Chapter 5, Paper 3

Using the Head-Turning Technique to Explore Cross-Linguistic Performance Differences*

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INTRODUCTION

During the first year of life, infants learn about the phonological organization of their native language. By the end of that year, they know the first words of their language. In order to begin the process of building a vocabulary, infants have to have some way

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of finding out, or at least hypothesizing, what patterns in the speech input correspond to individual lexical items for which they should construct a representation in memory. How can the course of infants' development during this crucial first year of life be charted? When exactly do children acquire the ability to learn new words? It is reasonable to assume that production of the child's first word, although a milestone from one point of view, is actually preceded by considerable earlier development of word perceptual abilities; but without any productive capacity, the child is not easily able to communicate the extent of this perceptual development. Here, the head-turning paradigm has proved invaluable in providing a window into perceptual development in the first year of life. For instance, head-turning studies have shown that between 6 and 12 months of age infants become sensitive to native vowel and consonant categories (Jusczyk, Friederici, Wessels, Svenkerud, & Jusczyk, 1993; Polka & Werker, 1994), and to phonotactically legal onset and offset clusters (Friederici & Wessels, 1993).

Also with this task it has been shown that infants are sensitive to the prosodic structure of words (Jusczyk, Cutler, & Redanz, 1993). Jusczyk and colleagues showed that American-English infants become sensitive to the predominant strong-weak[1] (S/W) stress pattern of English somewhere between 6 and 9 months of age. Nine-month-old American-English infants, but not 6-month-olds, listen significantly longer to Disyllabic words with a S/W pattern (e.g., *final),* which is predominant in English (see Cutler & Carter, 1987), than to words with a W/S pattern (e.g., *define).* This is important because adult studies have shown that word segmentation in languages such as English is based on the metrical structure of words, in terms of strong and weak syllables. For instance, Cutler and Norris (1988) and Cutler and Butterfield (1992) have shown that English listeners start segmenting fluent speech by assuming word boundaries at the onset of a strong syllable. This has been called the metrical segmentation strategy (MSS).

Finally, a modified version of the head-turning task has revealed that infants are capable of recognizing word patterns as early as 7,5 months. Jusczyk and Aslin (1995) investigated this issue using the Headturn Procedure (see Kemler Nelson, 1995) which was slightly modified by an adapted version of the word monitoring paradigm. In this paradigm, infants are first familiarized with novel words that are repeated several times in isolation. Then, they hear sentences containing the familiar words but also sentences containing unfamiliar words. If infants detect a similarity between the pattern they heard in isolation and the pattern in sentential context, they will listen longer to the sentences with familiar words than to the sentences with unfamiliar words.

With this version of the task, Newsome and Jusczyk (1995) showed that, as the above review would predict, sensitivity to S/W foot structures is also discernible in word-pattern recognition at this early stage. Their findings demonstrate that 7i-month-old infants recognize S/W words *(doctor)* in fluent speech after having been familiarized with those words. However, if the infants are familiarized with only the strong syllables of those words (e.g., *dock)* they no longer treat the passages containing the whole words as familiar. The results suggest that 7,5-month-old English-learning infants treat S/W patterns in fluent speech as cohesive units rather than two independent syllables. In the case of W/S words (e.g., *guitar),* the infants showed the opposite pattern. When familiarized with the whole words, they did not treat the passages containing those words as familiar, but they did attend longer to the passages when familiarized with only the strong syllable (e.g., *tar).* Newsome and Jusczyk interpreted those findings as evidence that the infants use a metrical segmentation strategy in fluent speech in which strong syllables are assumed to indicate word onsets. Further investigation by Houston, Jusczyk, and Newsome (1995) strengthened the claim that English-learning infants use a metrical segmentation strategy by showing that it is used even across word boundaries. When presented with passages containing W/S words that were always followed by the same function word (e.g., *guitar is),* 7,5-month-olds no longer treated the strong syllable (e.g., *tar)* as familiar. Instead, they treated the S/W patterns formed across word boundaries (e.g., *taris)* as familiar. These results suggest that English-learning infants recognized the sequence *taris* in sentential context.

In the present study we report, first, a replication of the Newsome and Jusczyk study in Dutch, using the head-turning technique developed by Jusczyk and Aslin (1995). This allows us to make a cross-linguistic comparison between infant speech segmentation in English and Dutch. Dutch is a language with a similar foot structure to that of English, and its vocabulary is also predominantly strong-initial; thus it presents an appropriate test for the use of the S/W foot in speech segmentation. In Table 1, three corpus studies of metrical[2] stress are compared which demonstrate the similarities between English and Dutch were conducted. The two studies on English were conducted by Cutler and Carter (1987), and the study on Dutch was conducted by van Kuijk (1996).

