de namen va de wezens te herkennen?

3. Vond je het *makkelijk/moeilijk* om de namen van de wezens te onthouden?

4. Wil je nog iets zeggen over het spel?

5. Hoe oud was je toen je Nederlands leerde?

6. Welke taal spreek je thuis met je ouders?

7. Welke talen spreek je nog meer?

8. Hoe oud was je toen je deze andere taal leerde?

9. Gebruik je deze andere taal *elke dag/elke week/elke maand/bijna nooit*?

10. Met welke hand schrijf/teken je?

Vragen voor leerkracht:
10. Wat is de moedertaal van het kind?

11. Heeft het kind dyslexie, een gehoor- of spraakprobleem?

3. Instructions, as presented auditorily during the experiment

Hallo! Wat leuk dat je mee wil doen aan dit spel.

Het spel gaat als volgt:

- Je ziet straks twee verschillende wezentjes op het beeldscherm en door de koptelefoon hoor je hun naam.
- Probeer goed te onthouden hoe de wezentjes heten want je hebt hun namen nodig voor de rest van het spelletje.

Weet je de namen nog? Dat kijken we even na:

- Kijk goed naar de plaatjes op de drukknopjes vóór je;
- Je hoort straks één van de twee namen
- En als je weet bij welk wezentje deze naam hoort, druk je op de knop met het juiste plaatje.

- Dat klopt!
- Oeps, dit is niet het juist plaatje.

Goed zo! Dat ging prima! Dan gaan we nu met het spelletje beginnen:

- Je gaat straks naar een buitenaardse taal luisteren.
- Soms zit de naam van één van de wezentjes in deze vreemde taal verstopt.

- Luister goed naar de vreemde zinnen en zodra je een naam van een wezentje hoort, druk je zo snel mogelijk op de rode knop.
- Het is belangrijk dat je meteen drukt als je één van de twee namen herkent.

We gaan nu eerst even oefenen met dit spelletje.

- Heel goed! Als je weet bij welk wezentje de naam hoort, druk je op de knop met het juiste plaatje.

- Oeps, er zat geen naam in deze zin. Je had niet hoeven drukken. Druk op de rode knop om door te gaan met het spel.

Goed gedaan!

- Nu zijn we klaar met het oefenen en gaan we beginnen met het echte spel.
- We doen het spel 4 keer.

- Je krijgt nu een kaart,
- en elke keer als je klaar bent met het spel krijg je een sticker die je hier op mag plakken.
- Als de stickerkaart vol is mag je iets lekkers uitzoeken.

- Als je nog vragen hebt kan je ze nu stellen.

- Druk op de rode knop om het eerste spel te beginnen

- Niet vergeten: zodra je één van de twee namen herkent druk je meteen op de rode knop.
- Dan krijg je de plaatjes te zien en mag je kiezen bij welk wezentje de naam hoort.

Goed gedaan! Je mag nu een sticker kiezen en in het vakje van spel één plakken.

Druk op de rode knop om door te gaan met het volgende spel.

Goed gedaan! Je mag weer een sticker kiezen en bij spel twee plakken.

Druk op de rode knop om door te gaan met het derde spel.

Goed zo! Je mag nu een sticker bij spel drie plakken.

