Madole, K. L., Oakes, L. M., & Cohen, L. B. (1993). Developmental changes in infants' attention to function and form-function correlations. *Cognitive Development, 8*, 189-209.

Mandler, J. M., & McDonough, L. (2000). Advancing Downward to the Basic Level. *Journal of Cognition and Development, 1*(4), 379-403.

Mani, N., & Plunkett, K. (2008). *Phonological Priming in Infancy.* Paper presented at the CogSci 2008: 30th Annual Meeting of the Cognitive Science Society, Washington, DC, USA.

Markman, E. M., & Hutchinson, J. E. (1984). Children's sensitivity to constraints on word meaning: Taxonomic versus thematic relations. *Cognitive Psychology, 16*(1), 7-27.

McDonough, L. (2002). Basic-level nouns: first learned but misunderstood. *Journal of Child Language, 29*, 357-377.

Meints, K., Plunkett, K., & Harris, P. L. (1999). When does an ostrich become a bird? The role of typicality in early word comprehension. *Developmental Psychology, 35*(4), 1072-1078.

Naigles, L. G., & Gelman, S. A. (1995). Overextensions in comprehension and production revisited: Preferential-looking in a study of dog, cat, and cow. *Journal of Child Language, 22*(1), 19-46.

Nation, K., & Snowling, M. J. (1999). Developmental differences in sensitivity to semantic relations among good and poor comprehenders: Evidence from semantic priming. *Cognition, 70* (1), B1-B13.

Nelson, K. (1974). Concept, word and sentence: Interrelations in acquisition and development. *Psychological Review, 81*, 267-285.

Poulin-Dubois, D., Klein, B. P., Graham, S. A., & Frank, I. (1993). Is the noun-category bias a noun-shape bias? In E. V. Clark (Ed.), *The proceedings of the twenty-fifth annual Child Language Research Forum* (pp. 221-226). Stanford: Centre for the Study of Language and Information.

Reznick, J. S. (1990). Visual preference as a test of infant word comprehension. *Applied Psycholinguistics, 11*(2), 145-166.

Reznick, J. S., & Goldfield, B. A. (1992). Rapid change in lexical development in comprehension and production. *Developmental Psychology, 28*(3), 406-413.

Rosch, E., & Mervis, C. B. (1975). Family resemblances: Studies in the internal structure of categories. *Cognitive Psychology, 7*(4), 573-605.

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology, 8*(3), 382-439.

Soja, N. N., Carey, S., & Spelke, E. S. (1991). Ontological categories guide young children's inductions of word meaning: Object terms and substance terms. *Cognition, 38*(2), 179-211.

Swingley, D. (2003). Phonetic detail in the developing lexicon. *Language and Speech, 46*, 265-294.

Ward, T. B., Becker, A. H., Duffin Hass, S., & Vela, E. (1991). Attribute availability and the shape bias in children's category generalization. *Cognitive Development, 6*(2), 143-167.

Waxman, S. R., & Gelman, R. (1986). Preschoolers' use of superordinate relations in classification and language. *Cognitive Development, 1*, 139-156.

Yoshida, H., & Smith, L. B. (2003). Known and novel noun extensions: Attention at two levels of abstraction. *Child Development, 74*(2), 564-577.

Schwa Syllables Facilitate Word Segmentation for 9-month-old German-learning Infants

Sonja Bartels[1], Isabelle Darcy[2] and Barbara Höhle[1]
[1]University of Potsdam and [2]Indiana University

1. Introduction

During the second half of their first year of life, several months before they speak their first words, infants become able to detect words in fluent speech. Research has found that infants make use of several different cues to segment words from fluent speech, among them statistical regularities (Saffran, Aslin & Newport, 1996), allophonic variations (Jusczyk, Hohne & Bauman, 1999), phonotactic information (Friederici & Wessels, 1993; Mattys et al., 1999) and prosodic / rhythmical information (Jusczyk, Houston & Newsome, 1999). In the early stages of language acquisition statistical and prosodic cues seem to prevail. Later on, other cues become integrated as well. The weighting of the cues seems to change with age (Thiessen & Saffran, 2003; Mattys et al., 1999).