In each study, the proportion of strong and weak syllables in word-initial position were calculated. Cutler and Carter only incorporated lexical words (content words) in their analysis and no grammatical words (function words). They assume that humans process lexical words and grammatical words in different ways, and that the MSS is mainly used to find the onsets of lexical words. In the English MRC corpus (weighted for word frequency), 84 percent of the lexical words began with a strong syllable. In the corpus of spontaneous British conversation, 90 percent of the lexical words began with a strong syllable. For Dutch, there is no transcribed corpus of spontaneous speech available. In the CELEX-database (weighted for word frequency), 76 percent of the words began with a strong syllable, and 24 percent of the words began with a weak syllable. The number of weak-initial syllables is higher in the Dutch CELEX corpus than in the English MRC corpus, which are comparable lexical databases, but this can be explained by the fact that both lexical and grammatical words were included in the Dutch study. The database studies show that for both English and Dutch metrical stress is a good indicator for the location of word boundaries, and that a strategy in which the listener postulates word boundaries at the onset of strong syllables would be highly successful.

The preponderance of initial strong syllables and the importance of the S/W foot both English and Dutch are also manifested in child production studies. The pro-

TABLE 1.
Proportion of strong syllables (with full vowel) and weak syllables (with schwa or reduced vowel) in word-initial position in the British-English MRC corpus, the London-Lund corpus, and the Dutch CELEX corpus.*

English	**English**	**Dutch**
MRC	LONDON-LUND	CELEX
98,000 lexical words weighted for word freq.	190,000 lexical words spontaneous conversation	329,773 lex-gram words weighted for word freq.
initial = Strong 0.84	initial = Strong 0.90	initial = Strong 0.76
initial = Weak 0.16	initial = Weak 0.10	initial = Weak 0.24
Cutler & Carter (1987)	*Cutler & Carter (1987)*	*van Kuijk (1996)*

*English data taken from Cutler and Carter, 1987, and Dutch material from van Kuijk, 1996. Used with permission.

duction data support the hypothesis that young children map words and phrases preponderantly onto the SAV template. Evidence that English-learning children use a SAV template has been shown, among others, by Demuth (1996), and Gerken (1994b). Wijnen, Krikhaar, and den Os (1994) and Fikkert (1994) show that during the second year of life Dutch children also manifest a SAV constraint in the course of utterance preparation. Note that in the Dutch studies, a "weak" syllable could contain a schwa, or a full vowel with secondary word stress. When children apply a S/W template, the strong syllable of the intended word is mapped onto the strong syllable of the template. If the target word also contains weak syllables, only those syllables that fit the template are retained, while those that do not fit the template are omitted. For instance, the Dutch word *andere* ("other") is realized as [anre] and the word *olifant* ("elephant") as ['oxant]. However, in the words *kastanje* ("chestnut") and *pantoffel* ("slipper") the first weak syllable does not fit the template and is omitted. The words are thus realized as the SAV words ['tane] and [tofet]. These observations demonstrate that the rhythmic regularities of the language are encoded by young children and reflected in their speech production.

The Dutch study by Wijnen and colleagues also reports the rhythmic structure of the input spoken by the mother to the child. The input is important since these are the utterances by means of which the child builds up a metrical representation which will be used in speech segmentation. The rhythmic structure of the content words of one mother-child pair are given in Table 2. These data are deduced from Figure 1 and Table 1 in the Wijnen et al. study. The data show that the mother's choice of words in her child-directed speech quite closely matches the rhythmic patterns of the child's vocabulary. Almost 90 percent of the words, in both mother and child have a strong initial syllable and the SAV rhythmic structure is clearly prevalent. Only 12 percent of the child's utterances and 13 percent of the mother's utterances have a weak-initial syllable. Kelly and Martin (1994) also report the rhythmic structure of parental speech in English to children 1 to 2 years old. Similar to the Dutch study, strong syllables cor-

TABLE 2.
Rhythmic structure of the content words in child and mother's speech during a period of 4 months (18-22 months). The data are deduced from Figure 1 and Table 1 in the study by Wynen et al. (1994).

18-22 months		Input (mother)	
S initial words	88%	S initial words	87%
S	28%	S	20%
SW	53%	SW	60%
SWW	7%	SWW	7%

respond with word boundaries 95 percent of the time, and only 5 percent of the words in the parents' utterances have a weak-initial syllable.

The English and Dutch database studies and the child production studies show that in both languages stress is a good indicator for the location of word boundaries. Most of the words have a strong initial syllable, and the importance of the S/W foot is also manifested in the parent-child interaction. Therefore, Dutch 7,5-month-old infants were expected to rely on the S/W foot in early word recognition, just like the American-English infants.