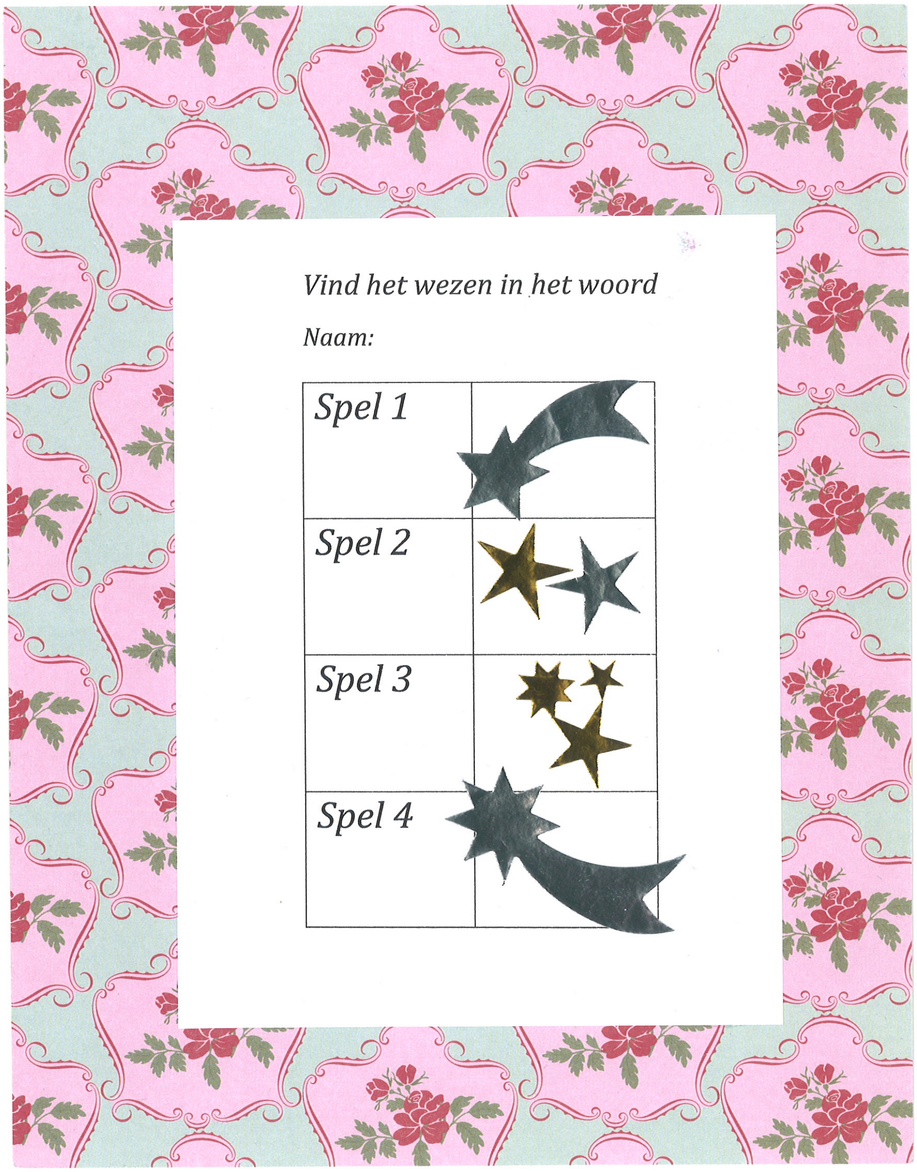
Druk op de rode knop om door te gaan met het laatste spel.

Dat ging goed! Je mag nu een sticker kiezen bij spel vier plakken.

- Dit was alweer het laatste spel.
- Je hebt de hele kaart volgestickerd.
- Je mag iets lekkers kiezen voor onderweg terug naar de klas.

Leuk dat je mee wilde doen!

4. Sticker card, handed to all children after the training phase



5. Test items, categorized per list

List 1: Darnám and Mérnel

Test item	Target	Item
felisixmernel	FRONT	TEST
felisixmernel	FRONT	TEST
bidifixmernel	FRONT	TEST
rinibixmernel	FRONT	TEST
rinibixmernel	FRONT	TEST
ridifexmernel	FRONT	TEST
finisixmernel	FRONT	TEST
finisixmernel	FRONT	TEST
fesibixmernel	FRONT	TEST
lirefixmernel	FRONT	TEST
lirefixmernel	FRONT	TEST
lifisixmernel	FRONT	TEST
fisidixmernel	FRONT	TEST
fisidixmernel	FRONT	TEST
firidixmernel	FRONT	TEST
nesefixmernel	FRONT	TEST
nesefixmernel	FRONT	TEST
refidixmernel	FRONT	TEST
nirefixmernel	FRONT	TEST
nirefixmernel	FRONT	TEST
resebixmernel	FRONT	TEST
niferixmernel	FRONT	TEST
niferixmernel	FRONT	TEST
nefidixmernel	FRONT	TEST
nedifixmernel	FRONT	TEST
nedifixmernel	FRONT	TEST
rifebixmernel	FRONT	TEST
siredixmernel	FRONT	TEST
siredixmernel	FRONT	TEST
rinefixmernel	FRONT	TEST
ralufudarxnam	BACK	TEST
ralufudarxnam	BACK	TEST
narufudarxnam	BACK	TEST
lusufudarxnam	BACK	TEST
lusufudarxnam	BACK	TEST
fulusudarxnam	BACK	TEST
runafudarxnam	BACK	TEST
runafudarxnam	BACK	TEST
dunufudarxnam	BACK	TEST