The focus of this article lies on segmentation by means of prosodic information. For languages with a predominant trochaic stress pattern (like English or Dutch) it has been found that by 9 months of age infants are able to segment trochaic words from fluent speech. Dutch-learning infants are able to segment trochaic words at the age of 9 months, but not yet at the age of 7.5 months (Kuijpers et al., 1998). English infants, however, seem to develop the ability to segment trochaic words from fluent speech already at 7.5 months (Jusczyk, Houston & Newsome, 1999). What both of these studies had in common was that all stimuli used in the experiments were trochaic words with a final schwa syllable. So what we do not know yet is whether the quality of the vowel in the final syllable plays a role in the segmentation process as well. This question is especially interesting with respect to the acquisition of German, since schwa syllables have a very special distribution in German.

The goal of our research was first to establish whether the ability to segment trochaic words from fluent speech appears in German infants at roughly the same age as it does in Dutch and English infants and secondly to investigate the question whether the quality of the vowel in the final syllable plays a role in the segmentation process as well.

Section 2 presents the theoretical background. Section 3 looks at the distribution of schwa syllables in two corpora of German language. The experiments which investigate our research questions are presented in section 4. A discussion follows in section 5.

2. Theoretical background: schwa syllables in German

With respect to vowel quality in unstressed syllables we will make a twofold distinction: full-vowel syllables and schwa syllables. Examples for a weak syllable with a full vowel are the final syllables of the words *Kaktus* /ˈkaktʊs/ "cactus" and *Panda* /ˈpanda/ "panda". The nucleus of a schwa syllable can be either a schwa as in the examples *Vase* /ˈvaːzə/ "vase" and *Freude* /ˈfrɔydə/ "joy"or a syllabic consonant as in the examples *Segel* /ˈzeːgl̩/ "sail" and *Garten* /ˈgartn̩/ "garden".

Unlike in English, where the vast majority of vowels in an unstressed syllable is reduced to schwa, in German a full vowel in an unstressed syllable is often retained. The unstressed syllables of words like *cactus* and *panda*, for instance, are pronounced with a schwa in English, but with a full vowel in German. In other words: whereas vowel quality represents a correlate of stress in English, it does not in German.

Schwa syllables in German have a very characteristic distribution: in German, schwa never appears at the onset of words (Wiese, 1996). Schwa also does not appear in the first syllable of monomorphemic content words, with the exception of words prefixed by *Ge-* and *Be-* (Féry, 2001). Thirdly, schwa cannot be the only vowel of a word (Wiese, 1996). On the other hand, schwa syllables very often appear at the end of a word, forming a trochaic unit with the stressed penultimate syllable (Eisenberg, 1991, Wiese, 1996). Additionally, schwa is the only vowel that appears in inflectional suffixes in German.

Disyllabic German noun forms represent the most typical case of a word-final schwa syllable and a trochaic stress pattern. For a large proportion of the nouns, schwa is either part of the underived word, as in *Hase* /ˈhaːzə/ "bunny" or *Freude* /ˈfrɔydə/ "joy", or it is part of the inflectional suffix, as in *Bären* /ˈbɛrən/ "bears", *Gäste* /ˈgɛstə/ "guests" or *Kusses* /ˈkʊsəs/ "of the kiss". As such, schwa syllables would represent a good cue to word endings in German.

3. The distribution of stress patterns and schwa syllables in German: a corpus analysis

In this section we will have a closer look at the distribution of stress patterns and schwa syllables in two different German language corpora. Section 3.1. looks at a corpus of written language and section 3.2. looks at a corpus of child-directed speech.