EXPERIMENT 1

Method

Subjects

Twenty-four Dutch infants (12 male, 12 female) were tested. The average age was 7 months and 14 days. The ages ranged from 7 months and 6 days to 7 months and 27 days. Nineteen additional infants were tested but not included in the analysis for the following reasons: crying (12), sleeping (1), looking times too short (the average looking time for a stimulus being less than 3 seconds) (4) not interested, (no measurable looking time at all, the test phase was aborted) (2).

Dutch material

The Dutch material was constructed by analogy with the English material (Newsome & Jusczyk, 1995). Four words with a S/W pattern were selected: *bokser* [bokser] ("boxer"), *karper* [karper] ("carp"), *pendel* [pendel] ("hanging lamp"), and *kusten* [kyste(n)] ("coasts"). These words were selected for four reasons; they contrast in the vowel qualities of the stressed syllable, the weak syllable always contains a schwa, the onset consonant is always a stop consonant, and infants are not likely to have earlier experience with these words. Each target word occurred six times in a passage of six sentences; twice in the beginning, twice in the middle, and twice at the end of the sentence (see Table 3). The target words were preceded by a limited set of determinants to avoid the possibility that there might be a dif-

TABLE 3.
The Dutch passages that were used in the experiments with the target words *bokser* ('boxer'), *karper ('carp'), pendel* ('hanging lamp'), and *kusten* ('coasts').

Bokser	*Karper*
De *bokser* moet wel een erg sterke man zijn.	De *karper* zwemt in de vijver bij de school.
Hij is de beste *bokser* van de hele wereld.	De jongen wil de nieuwe *karper* gaan vangen.
E!ke dag gaat hij trainen met een andere *bokser.*	Dan ziet de meester nog een andere *karper.*
Die *bokser* is echter veel gespierder dan hij.	Hij moet nu de beste *karper* met rust laten.
Soms moet hij vechten tegen een nieuwe *bokser.*	Die *karper* zal nog een hele tijd blijven leven.
Dat is geen oude *bokser* maar een jonge.	Nu gaan ze op de foto met de oude *karper.*
Pendel	*Kusten*
Die *pendel* ligt op het bureau van mijn oom.	De *kusten* zijn hier bebouwd met hoge hotels.
Hij is dan ook erg trots op de beste *pendel.*	Aan de andere *kusten* zijn erg veel toeristen.
Volgens hem is het al een heel oude *pendel.*	Met de boot varen zij langs de nieuwe *kusten.*
Hij vindt deze nieuwe *pendel* iets minder apart.	De visser kent alle oude *kusten* van dit land.
De pendel heeft hij in een dure zaak gekocht.	Die *kusten* zijn nog niet door de gasten ontdekt.
Ik heb de andere *pendel* ook wel eens gebruikt	Morgen ga ik vissen bij de beste *kusten.*

ferent set of word-to-word transitions for one kind of target versus another. In addition, it reduces the possibility that the infant might segment one target word more easily than another.

Recording

There were four passages of six sentences and these were read by a female speech therapist in a lively voice. She was instructed to read them as if she was talking to a small child. The recordings were made in a sound-treated booth with a Sennheiser ME40 microphone. The passages were recorded together with eight filler passages so that the speaker would not contrastively stress the target words. After reading the passages, the speaker repeated each isolated target word *(bokser, karper, pendel, kusten)* with some variation 15 times in a row. Thus, there were four wordlists, and in each wordlist, the target word (e.g., *bokser)* was repeated in a varied way. First, the wordlists and the passages were digitized with the speech editing system XWAVES using a 16 kHz sampling frequency after low-pass filtering. Then, the duration of each passage, ranging from 16.25 seconds to 19.61 seconds, was set to a length of 20 seconds by adapting the silence between the sentences. The duration of the word lists, ranging from 17.6 seconds to 21.7 seconds, was set to a length of 21.5 seconds by adapting the silence between the 15 isolated words. Finally, the wordlists and passages were converted to NESU, a program for executing realtime stimulus presentation tasks.

Design

Half of the infants were familiarized with the isolated words *bokser* and *karper,* and the other half with *pendel* and *kusten?* Subsequently, they all heard four blocks of four passages (16 trials). The order of the passages within the blocks was randomized and counterbalanced across subjects.

Apparatus

The infant was seated on the parent's lap in the center of a three-sided enclosure, 4 x 6 ft on three sides. A green light was mounted at eye level on the center panel. A red light and acoustic speakers (Canton) were mounted on each of the side panels, approximately 78 degrees to the left and right of the infant when it was facing midline. The computer configuration (Hermac PC) was placed in a separate room, next to the experimental room. During the course of the experiment, both the experimenter and the caregiver listened to a masking tape over tight-fitting closed headphones (Sennheiser HD250). The masker consisted of isolated sentences from the test and filler passages, recorded in random order without any silence between the sentences. The experimenter was seated in the separate room and watched the infant's behavior on a monitor (Sony) that was connected with a video camera (Sony) placed above the green light in the center panel. The experimenter recorded the infant's listening times via a response box with two buttons. The response box started and stopped the lights and the speech trials (see Procedure), and was connected to the computer which recorded and stored the direction, the number, and the duration of headturns.