List 2: Darnám and Mérnel

Test item	Target	Item
felisixmernel	FRONT	TEST
bidifixmernel	FRONT	TEST
bidifixmernel	FRONT	TEST
rinibixmernel	FRONT	TEST
ridifexmernel	FRONT	TEST
ridifexmernel	FRONT	TEST
finisixmernel	FRONT	TEST
fesibixmernel	FRONT	TEST
fesibixmernel	FRONT	TEST
lirefixmernel	FRONT	TEST
lifisixmernel	FRONT	TEST
lifisixmernel	FRONT	TEST
fisidixmernel	FRONT	TEST
firidixmernel	FRONT	TEST
firidixmernel	FRONT	TEST
nesefixmernel	FRONT	TEST
refidixmernel	FRONT	TEST
refidixmernel	FRONT	TEST
nirefixmernel	FRONT	TEST
resebixmernel	FRONT	TEST
resebixmernel	FRONT	TEST
niferixmernel	FRONT	TEST
nefidixmernel	FRONT	TEST
nefidixmernel	FRONT	TEST
nedifixmernel	FRONT	TEST
rifebixmernel	FRONT	TEST
rifebixmernel	FRONT	TEST
siredixmernel	FRONT	TEST
rinefixmernel	FRONT	TEST
rinefixmernel	FRONT	TEST
ralufudarxnam	BACK	TEST
narufudarxnam	BACK	TEST
narufudarxnam	BACK	TEST
lusufudarxnam	BACK	TEST
fulusudarxnam	BACK	TEST
fulusudarxnam	BACK	TEST
runafudarxnam	BACK	TEST
dunufudarxnam	BACK	TEST
dunufudarxnam	BACK	TEST

nufududarxnam	BACK	TEST	nufududarxnam	BACK	TEST
nufududarxnam	BACK	TEST	lusafudarxnam	BACK	TEST
lusafudarxnam	BACK	TEST	lusafudarxnam	BACK	TEST
rasududarxnam	BACK	TEST	rasududarxnam	BACK	TEST
rasududarxnam	BACK	TEST	nafasudarxnam	BACK	TEST
nafasudarxnam	BACK	TEST	nafasudarxnam	BACK	TEST
dusufudarxnam	BACK	TEST	dusufudarxnam	BACK	TEST
dusufudarxnam	BACK	TEST	bafasudarxnam	BACK	TEST
bafasudarxnam	BACK	TEST	bafasudarxnam	BACK	TEST
badusudarxnam	BACK	TEST	badusudarxnam	BACK	TEST
badusudarxnam	FRONT	TEST	bafududarxnam	BACK	TEST
bafududarxnam	BACK	TEST	bafududarxnam	BACK	TEST
nalusudarxnam	BACK	TEST	nalusudarxnam	BACK	TEST
nalusudarxnam	BACK	TEST	budusudarxnam	BACK	TEST
budusudarxnam	BACK	TEST	budusudarxnam	BACK	TEST
safududarxnam	BACK	TEST	safududarxnam	BACK	TEST
safududarxnam	BACK	TEST	runududarxnam	BACK	TEST
runududarxnam	BACK	TEST	runududarxnam	BACK	TEST
ranududarxnam	BACK	TEST	ranududarxnam	BACK	TEST
ranududarxnam	BACK	TEST	lufusudarxnam	BACK	TEST
lufusudarxnam	BACK	TEST	lufusudarxnam	BACK	TEST
biresixrefi	NONE	FILL3	biresixrefi	NONE	FILL3
sirenixlise	NONE	FILL3	sirenixlise	NONE	FILL3
ninirexfebe	NONE	FILL3	ninirexfebe	NONE	FILL3
ribibexnebi	NONE	FILL3	ribibexnebi	NONE	FILL3
lifesexbere	NONE	FILL3	lifesexbere	NONE	FILL3
lininexberi	NONE	FILL3	lininexberi	NONE	FILL3
feneferexfi	NONE	FILL3	feneferexfi	NONE	FILL3
nibenefexli	NONE	FILL3	nibenefexli	NONE	FILL3
sebinisexfe	NONE	FILL3	sebinisexfe	NONE	FILL3
bifenesixfe	NONE	FILL3	bifenesixfe	NONE	FILL3
finefibexbe	NONE	FILL3	finefibexbe	NONE	FILL3
ririserixsi	NONE	FILL3	ririserixsi	NONE	FILL3
selibifexse	NONE	FILL3	selibifexse	NONE	FILL3
duraruxruru	NONE	FILL3	duraruxruru	NONE	FILL3
basubaxbaru	NONE	FILL3	basubaxbaru	NONE	FILL3
susufaxnura	NONE	FILL3	susufaxnura	NONE	FILL3
bufafuxluba	NONE	FILL3	bufafuxluba	NONE	FILL3
nadubuxbufu	NONE	FILL3	nadubuxbufu	NONE	FILL3
safuruxdufa	NONE	FILL3	safuruxdufa	NONE	FILL3
sunalubaxna	NONE	FILL3	sunalubaxna	NONE	FILL3
lufaruluxbu	NONE	FILL3	lufaruluxbu	NONE	FILL3
bubulufaxlu	NONE	FILL3	bubulufaxlu	NONE	FILL3