3.1. Disyllabic noun forms in written language

For the analysis, the 2.5 version of the CELEX German database was used, i.e. the third release (Baayen et al., 1995). All monomorphemic disyllabic noun forms were extracted from the written corpora of the database. The original list of 6,523 noun forms was purged manually of proper names, foreign words and words that had been assigned the wrong number of syllables. The final list

consisted of 6,399 monomorphemic disyllabic nouns forms. Of these, 5,270 were stressed on the first syllable and had a final schwa syllable, 590 were stressed on the first syllable and had a full vowel in the second syllable and 539 were stressed on the second syllable. The percentage distribution is illustrated in figure 1.
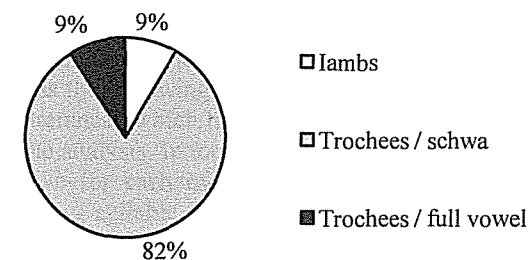

Figure 1: Monomorphemic disyllabic noun forms

As can be seen in figure 1, the overwhelming majority of nouns has a trochaic stress pattern and a final schwa syllable.

3.2. Disyllabics in child-directed speech

For the experiments that will be presented in section 4 it is crucial to know what the actual distribution of stress patterns and schwa syllables in the input of children is like. Therefore, a further analysis was carried out on child-directed speech. For this analysis, the Caroline Corpus of the CHILDES database (MacWhinney, 2000) was used. The corpus was recorded when Caroline was between 10 months and 4 years and 3 months old. The recordings were made at irregular time intervals and varied in length. In total, there are 239 transcripts of recordings available on the database. During the recordings Caroline's mother was always present and interacting with the child. Thus this corpus not only represents an extensive data pool of child language but also an extensive data pool of child-directed speech. Since our main interest lies in the earlier stages of language acquisition, only a subpart of all transcripts was chosen for the analysis. In these transcripts, 60 in total, Caroline was between 0;11.25 and 1;11.02 years old. The first two transcripts were not included in the analyses, since the utterances in them and the transcripts themselves were very short. The 60 transcripts comprise 4,907 different utterances of the mother, amounting to 2,897 different word types and a total number of 34,063 word tokens. This time, the analysis was carried out on all content words, not only on nouns. After eliminating all monosyllabic words and words with more than two syllables from the list, as well as interjections, onomatopoetic expressions, English words, unknown brand names whose pronunciation cannot be verified in a dictionary

(e.g. *Vitam*), non-words (e.g. the mother's imitation of her child's mispronunciations) and words that have more than one possible stress pattern, a total number of 6,640 disyllabic content word forms remained. Of these, 694 were stressed on the second syllable, 4,844 were stressed on the first syllable and had a final schwa syllable and 1,102 were stressed on the first syllable and had a full vowel in the second syllable. Among the latter ones were many compounds and proper names which were not eliminated from the analysis this time in order to get a clear picture of what children actually hear. Figure 2 shows the percentage distribution.
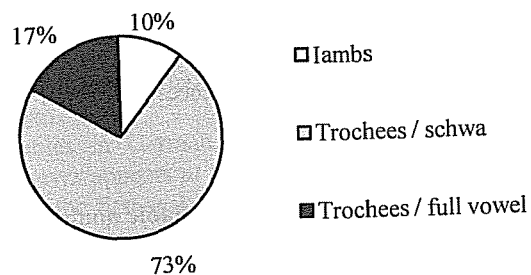

Figure 2: Disyllabic content word forms

As can be seen, the picture is not very different from the one of the disyllabic noun forms in section 3.1., except that there are a few more trochees with a full vowel in the second syllable. The overwhelming majority of all content word forms are trochaic (90%) and a large proportion of the trochaic words has a final schwa syllable (81%).