Procedure

During the experiment, the light in the room was dimmed. Each trial began by the blinking of the green light to draw the infant's attention to the center position. When the infant had oriented in that direction, the green light was extinguished and the red light above one of the loudspeakers began to flash. When the infant made a headturn of at least 30° in the direction of the flashing light, the speech trial was started. The light remained on for the entire duration of the trial. The speech trial was continued either to completion (21.5 seconds for familiarization, 20 seconds for test trials) or until the infant looked away for at least 2 seconds. If the infant looked back within 2 seconds, the speech trial continued; the 2 seconds were not included in the listening time. The experiment had two phases. First, infants were familiarized with two target words which were presented on alternating trials and repeated several times in isolation. The familiarization criterion was reached when the infant accumulated at least 30 seconds of orientation time to each word. The test phase in which the four passages were presented started immediately after the familiarization phase. Each infant was tested on four blocks, and each passage occurred once in a given block. The order of the passages within a block was randomized.

Results

Mean listening times to the passages with the familiar words and the unfamiliar words were calculated for each infant. The mean listening times were 6.84 seconds to the passages with the familiar words (*SD* = 2.22 seconds), and 6.72 seconds to the passages with the unfamiliar words (*SD* = 1.93 seconds) (see Figure 1). Of the 24 infants, 11 infants listened longer to the passages with the familiar words, and thirteen to the passages with the unfamiliar words. The difference in average listening time was not significant in a two-tailed paired t test [t (23) = 0.37, p = 0.716]. The results show that 7,5-monfh-old Dutch infants did not have a preference for the passages containing the words they were familiarized with. The mean listening times to three passages (those containing *bokser, karper, kusteni)* were longer for those infants who were not familiarized with these target words than for the infants who were familiarized with the target words. The differences were 860 ms for the *bokser* passage, 610 ms for the *karper* passage, and 330 ms for the *kusten* passage. Despite the non-significant results, it seems that there is a slight tendency for a novelty preference in three of the passages.

Apparently, the Dutch 7,5-month-old infants were not able to recognize S/W words in fluent speech, whereas the 7,5-month-old American-English infants did recognize words of this structure (Newsome & Jusczyk, 1995; see also Jusczyk, this volume). The difference between the Dutch and the American-English results might have been the result of an acoustic difference in the materials used. For instance, the American-English words might have been realized with a lengthening of the vowel in the stressed syllable, a lengthening which is uncommon in Dutch when the stressed syllable contains a phonologically short vowel. This means that the American-English

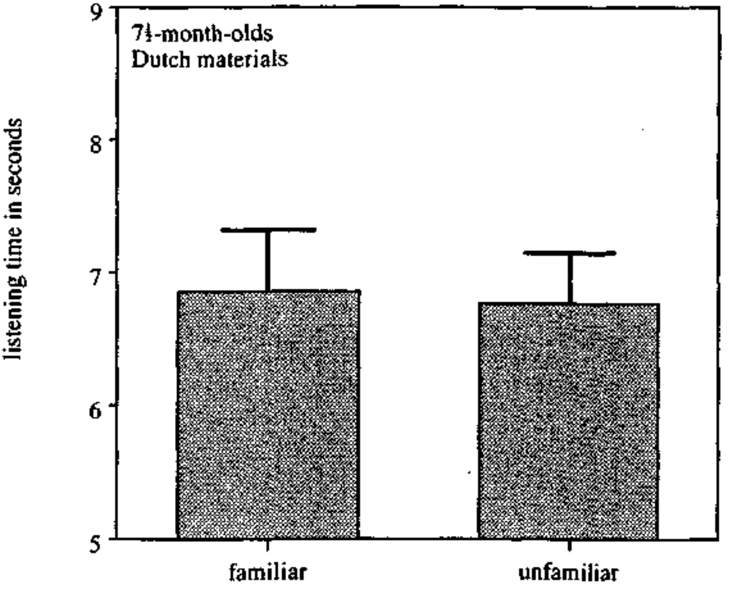

Figure 1. Average listening times of 7½-month-old Dutch infants to Dutch passages containing familiar or unfamiliar S/W words. Error bars indicate the standard error of the mean.

infants might have been exposed to a more salient S/W distinction than the Dutch infants. This difference between strong and weak syllables in English may induce the infants to use the S/W template whereas this difference may not be strong enough in Dutch for the infants to use the pattern.