dufusafuxsu	NONE	FILL3	dufusafuxsu	NONE	FILL3
rasasunuxdu	NONE	FILL3	rasasunuxdu	NONE	FILL3
nurunuluxfu	NONE	FILL3	nurunuluxfu	NONE	FILL3
lunafusaxdu	NONE	FILL3	lunafusaxdu	NONE	FILL3
silirixsifi	NONE	FILL3	silirixsifi	NONE	FILL3
dibisexlife	NONE	FILL3	dibisexlife	NONE	FILL3
febibixseli	NONE	FILL3	febibixseli	NONE	FILL3
benefixfefi	NONE	FILL3	benefixfefi	NONE	FILL3
felisexbiri	NONE	FILL3	felisexbiri	NONE	FILL3
nififixbire	NONE	FILL3	nififixbire	NONE	FILL3
referixdise	NONE	FILL3	referixdise	NONE	FILL3
bininibexfi	NONE	FILL3	bininibexfi	NONE	FILL3
sinibebixfi	NONE	FILL3	sinibebixfi	NONE	FILL3
nelibesexne	NONE	FILL3	nelibesexne	NONE	FILL3
sinisenixli	NONE	FILL3	sinisenixli	NONE	FILL3
disiberixri	NONE	FILL3	disiberixri	NONE	FILL3
rifelinixdi	NONE	FILL3	rifelinixdi	NONE	FILL3
libesisixfi	NONE	FILL3	libesisixfi	NONE	FILL3
budubaxfudu	NONE	FILL3	budubaxfudu	NONE	FILL3
lulufuxsara	NONE	FILL3	lulufuxsara	NONE	FILL3
dunaduxfuru	NONE	FILL3	dunaduxfuru	NONE	FILL3
susuruxbura	NONE	FILL3	susuruxbura	NONE	FILL3
raruruxnudu	NONE	FILL3	raruruxnudu	NONE	FILL3
furafuxbabu	NONE	FILL3	furafuxbabu	NONE	FILL3
babarabuxra	NONE	FILL3	babarabuxra	NONE	FILL3
nunadusaxba	NONE	FILL3	nunadusaxba	NONE	FILL3
fusurubaxsa	NONE	FILL3	fusurubaxsa	NONE	FILL3
sulubabaxna	NONE	FILL3	sulubabaxna	NONE	FILL3
bufafanaxna	NONE	FILL3	bufafanaxna	NONE	FILL3
raluraluxba	NONE	FILL3	raluraluxba	NONE	FILL3
duburubuxba	NONE	FILL3	duburubuxba	NONE	FILL3
serenixrili	NONE	FILL3	serenixrili	NONE	FILL3
didibixfebi	NONE	FILL3	didibixfebi	NONE	FILL3
ninebixfebi	NONE	FILL3	ninebixfebi	NONE	FILL3
dibilixrili	NONE	FILL3	dibilixrili	NONE	FILL3
bibelixsesi	NONE	FILL3	bibelixsesi	NONE	FILL3
firisexfini	NONE	FILL3	firisexfini	NONE	FILL3
binebexsiri	NONE	FILL3	binebexsiri	NONE	FILL3
nefinexlifi	NONE	FILL3	nefinexlifi	NONE	FILL3
sefifenexdi	NONE	FILL3	sefifenexdi	NONE	FILL3
sibifibixri	NONE	FILL3	sibifibixri	NONE	FILL3
direbirexri	NONE	FILL3	direbirexri	NONE	FILL3
sifenesexbi	NONE	FILL3	sifenesexbi	NONE	FILL3