The line of reasoning underlying our study is the following: if schwa syllables are indeed very frequent at the end of words, but not within words, they should – together with the trochaic stress pattern – represent a more effective cue to a word or a word ending than a trochaic foot alone. A segmentation strategy based on the trochaic foot alone would successfully segment a large part of the disyllabic content words. However, it would also missegment syllables that do not form a word. Imagine the following example:

(1) a. Er **legte** den [**Balken**] auf die **Straße**.
      He put the beam on the street.

    b. Der [**Ball** ist] auf die **Straße** ge**rollt**.
      The ball has onto the street rolled
      'The ball has rolled onto the street.'

Stressed syllables are printed bold in the example. A segmentation strategy based on the trochaic foot would successfully segment the words *legte*, *Balken* and *Straße*. But it would also missegment [*Ball ist*] as a single word.

The hypothesis whether a trochaic foot with a schwa syllable is a more effective cue to a word or a word ending than the trochaic foot alone was tested with the help of the same corpus of child-directed speech that had been used for the analysis above. Of the mother's 4,907 utterances 100 were randomly selected. All trochaic feet that occurred in this subsample were analyzed with respect to word boundaries and the quality of the vowel in the second syllable. The procedure was the following: first of all, all stressed syllables in the sample were marked. Utterances which had more than one possible stress pattern were not included in the analysis. In total, there were 390 stressed syllables. After that, it was noted down for each of the stressed syllables whether the following syllable was a schwa syllable or a full-vowel syllable and if there was a word boundary between the syllables. The results are shown in figure 3.
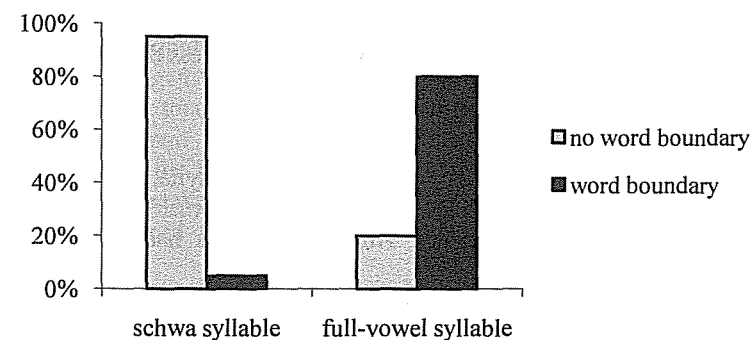

Figure 3: Syllable types and word boundaries

When the stressed syllable was followed by a schwa syllable, there was no word boundary between them in 95% of all cases. On the other hand, if the stressed syllable was followed by a full-vowel syllable there was a word boundary between them in 80% of all cases and only in 20% of the cases the syllables belonged to the same word. Thus, in direct comparison, a trochaic foot with a schwa syllable would be a more effective cue to a word or a word ending than the trochaic foot alone.

4. The role of schwa syllables in infants' word segmentation

If infants are especially sensitive to distributional information during the early stages of language acquisition, are German-learning infants also sensitive to the distribution of schwa syllables in their language? And if so, do they use this information to segment words from fluent speech? In order to investigate this question we carried out two experiments. Experiment 1 tested whether 8- to

9-month-old German-learning infants would be able to segment trochees with a final schwa syllable from fluent speech and experiment 2 tested whether infants of the same age also would be able to segment trochees with two full-vowel syllables from fluent speech. If German-learning infants are sensitive to the distribution of schwa syllables, we would expect them to find it easier to segment trochees with a final schwa syllable than to segment trochees with two full vowel-syllables. Accordingly, we would expect that they show the ability to segment trochees with a schwa final syllable earlier.