EXPERIMENT 2

The experiment was replicated with a new group of 7,5-month-old Dutch infants, but now the original English materials, used by Newsome and Jusczyk (1995), were presented to the infants. Since the paradigm is based on infants' recognition of acoustic patterns, without any further cognitive demand, it is appropriate to investigate the infant behavior not only when words and sentences in their native language (Dutch) are presented, but also when a foreign language (English) is presented.

Method

Subjects

Twenty-four Dutch infants (11 male, 13 female) were tested. The infants had an average age of 7 months and 16 days. The ages ranged from 7 months and 4 days to 7 months and 26 days. Thirteen additional infants were tested but not included in the analysis for the following reasons: crying (4), looking times too short (2), not interested (4), restless (1), sleeping (1), and equipment failure (1).

Material

The original American-English wordlists and passages (Newsome & Jusczyk, 1995) were digitized in the same way as the Dutch materials in Experiment 1, and converted to the NESU program for realtime stimulus presentation.

*Design **and procedure***

Half of the infants were familiarized with the isolated words *doctor* and *candle,* and the other half with the words *kingdom* and *hamlet.* Subsequently, they all heard four blocks of four passages (16 trials). The order of the passages within the blocks was randomized and counterbalanced across subjects. The apparatus and procedure were identical to those in the previous experiment.

Results

For each infant, mean listening times to the passages with the familiar words and the unfamiliar words were calculated. The mean listening times were 7.58 seconds to the passages with the familiar words *(SD* = 2.93 seconds), and 8.01 seconds to the passages with the unfamiliar words *(SD* = 3.34 seconds) (see Figure 2). As in the previous experiment, 11 infants listened longer to the passages with the familiar words and 13 infants listened longer to the passages with the unfamiliar words. The difference in average listening time was not significant in a two-tailed paired t test [$t(23) = 1.03, p = 0.314$]. In comparison with the results from the previous experiment, Dutch infants listened somewhat longer to the English materials (mean listening time across passages 7.80 seconds) than to the Dutch materials (mean listening time across passages 6.78 s). On the one hand, this may have resulted from a difference in the length of the speech trials; the English passages were somewhat longer (23-24 seconds) than the Dutch passages (20 seconds). On the other hand, it may have been due to the novelty of the stimulus language, though this, of course, cannot be unequivocally determined here.

Again, the 72-month-old infants did not listen longer to the passages with the familiar target words than to the passages with the unfamiliar target words. Apparently, the differences between the American-English study and the Dutch study testing 72-month-old infants is not due to acoustic differences in the materials used. It is possible that at the age of *7i* months, Dutch infants are not able to recognize S/W words in fluent speech, and therefore behave differently than the American-English infants. If the discrepancy between the two studies is due to an age effect, then Dutch infants who are somewhat older, should be able to use the S/W segmentation strategy.

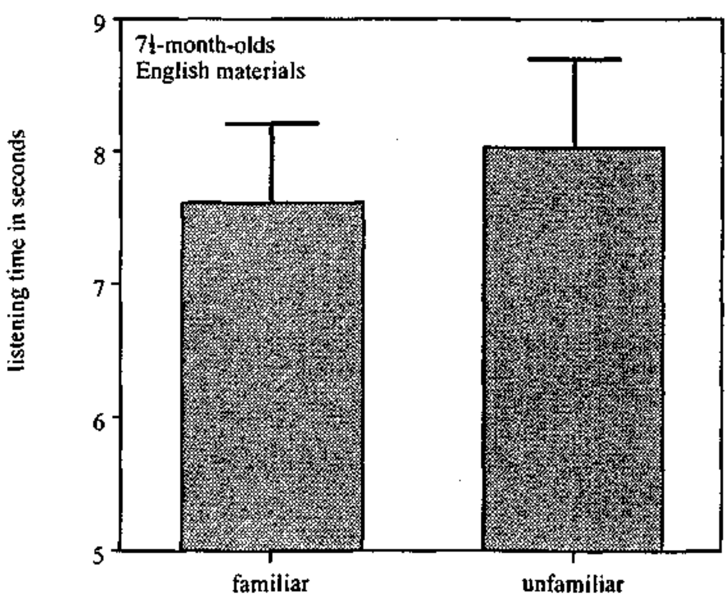

Figure 2. Average listening times of 7½-month-old Dutch infants to English passages containing familiar or unfamiliar S/W words. Error bars indicate the standard error of the mean.

EXPERIMENT 3

In order to test whether older Dutch infants recognize S/W words in fluent speech, the first experiment was repeated using the same Dutch materials, but now with 9-month-old Dutch infants.

Subjects

Twenty-four 9-month-old Dutch infants (14 male, 10 female) were tested. The infants had an average age of 9 months and 8 days. The ages ranged from 9 months and 2 days to 9 months and 21 days. Twenty-eight additional infants were tested but not included in the analysis for the following reasons: crying (7), looking times too short (9), not interested (10), and equipment failure (2).