silisilixse	NONE	FILL3	silisilixse	NONE	FILL3
nanusaxbufu	NONE	FILL3	nanusaxbufu	NONE	FILL3
lusanaxradu	NONE	FILL3	lusanaxradu	NONE	FILL3
sufuduxnasu	NONE	FILL3	sufuduxnasu	NONE	FILL3
rasabaxduna	NONE	FILL3	rasabaxduna	NONE	FILL3
rabubaxfaba	NONE	FILL3	rabubaxfaba	NONE	FILL3
fananaxluba	NONE	FILL3	fananaxluba	NONE	FILL3
sabafuxnusu	NONE	FILL3	sabafuxnusu	NONE	FILL3
fafubaxsara	NONE	FILL3	fafubaxsara	NONE	FILL3
sabulufuxsu	NONE	FILL3	sabulufuxsu	NONE	FILL3
basafufaxfa	NONE	FILL3	basafufaxfa	NONE	FILL3
sabaduraxna	NONE	FILL3	sabaduraxna	NONE	FILL3
fubasuraxba	NONE	FILL3	fubasuraxba	NONE	FILL3
rurabaruxnu	NONE	FILL3	rurabaruxnu	NONE	FILL3
barabaduxbu	NONE	FILL3	barabaduxbu	NONE	FILL3
dubudarxnamfa	BACK	FILL2	dubudarxnamfa	BACK	FILL2
duradarxnamdu	BACK	FILL2	duradarxnamdu	BACK	FILL2
dinixmernelse	FRONT	FILL2	dinixmernelse	FRONT	FILL2
nebixmernelni	FRONT	FILL2	nebixmernelni	FRONT	FILL2
rirexmernelfe	FRONT	FILL2	rirexmernelfe	FRONT	FILL2
sinixmernelne	FRONT	FILL2	sinixmernelne	FRONT	FILL2
bebixmernelfi	FRONT	FILL2	bebixmernelfi	FRONT	FILL2
faludarxnamdu	BACK	FILL2	faludarxnamdu	BACK	FILL2
sabadarxnambu	BACK	FILL2	sabadarxnambu	BACK	FILL2
lusadarxnamna	BACK	FILL2	lusadarxnamna	BACK	FILL2
buludarxnamfa	BACK	FILL2	buludarxnamfa	BACK	FILL2
fanadarxnamru	BACK	FILL2	fanadarxnamru	BACK	FILL2
burudarxnamnu	BACK	FILL2	burudarxnamnu	BACK	FILL2
sefexmernelbe	FRONT	FILL2	sefexmernelbe	FRONT	FILL2
birexmernelre	FRONT	FILL2	birexmernelre	FRONT	FILL2
firixmernelfi	FRONT	FILL2	firixmernelfi	FRONT	FILL2
fefexmernelsi	FRONT	FILL2	fefexmernelsi	FRONT	FILL2
benixmernelne	FRONT	FILL2	benixmernelne	FRONT	FILL2
subadarxnamsa	BACK	FILL2	subadarxnamsa	BACK	FILL2
rusudarxnamdu	BACK	FILL2	rusudarxnamdu	BACK	FILL2
sadarxnambasu	BACK	FILL1	sadarxnambasu	BACK	FILL1
radarxnamdusa	BACK	FILL1	radarxnamdusa	BACK	FILL1
badarxnamfana	BACK	FILL1	badarxnamfana	BACK	FILL1
dudarxnamranu	BACK	FILL1	dudarxnamranu	BACK	FILL1
fudarxnamduru	BACK	FILL1	fudarxnamduru	BACK	FILL1
sexmernelbere	FRONT	FILL1	sexmernelbere	FRONT	FILL1
nixmernelreni	FRONT	FILL1	nixmernelreni	FRONT	FILL1
fexmernelbise	FRONT	FILL1	fexmernelbise	FRONT	FILL1

bexmernelfibi	FRONT	FILL1	bexmernelfibi	FRONT	FILL1
lixmernelsine	FRONT	FILL1	lixmernelsine	FRONT	FILL1
budarxnamnaba	BACK	FILL1	budarxnamnaba	BACK	FILL1
sudarxnamfuna	BACK	FILL1	sudarxnamfuna	BACK	FILL1
radarxnamduru	BACK	FILL1	radarxnamduru	BACK	FILL1
nadarxnamfasa	BACK	FILL1	nadarxnamfasa	BACK	FILL1
dudarxnamsasu	BACK	FILL1	dudarxnamsasu	BACK	FILL1
sixmernelfibi	FRONT	FILL1	sixmernelfibi	FRONT	FILL1
sixmernelfebe	FRONT	FILL1	sixmernelfebe	FRONT	FILL1
bixmernelsise	FRONT	FILL1	bixmernelsise	FRONT	FILL1
nixmernelline	FRONT	FILL1	nixmernelline	FRONT	FILL1
dixmernelrene	FRONT	FILL1	dixmernelrene	FRONT	FILL1

List 3: Dárnam and Mernél

List 4: Dárnam and Mernél

Test item	Target	Item	Test item	Target	Item
bidifimerxnel	FRONT	TEST	felisimerxnel	FRONT	TEST
fesibimerxnel	FRONT	TEST	finisimerxnel	FRONT	TEST
firidimerxnel	FRONT	TEST	fisidimerxnel	FRONT	TEST
lifisimerxnel	FRONT	TEST	lirefimerxnel	FRONT	TEST
nedifimerxnel	FRONT	TEST	nefidimerxnel	FRONT	TEST
nesefimerxnel	FRONT	TEST	niferimerxnel	FRONT	TEST
nirefimerxnel	FRONT	TEST	refidimerxnel	FRONT	TEST
resebimerxnel	FRONT	TEST	ridifemerxnel	FRONT	TEST
rinibimerxnel	FRONT	TEST	rifebimerxnel	FRONT	TEST
rinefimerxnel	FRONT	TEST	siredimerxnel	FRONT	TEST
bafuduxdarnam	BACK	TEST	bafasuxdarnam	BACK	TEST
budusuxdarnam	BACK	TEST	dunufuxdarnam	BACK	TEST
dusufuxdarnam	BACK	TEST	fulusuxdarnam	BACK	TEST
lufusuxdarnam	BACK	TEST	lusufuxdarnam	BACK	TEST
lusafuxdarnam	BACK	TEST	nalusuxdarnam	BACK	TEST
narufuxdarnam	BACK	TEST	nafasuxdarnam	BACK	TEST
nufuduxdarnam	BACK	TEST	ralufuxdarnam	BACK	TEST
ranuduxdarnam	BACK	TEST	rasuduxdarnam	BACK	TEST
runuduxdarnam	BACK	TEST	runafuxdarnam	BACK	TEST
safuduxdarnam	BACK	TEST	badusuxdarnam	BACK	TEST
felisimerxnel	FRONT	TEST	bidifimerxnel	FRONT	TEST
finisimerxnel	FRONT	TEST	fesibimerxnel	FRONT	TEST
fisidimerxnel	FRONT	TEST	firidimerxnel	FRONT	TEST
lirefimerxnel	FRONT	TEST	lifisimerxnel	FRONT	TEST
nefidimerxnel	FRONT	TEST	nedifimerxnel	FRONT	TEST
niferimerxnel	FRONT	TEST	nesefimerxnel	FRONT	TEST
refidimerxnel	FRONT	TEST	nirefimerxnel	FRONT	TEST