4.1. Experiment 1
4.1.1. Participants

Twenty-eight infants from the Potsdam area participated in the experiment. The infants were 8 to 9 months old (average age: 8;26, range: 8;01 – 9;12). All infants were healthy, term-born infants with a monolingual German family background. Twelve of the infants were girls and 16 were boys. Thirteen additional infants were tested but not included in the analysis because of failure to complete the experiment or an average looking time of less than 3 seconds.

4.1.2. Stimuli

Four different trochaic words with a final schwa syllable were used as stimuli: *Balken* /ˈbalkn̩/ "beam" and *Pinsel* /ˈpɪnzl̩/ "brush", *Felsen* /ˈfɛlzn̩/ "rock" and *Kurbel* /ˈkʊrbl̩/ "crank". All of the words had a CVC•C(V)C structure.

For each of the four words, a 6-sentence text passage was created in which the word appeared once in every sentence. Care was taken that the position of the critical word varied across the sentences and that the words preceding and succeeding the critical word were never the same. The following is an example text passage:

> Der **Balken** lag quer über dem tiefen Abgrund. Es war ein sehr breiter und stabiler **Balken**. Über diesen **Balken** spazierten die Wanderer auf die andere Seite des Tales. Manchmal liefen auch Kinder den **Balken** entlang. Auf dem dicken **Balken** zu spielen war sehr gefährlich. Zum Glück ist noch nie ein Kind vom **Balken** gefallen.

The material was recorded by a female native speaker of German who was told to speak the four target words and the four text passages in a lively and prosodically variable manner as if speaking to a child. Every target word was recorded about 40 times in isolation, each time with a slightly different intonation. Subsequently all the materials were digitized. Of the digitized material, eight different audio files were created, one for each of the four text passages and one for each of the four target words. The files for the target words

contained about 30 different tokens of the relevant target word, with pauses of 600 ms in between. The audio files with the text passages had an average duration of 19 seconds (*Balken* text: 18.65 s, *Pinsel* text: 19.19 s, *Felsen* text: 19.34 s, *Kurbel* text: 19.03 s).

4.1.3. Procedure

The experiment was carried out with a modified version of the Head-turn Preference Procedure (HPP), the one that had been developed by Jusczyk and Aslin (1995) to study infants' segmentation strategies.

During the experiment the infant sat on the lap of a caregiver in the center of a sound-attenuated test booth. To eliminate bias, the caregiver listened to masking music over tight-fitting headphones. Inside the test booth, a green light was mounted at eye level on the front wall. Directly above the green light was a small round hole for the lens of a video camera which was used to record and monitor the experiment. On each of the side walls, a red lamp was mounted at the level of the infant's head. Behind each of the red lamps was a loudspeaker from which the stimuli were played.

Each trial began with the blinking of the green light on the front wall. As soon as the child focused on that light, one of the red lights on the side walls started to flash and the green light was extinguished. When the child had oriented towards the flashing red light, the stimulus for that trial began to play from the loudspeaker behind the flashing light and continued until its completion or until the child looked away for more than two consecutive seconds.

After that, a new trial was started. If the infant looked away for less than two seconds the acoustic stimulus continued but the time was not included in the orientation time. An experimenter in an adjacent room who could not hear the acoustic stimuli watched the child via a monitor and coded the child's looking behavior using a button-box connected to a computer. The side from which each stimulus was played was randomized by the computer software which was also responsible for the termination of each trial.

The experiment started with a familiarization phase during which the infants listened to two of the test words for at least 30 s on each of the two sides. Half of the infants were familiarized with *Balken* and *Pinsel* and the other half was familiarized with *Felsen* and *Kurbel*. The familiarization phase was immediately followed by the test phase. During the test phase all infants listened to the four text passages. All text passages were presented four times in blocks of four trials. Within each block the order of the text passages was randomized.

If the infants are able to segment trochaic words with a schwa syllable from fluent speech, they should listen significantly longer to the text passages containing the words with which they have been familiarized.