Material, Design, Apparatus, Procedure

These were identical to those in the first experiment.

Results

For each infant, mean listening times to the passages with the familiar words and the unfamiliar words were calculated. Of the 24 infants, 17 listened longer to

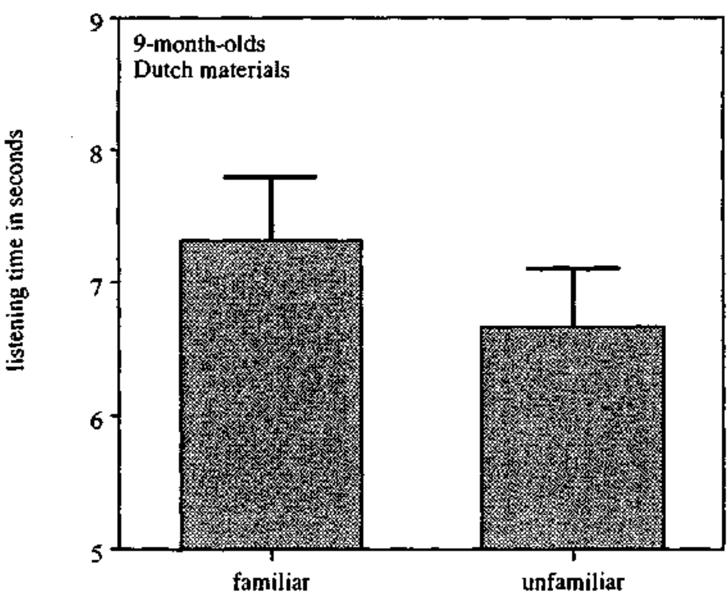

Figure 3. Average listening times of 9-month-old Dutch infants to Dutch passages containing familiar or unfamiliar S/W words. Error bars indicate the standard error of the mean.

the passages with the familiar words and seven to the passages with the unfamiliar words. The mean listening times were 7.30 seconds to the passages with the familiar words (*SD* = 2.27 seconds), and 6.61 seconds to the passages with the unfamiliar words (*SD* = 2.31 seconds) (see Figure 3). The difference in average listening time was marginally significant in a two-tailed paired t test [t (23) = 1.95, p = 0.064]. "

The 9-month-old infants showed a tendency toward recognition of the words they were familiarized with, which together with the results of Experiments 1 and 2, suggests that Dutch infants use the S/W word segmentation strategy some time around 9 months. However, we cannot rule out the possibility that infants at this age already have other strategies for detecting word boundaries in fluent speech and that they do not only rely on the metrical (S/W) structure of the word. For instance, infants at this age are sensitive to legal and illegal onset and offset clusters (Friederici & Wessels, 1993) and this could have helped them to recognize the words in fluent speech. A closer look at the passages shows that for three passages (*bokser, karper, pendel,* but not *kusten)* the mean listening times are longer for those infants who were familiarized with the target word than for infants who were not familiarized with the target

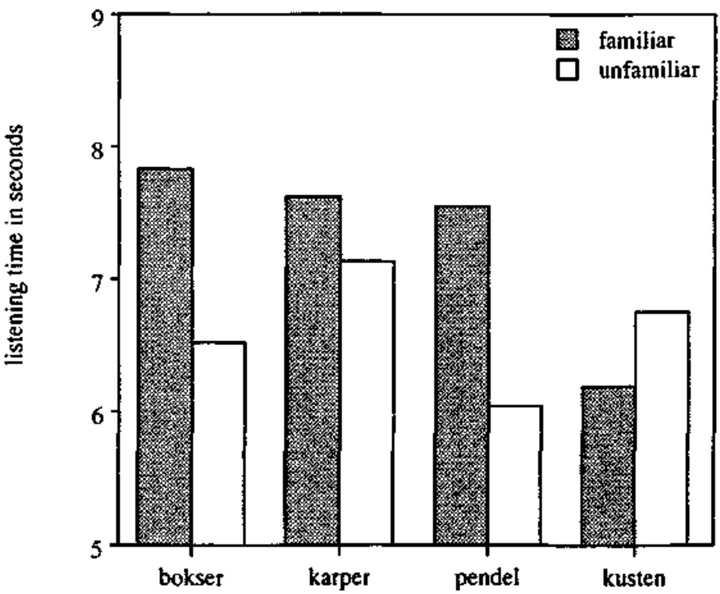

Figure 4. Average listening times of 9-month-old Dutch infants to each of the four passages. Gray bars indicate the listening times to the passages after target-word familiarization, white bars indicate the listening times without target-word familiarization.