ridifemerxnel	FRONT	TEST	resebimerxnel	FRONT	TEST
rifebimerxnel	FRONT	TEST	rinibimerxnel	FRONT	TEST
siredimerxnel	FRONT	TEST	rinefimerxnel	FRONT	TEST
badusuxdarnam	BACK	TEST	bafuduxdarnam	BACK	TEST
bafasuxdarnam	BACK	TEST	budusuxdarnam	BACK	TEST
dunufuxdarnam	BACK	TEST	dusufuxdarnam	BACK	TEST
fulusuxdarnam	BACK	TEST	lufusuxdarnam	BACK	TEST
lusufuxdarnam	BACK	TEST	lusafuxdarnam	BACK	TEST
nalusuxdarnam	BACK	TEST	narufuxdarnam	BACK	TEST
nafasuxdarnam	BACK	TEST	nufuduxdarnam	BACK	TEST
ralufuxdarnam	BACK	TEST	ranuduxdarnam	BACK	TEST
rasuduxdarnam	**BACK**	**TEST**	runuduxdarnam	BACK	TEST
runafuxdarnam	BACK	TEST	safuduxdarnam	BACK	TEST
bidifimerxnel	FRONT	TEST	felisimerxnel	FRONT	TEST
fesibimerxnel	FRONT	TEST	finisimerxnel	FRONT	TEST
firidimerxnel	FRONT	TEST	fisidimerxnel	FRONT	TEST
lifisimerxnel	FRONT	TEST	lirefimerxnel	FRONT	TEST
nedifimerxnel	FRONT	TEST	nefidimerxnel	FRONT	TEST
nesefimerxnel	FRONT	TEST	niferimerxnel	FRONT	TEST
nirefimerxnel	FRONT	TEST	refidimerxnel	FRONT	TEST
resebimerxnel	FRONT	TEST	ridifemerxnel	FRONT	TEST
rinibimerxnel	FRONT	TEST	rifebimerxnel	FRONT	TEST
rinefimerxnel	FRONT	TEST	siredimerxnel	FRONT	TEST
bafuduxdarnam	BACK	TEST	badusuxdarnam	BACK	TEST
budusuxdarnam	BACK	TEST	bafasuxdarnam	BACK	TEST
dusufuxdarnam	BACK	TEST	dunufuxdarnam	BACK	TEST
lufusuxdarnam	BACK	TEST	fulusuxdarnam	BACK	TEST
lusafuxdarnam	BACK	TEST	lusufuxdarnam	BACK	TEST
narufuxdarnam	BACK	TEST	nalusuxdarnam	BACK	TEST
nufuduxdarnam	BACK	TEST	nafasuxdarnam	BACK	TEST
ranuduxdarnam	BACK	TEST	ralufuxdarnam	BACK	TEST
runuduxdarnam	BACK	TEST	rasuduxdarnam	BACK	TEST
safuduxdarnam	BACK	TEST	runafuxdarnam	BACK	TEST
biresixrefi	NONE	FILL3	biresixrefi	NONE	FILL3
sirenixlise	NONE	FILL3	sirenixlise	NONE	FILL3
ninirexfebe	NONE	FILL3	ninirexfebe	NONE	FILL3
ribibexnebi	NONE	FILL3	ribibexnebi	NONE	FILL3
lifesexbere	NONE	FILL3	lifesexbere	NONE	FILL3
lininexberi	NONE	FILL3	lininexberi	NONE	FILL3
feneferexfi	NONE	FILL3	feneferexfi	NONE	FILL3
nibenefexli	NONE	FILL3	nibenefexli	NONE	FILL3
sebinisexfe	NONE	FILL3	sebinisexfe	NONE	FILL3
bifenesixfe	NONE	FILL3	bifenesixfe	NONE	FILL3