4.1.4. Results

Mean orientation times to the texts with the familiarized words and to the texts with the non-familiarized words were calculated for each of the 28 infants. On average, the infants listened for 6.19 s to the text passages with the familiarized words and for 5.32 s to the text passages with the non-familiarized words. A paired t-test (all t-tests reported are two-tailed) revealed that the difference in listening time was statistically significant (t(27) = 3.08, p < 0.01).
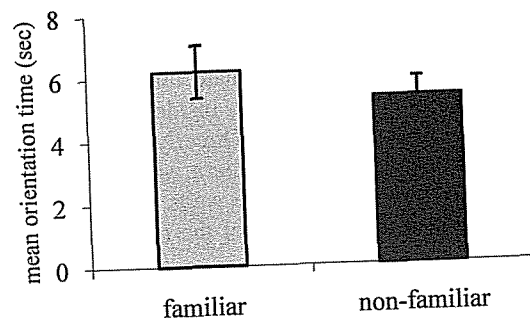

Figure 4

Thus, at 8 to 9 months of age, German infants, like English and Dutch infants, are able to segment trochees with a final schwa syllable from fluent speech.

4.2. Experiment 2
4.2.1. Participants

Twenty-four infants from the Potsdam and Berlin area participated in the experiment. The infants were 8 to 9 months old (average age: 8;25, range: 8;15 – 9;10). All infants were healthy, term-born infants with a monolingual German family background. Half of the infants were boys and half of the infants were girls. Twelve additional infants were tested but not included in the analysis for the following reasons: failure to complete the experiment (5), average looking time of less than 3 seconds (2), fussiness or crying (4), parental interference (1).

4.2.2. Stimuli and procedure

The aim was to model the stimuli of this experiment as closely as possible to the ones in experiment 1. Since there are not enough trochaic words with two full vowel syllables and a CVC•CVC syllable structure in the German language that would fulfil the criteria, it was decided to run the experiment with non-words. The following non-words were chosen: *Tilsum* /ˈtɪlzʊm/, *Lumpos* /ˈlʊmpɔs/, *Melgat* /ˈmɛlgat/ and *Rasnik* /ˈrasnɪk/. None of the syllables were

similar to a derivational or inflectional affix and their segmental inventory was as variable as possible. For the test phase, the text passages from experiment 1 were used with the only modification that the critical words were replaced by the non-words above.

The material was recorded by a female native speaker of German who spoke the four target words and the four text passages in a lively and prosodically variable manner as if speaking to a child. Every target word was recorded about 30 times in isolation, each time with a slightly different intonation. Subsequently the whole material was digitized. Of the digitized material, eight different audio files were created, one for each of the four text passages and one for each of the four target words. The files for the target words contained about 16 different tokens of the relevant target word, with pauses of 600 ms in between. The audio files with the text passages had an average duration of 22.6 seconds (*Tilsum* text: 22.4 s, *Lumpos* text: 21.82 s, *Melgat* text: 22.15 s, *Rasnik* text: 21.87 s).

The procedure was the same as in experiment 1. Half of the infants were familiarized with the target words *Tilsum* and *Lumpos* and the other half with the target words *Melgat* and *Rasnik*. During the test phase, all the infants heard the same four text passages. The text passages were presented four times in blocks of four trials. Within each block, the order of the text passages was randomized.

Again, if the infants are able to segment trochaic words with two full vowel syllables from fluent speech, we expect them to listen significantly longer to the text passages containing the words with which they have been familiarized.