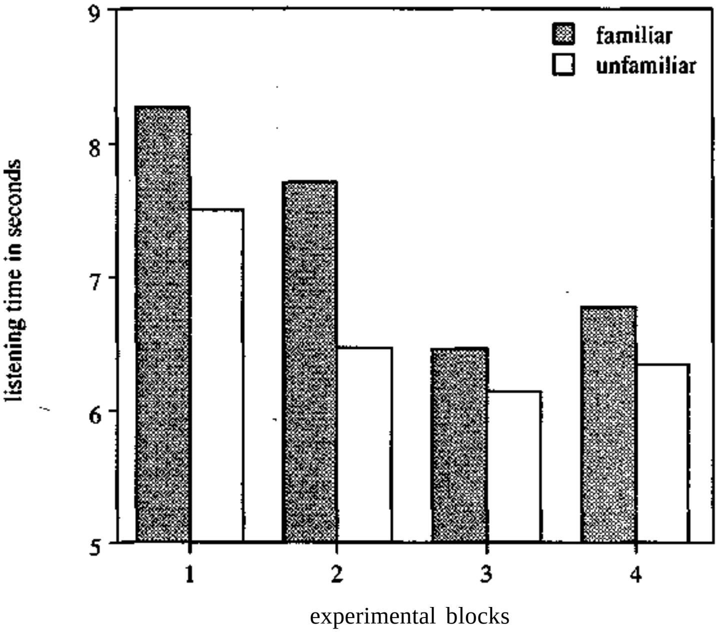

Fig. 5. Average listening times of 9-month-old Dutch infants to each of the four experimental blocks. Gray bars indicate the listening times to the passages after target-word familiarization, white bars indicate the listening times without target-word familiarization.

word. Across these three passages, the mean listening times were 7.67 seconds to the passages with the familiar words (*SD* = 4.98 seconds), and 6.57 seconds to the passages with the unfamiliar words (*SD* = 4.33 seconds). This difference was significant in a two-tailed paired t test [t (23) = 2.56, *p* = 0.017]. This result shows that word recognition in fluent speech is very likely to occur by 9 months and that the apparent trend toward a novelty preference, as found for some materials at the age of *1*\ months (Experiment 1), has disappeared. Moreover, in each of the four experimental blocks, the mean listening times to the passages with the familiar words were longer than the mean listening times to the passages with the unfamiliar words (see Figure 4 and 5). Thus, over all four blocks, the infants consistently prefer the passages which contain the words with which they were previously familiarized.

DISCUSSION

In the present study, the head-turning technique was used to investigate whether Dutch infants are able to recognize words with a S/W metrical structure in fluent speech. Newsome and Jusczyk (1995) showed that 72-month-old American-English infants use the whole S/W foot *(doctor)* to recognize words in fluent speech. They can recognize the occurrence of S/W patterns in fluent speech and treat them as cohesive. They do not demonstrate an ability to locate W/S words in fluent speech, and they do not attend longer to a passage containing a S/W target word after being familiarized with only its strong syllable. The findings by Newsome and Jusczyk suggest that infants at this age are developing a sensitivity to the foot structure of English words (i.e., word-initial syllables are predominantly strong and followed by a weak syllable). Infants at this age seem to be able to exploit the prosodic regularity of their native language for word segmentation in fluent speech. In order to make a clear comparison between infant segmentation strategies in Dutch and English (two languages with a similar foot structure), we adopted the same paradigm, constructed Dutch materials analogous with the English materials, and conducted the experiments with Dutch children. Since the paradigm is used with young infants, it is not based on the comprehension of words but on the recognition of repeating acoustic patterns, that is, potential words. This allowed us to extend the cross-linguistic comparison by presenting not only the Dutch materials but also the English materials to Dutch infants.

The results show that Dutch 72-month-old infants do not detect familiar S/W words in fluent speech. Exposure to a repeated isolated S/W word (e.g., *bokser)* does not prime the infant to listen longer to a passage containing the word. This was true whether the infants listened to Dutch words and passages (Experiment 1), or to English words and passages (Experiment 2). However, it was found that Dutch 9-month-old infants, listening to Dutch words and passages, displayed a tendency to listen longer to passages containing the familiar word. This could be based on a metrical segmentation strategy (Cutler & Butterfield, 1992; Cutler & Norris, 1988), but infants at this age might equally have used additional cues to detect word boundaries in fluent speech, such as phonotactic information (Friederici & Wessels, 1993). The discrepancy between the Dutch and the American-English results is not likely to be due to differences in experimental set-up or experimental procedure, since in both studies the paradigm was exactly the same; moreover, the third author, who was one of the experimenters in the Dutch studies here, conducted part of the American-English study (Jusczyk, Houston & Newsome, in preparation; Newsome & Jusczyk, 1995).