finefibexbe	NONE	FILL3	finefibexbe	NONE	FILL3
ririserixsi	NONE	FILL3	ririserixsi	NONE	FILL3
selibifexse	NONE	FILL3	selibifexse	NONE	FILL3
duraruxruru	NONE	FILL3	duraruxruru	NONE	FILL3
basubaxbaru	NONE	FILL3	basubaxbaru	NONE	FILL3
susufaxnura	NONE	FILL3	susufaxnura	NONE	FILL3
bufafuxluba	NONE	FILL3	bufafuxluba	NONE	FILL3
nadubuxbufu	NONE	FILL3	nadubuxbufu	NONE	FILL3
safuruxdufa	NONE	FILL3	safuruxdufa	NONE	FILL3
sunalubaxna	NONE	FILL3	sunalubaxna	NONE	FILL3
lufaruluxbu	NONE	FILL3	lufaruluxbu	NONE	FILL3
bubulufaxlu	NONE	FILL3	bubulufaxlu	NONE	FILL3
dufusafuxsu	NONE	FILL3	dufusafuxsu	NONE	FILL3
rasasunuxdu	NONE	FILL3	rasasunuxdu	NONE	FILL3
nurunuluxfu	NONE	FILL3	nurunuluxfu	NONE	FILL3
lunafusaxdu	NONE	FILL3	lunafusaxdu	NONE	FILL3
silirixsifi	NONE	FILL3	silirixsifi	NONE	FILL3
dibisexlife	NONE	FILL3	dibisexlife	NONE	FILL3
febibixseli	NONE	FILL3	febibixseli	NONE	FILL3
benefixfefi	NONE	FILL3	benefixfefi	NONE	FILL3
felisexbiri	NONE	FILL3	felisexbiri	NONE	FILL3
nififixbire	NONE	FILL3	nififixbire	NONE	FILL3
referixdise	NONE	FILL3	referixdise	NONE	FILL3
bininibexfi	NONE	FILL3	bininibexfi	NONE	FILL3
sinibebixfi	NONE	FILL3	sinibebixfi	NONE	FILL3
nelibesexne	NONE	FILL3	nelibesexne	NONE	FILL3
sinisenixli	NONE	FILL3	sinisenixli	NONE	FILL3
disiberixri	NONE	FILL3	disiberixri	NONE	FILL3
rifelinixdi	NONE	FILL3	rifelinixdi	NONE	FILL3
libesisixfi	NONE	FILL3	libesisixfi	NONE	FILL3
budubaxfudu	NONE	FILL3	budubaxfudu	NONE	FILL3
lulufuxsara	NONE	FILL3	lulufuxsara	NONE	FILL3
dunaduxfuru	NONE	FILL3	dunaduxfuru	NONE	FILL3
susuruxbura	NONE	FILL3	susuruxbura	NONE	FILL3
raruruxnudu	NONE	FILL3	raruruxnudu	NONE	FILL3
furafuxbabu	NONE	FILL3	furafuxbabu	NONE	FILL3
babarabuxra	NONE	FILL3	babarabuxra	NONE	FILL3
nunadusaxba	NONE	FILL3	nunadusaxba	NONE	FILL3
fusurubaxsa	NONE	FILL3	fusurubaxsa	NONE	FILL3
sulubabaxna	NONE	FILL3	sulubabaxna	NONE	FILL3
bufafanaxna	NONE	FILL3	bufafanaxna	NONE	FILL3
raluraluxba	NONE	FILL3	raluraluxba	NONE	FILL3
duburubuxba	NONE	FILL3	duburubuxba	NONE	FILL3