4.2.3. Results

The infants had a mean orientation time of 5.59 s for the text passages containing the familiarized words and a mean orientation time of 5.84 s for the text passages with the non-familiarized words. Only 10 of the 24 infants listened longer to the text passages with the familiarized words. A paired t-test indicated that the difference in orientation time was not significant (t(23) = -.56, p = .58).
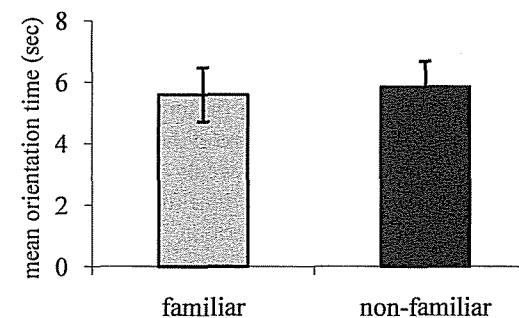

Figure 5

Thus, there is no evidence that 8- to 9-month-old German-learning infants can segment a trochaic word with two full vowel syllables at the same age they are able to segment a trochaic word with a final schwa syllable.

5. Discussion

Taken together, we provided evidence that German infants are able to segment disyllabic words from fluent speech at roughly the same age as their English and Dutch peers (Jusczyk, Houston & Newsome, 1999; Houston et al. 2000). However, this ability seems to be restricted to words that have a schwa in their second syllable. This pattern mirrors distributional properties found in a sample of German child-directed speech in which the overwhelming majority of all disyllabic content words were words with a schwa in the final syllable. In addition, the corpus analysis has revealed that for German, a segmentation strategy that takes vowel quality into account would be much more successful in finding word boundaries than a strategy which just relies on prosodic cues alone.

The difference in the infants' reactions to the trochaic words with a final schwa syllable and to the trochaic words containing two full-vowels allows for two conclusions that are relevant for the interpretation of the data. First of all, this pattern suggests that the children did not segment only the strong syllable of the disyllabic words. Secondly, it is not only the repeated presentation of the disyllabic strings in the familiarization phase that leads to a representation of this string as a coherent unit and thus to its detection in the continuous speech of the passages presented during the test phase. In fact, an explanation based solely on an infant's ability to analyze transitional properties (Saffran et al., 1996) does not account for our data. In both of these cases, infants should have shown the same results across the two experiments.

Thus, we can conclude that our experimental results show that a prosodic cue like stress alone may not be sufficient for German infants to perform this segmentation. According to our results, the German learners only seem to segment the trochaic words when the second syllable contains a schwa vowel. This leaves open two possible explanations. On the one hand, it might be the case that prosodic information is overridden by segmental information in the case of words with a final full-vowel syllable. On the other hand, it might be the case that prosodic information does not play a crucial role for the German learners at all. Even though we cannot decide between these two possibilities on the basis of the data reported here, there are findings that speak in favor of the first one. Höhle and colleagues (submitted) found that German learners as young as six months show a preference for strong-weak disyllabic strings even when both syllables have a full vowel – an effect that did not show up with French learning age peers. This suggests that German learners have developed a trochaic bias by the age of six months given the dominance of trochaic disyllabic feet in their input. We suggest that by the age tested in this experiment

this bias may have been refined to a bias towards trochaic feet with final schwa syllables.

Overall, our findings add evidence to the growing body of data which demonstrates that infants' word segmentation skills show crosslinguistic variation and are shaped by the properties of the phonological system of the target language from very early on (Nazzi et al. 2006; van Kampen et al., 2008).

Acknowledgements

References

Baayen, R. Harald, Richard Piepenbrock & Leon Gulikers (1995). *The CELEX lexical database (CD-ROM)*, Linguistic Data Consortium, University of Pennsylvania, Philadelphia, PA.

Eisenberg, Peter (1991). "Syllabische Struktur und Wortakzent." *Zeitschrift für Sprachwissenschaft 10*, 37-64.

Féry, Caroline (2001). *Phonologie des Deutschen: eine optimalitätstheoretische Einführung*. Potsdam, LiP.

Friederici, Angela D. & Jeanine M. I. Wessels (1993). "Phonotactic knowledge of word boundaries and its use in infant speech perception." *Perception & Psychophysics 54*, 287-295.