How can we explain the difference in perceptual behavior of Dutch and American-English infants whose native languages have a similar foot structure? We assume that acoustic and distributional differences in metrical structure underlie the cross-language differences, and the head-turning technique seems to be sensitive to these language-specific characteristics. We carried out acoustic measurements on the Dutch words *bokser/pendel* and the English words *doctor/candle.* These words were chosen because they are highly similar in segmental make-up. For both strong and weak syllables, we measured the duration (in ms), mean pitch (mean FO in Hz) and pitch variation (standard deviation of mean FO in Hz). To obtain measures of strong-syllable saliency, the value for the strong syllable was divided by the value for the weak syllable (S-W ratio) for each of these three variables.

First, the S-W ratio was calculated for the isolated words presented in the word lists during the familiarization phase. The S-W ratio was higher for the English words than for the Dutch words, especially with respect to mean pitch and pitch variation. For the Dutch words, the S-W ratio for mean pitch was 1.03 and for pitch variation 0.98, whereas for the English words the S-W ratio for mean pitch was 1.24 and for pitch variation 1.84. Second, the S-W ratio was calculated for the words occurring in the passages which were presented in the test phase. The acoustic measurements indicated that in sentential context the Dutch and English words did not differ in duration, mean pitch, or pitch variation. The acoustic data show that in the Dutch *word lists* the strong and weak syllable hardly differ, whereas in the English *word lists* the strong syllable is clearly marked by its mean pitch and, above all, by its pitch variation. This would cause the strong syllable to be more salient in the English words than in the Dutch words, and the American-English infants use this cue for word recognition. However, the Dutch infants also listened to the English words and passages but did not use this cue. This suggests that Dutch infants at *7,5* months are not as closely attuned to the metrical patterns of their language as are American-English infants of the same age, and it is reasonable to attribute this to the fact that the S/W patterns in American-English are more salient than those in Dutch.

Another explanation for the cross-linguistic performance differences is related to the distributional characteristics of strong and weak syllables in English and Dutch. It is known that Dutch is less sensitive to vowel reduction than English (Collins & Mees, 1981). In English, a full vowel almost always implies a stressed syllable, but in Dutch a full vowel also occurs often in an unstressed syllable (van der Hulst, 1984). For instance, the word "later" is pronounced with a full and reduced vowel in both English and Dutch (as ['leite] and ['later}). The words "extra" and "guitar," however, are pronounced with a full and reduced vowel in English (as ['ekstr^] or ['ekstra], and [gi'ta:] or [ge'ta:]), but with two full vowels in Dutch (as ['eksrra:] and [xi'ta:r]). In English strong syllables are mainly followed by a weak syllable, whereas in Dutch strong syllables may be followed by a weak syllable or a strong syllable. Sluijter & van Heuven (1996) report acoustic measurements confirming that vowel quality, in terms of full versus reduced vowels, is a more important cue for stress in American-English than in Dutch.

Thus, a strategy in which the listener postulates word boundaries at the onset of strong syllables will be highly successful in English, since a strong syllable mainly coincides with a stressed syllable and therefore with a word onset, but less successful in Dutch, since in this language a strong syllable either coincides with a stressed syllable and thus with a word onset, or with an unstressed syllable . Consequently, the distribution of strong and weak syllables will be different in the input to American-English infants than in the input to Dutch infants, and this might explain why Dutch infants are less sensitive to the S/W metrical structure in word segmentation than American-English infants.

In summary, the head-turning paradigm is an appropriate technique to investite infant speech segmentation cross-linguistically and has been shown to be sensitive to language-specific characteristics that play a role in infant speech segmentation. In the present study, 7,5-month-old Dutch infants presented with Dutch materials (Experiment 1) or English materials (Experiment 2) did not exhibit a segmentation strategy based on the S/W foot structure. However, by 9 months there appears to be a marginally significant segmentation strategy for the Dutch materials (Experiment 3). In the next experiment of our cross-linguistic investigation, the Dutch materials will be presented to American-English infants. It is expected that the American-English infants will be better at finding the S/W words in Dutch than the Dutch infants, because they have already mastered this segmentation strategy in their native language.

NOTES

[1]A strong syllable is defined as a syllable with primary or secondary stress containing a full vowel. A weak syllable contains the neutral vowel schwa, or a reduced vowel.

[2] Metrical stress refers to the occurrence of syllables with full vowels. Lexical stress refers to the occurrence of syllables with primary word stress.

[3] In an auditory experiment twenty adult listeners were asked to indicate the most stressed word in each sentence of the four passages. The sentences were presented in random order along with 48 filler sentences. The target word *bokser* was judged to be the most stressed word 4% of the time, the target word *karper* 13% of the time, the target word *pendel* 10% of the time, and the target word *kusten* 11% of the time. Therefore, the words *bokser* and *karper* were presented together in the familiarization phase, as were the words *pendel* and *kusten.*