serenixrili	NONE	FILL3	serenixrili	NONE	FILL3
didibixfebi	NONE	FILL3	didibixfebi	NONE	FILL3
ninebixfebi	NONE	FILL3	ninebixfebi	NONE	FILL3
dibilixrili	NONE	FILL3	dibilixrili	NONE	FILL3
bibelixsesi	NONE	FILL3	bibelixsesi	NONE	FILL3
firisexfini	NONE	FILL3	firisexfini	NONE	FILL3
binebexsiri	NONE	FILL3	binebexsiri	NONE	FILL3
nefinexlifi	NONE	FILL3	nefinexlifi	NONE	FILL3
sefifenexdi	NONE	FILL3	sefifenexdi	NONE	FILL3
sibifibixri	NONE	FILL3	sibifibixri	NONE	FILL3
direbirexri	NONE	FILL3	direbirexri	NONE	FILL3
sifenesexbi	NONE	FILL3	sifenesexbi	NONE	FILL3
silisilixse	NONE	FILL3	silisilixse	NONE	FILL3
nanusaxbufu	NONE	FILL3	nanusaxbufu	NONE	FILL3
lusanaxradu	NONE	FILL3	lusanaxradu	NONE	FILL3
sufuduxnasu	NONE	FILL3	sufuduxnasu	NONE	FILL3
rasabaxduna	NONE	FILL3	rasabaxduna	NONE	FILL3
rabubaxfaba	NONE	FILL3	rabubaxfaba	NONE	FILL3
fananaxluba	NONE	FILL3	fananaxluba	NONE	FILL3
sabafuxnusu	NONE	FILL3	sabafuxnusu	NONE	FILL3
fafubaxsara	NONE	FILL3	fafubaxsara	NONE	FILL3
sabulufuxsu	NONE	FILL3	sabulufuxsu	NONE	FILL3
basafufaxfa	NONE	FILL3	basafufaxfa	NONE	FILL3
sabaduraxna	NONE	FILL3	sabaduraxna	NONE	FILL3
fubasuraxba	NONE	FILL3	fubasuraxba	NONE	FILL3
rurabaruxnu	NONE	FILL3	rurabaruxnu	NONE	FILL3
barabaduxbu	NONE	FILL3	barabaduxbu	NONE	FILL3
dinimerxnelse	FRONT	FILL2	dinimerxnelse	FRONT	FILL2
faluxdarnamdu	BACK	FILL2	faluxdarnamdu	BACK	FILL2
sasuxdarnambu	BACK	FILL2	sasuxdarnambu	BACK	FILL2
dubuxdarnamfa	BACK	FILL2	dubuxdarnamfa	BACK	FILL2
ruruxdarnamna	BACK	FILL2	ruruxdarnamna	BACK	FILL2
risemerxnelbe	FRONT	FILL2	risemerxnelbe	FRONT	FILL2
naduxdarnamba	BACK	FILL2	naduxdarnamba	BACK	FILL2
firimerxnelfi	FRONT	FILL2	firimerxnelfi	FRONT	FILL2
sinimerxnelne	FRONT	FILL2	sinimerxnelne	FRONT	FILL2
bebimerxnelfi	FRONT	FILL2	bebimerxnelfi	FRONT	FILL2
sabaxdarnambu	BACK	FILL2	sabaxdarnambu	BACK	FILL2
rusuxdarnamdu	BACK	FILL2	rusuxdarnamdu	BACK	FILL2
rerimerxnelre	FRONT	FILL2	rerimerxnelre	FRONT	FILL2
fanaxdarnamdu	BACK	FILL2	fanaxdarnamdu	BACK	FILL2
buluxdarnamfa	BACK	FILL2	buluxdarnamfa	BACK	FILL2
sirimerxnelre	FRONT	FILL2	sirimerxnelre	FRONT	FILL2

firimerxnelri	FRONT	FILL2	firimerxnelri	FRONT	FILL2
sibemerxnelfe	FRONT	FILL2	sibemerxnelfe	FRONT	FILL2
dirimerxneli	FRONT	FILL2	dirimerxneli	FRONT	FILL2
dubaxdarnamsa	BACK	FILL2	dubaxdarnamsa	BACK	FILL2
simerxnelrine	FRONT	FILL1	simerxnelrine	FRONT	FILL1
fimerxnelbebi	FRONT	FILL1	fimerxnelbebi	FRONT	FILL1
bemerxnelfibe	FRONT	FILL1	bemerxnelfibe	FRONT	FILL1
dirimerxnelli	FRONT	FILL1	dirimerxnelli	FRONT	FILL1
nimerxnelline	FRONT	FILL1	nimerxnelline	FRONT	FILL1
saxdarnambasu	BACK	FILL1	saxdarnambasu	BACK	FILL1
baxdarnamfana	BACK	FILL1	baxdarnamfana	BACK	FILL1
raxdarnamrusa	BACK	FILL1	raxdarnamrusa	BACK	FILL1
fuxdarnambufu	BACK	FILL1	fuxdarnambufu	BACK	FILL1
duxdarnamranu	BACK	FILL1	duxdarnamranu	BACK	FILL1
simerxnelfibi	FRONT	FILL1	simerxnelfibi	FRONT	FILL1
nemerxnelnine	FRONT	FILL1	nemerxnelnine	FRONT	FILL1
bimerxnelsise	FRONT	FILL1	bimerxnelsise	FRONT	FILL1
simerxnelbesi	FRONT	FILL1	simerxnelbesi	FRONT	FILL1
fimerxnelsisi	FRONT	FILL1	fimerxnelsisi	FRONT	FILL1
luxdarnamnalu	BACK	FILL1	luxdarnamnalu	BACK	FILL1
naxdarnamfasa	BACK	FILL1	naxdarnamfasa	BACK	FILL1
baxdarnambulu	BACK	FILL1	baxdarnambulu	BACK	FILL1
duxdarnamsasu	BACK	FILL1	duxdarnamsasu	BACK	FILL1
fuxdarnamduru	BACK	FILL1	fuxdarnamduru	BACK	FILL1