Höhle, Barbara, R. Bijeljac-Babic, Birgit Herold, Jürgen Weissenborn & Thierry Nazzi (submitted) "Language specific prosodic preferences during the first half year of life: Evidence from German and French infants."

Houston, Derek M., Peter W. Jusczyk, Cecile Kuijpers, Riet Coolen & Anne Cutler (2000). "Crosslanguage word segmentation by 9-month-olds." *Psychonomic Bulletin & Review, 7*, 504-509.

Jusczyk, Peter W. & Richard N. Aslin (1995). "Infants' detection of the sound patterns of words in fluent speech." *Cognitive Psychology 29*, 1-23.

Jusczyk, Peter W., Elizabeth A. Hohne & Angela Bauman (1999). "Infants' sensitivity to allophonic cues for word segmentation." *Perception & Psychophysics 61*, 1465-1476.

Jusczyk, Peter W., Derek M. Houston & Mary Newsome (1999). "The beginnings of word segmentation in English-learning infants." *Cognitive Psychology 39*, 159-207.

Kuijpers, Cecile, Riet Coolen, Derek M. Houston & Anne Cutler (1998). "Using the Head-Turning technique to explore cross-linguistic performance differences." In C. Rovee-Collier, L. P. Lipsitt and H. Hayne: *Advances in infancy research*. Stamford, Ablex Publishing Corporation, 205-220.

MacWhinney, Brian (2000). *The CHILDES project: tools for analyzing talk.* Volume 1: Transcription format and programs. Volume 2: The database. 3rd ed. Lawrence Erlbaum.

Mattys, Sven L., Peter W. Jusczyk, Paul A. Luce & James L. Morgan (1999). "Phonotactic and prosodic effects on word segmentation in infants." *Cognitive Psychology 38*, 465-494.

Nazzi, Thierry, Galina Iakimova, Josiane Bertoncini, Séverine Frédonie, & Carmela Alcantara (2006) "Early segmentation of fluent speech by infants acquiring French: Emerging evidence for crosslinguistic differences. *Journal of Memory and Language* 54, 283-299."

Saffran, Jenny R., Richard N. Aslin & Elissa L. Newport (1996). "Statistical learning by 8-month-old infants." *Science 274*, 1926-1928.

Thiessen, Erik D. & Jenny R. Saffran (2003). "When cues collide: use of stress and statistical cues to word boundaries by 7- to 9-month-old infants." *Developmental Psychology 39*, 706-716.

Van Kampen, Anja, Güliz Parmaksiz, Ruben van de Vijver & Barbara Höhle (2008). "Metrical and statistical cues for word segmentation: Vowel harmony and word stress as cues to word boundaries by 6- and 9-month-old Turkish learners." In: A. Gavarro & M. J. Freitas (eds.). *Language and Development: Proceedings of GALA 2007.* Newcastle: Cambridge Scholars Publishing.

Wiese, Richard (1996). *The Phonology of German.* Oxford: Clarendon Press.

Structural Biases in Phonology:
Infant and Adult Evidence from Artificial Language Learning

Elika Bergelson and William J. Idsardi
University of Pennsylvania and University of Maryland

Introduction

Do biases in infant and adult language learning follow (or better yet, follow from) typological biases observed cross-linguistically? The evidence obtained thus far has been equivocal; the present study examines a previously uninvestigated type of bias: are certain phonological processes preferentially associated with certain positions in the word? In particular, do different phonological processes invoke different notions of *finality*? We investigated this question by switching the environments between two phonological processes (final devoicing and final stress) and testing adults and infants on their learning preferences between the typologically attested and unattested generalizations.

The infant language learner faces seemingly insurmountable challenges in her first few years of life. Not only must she eventually figure out that words exist, what they mean, and how they go together, but she must also (and perhaps first) figure out the extremely complicated phonological system of her native language. Fortunately, phonological systems are patterned and systematic. However, certain aspects of this systematicity seem quite difficult to induce from just the raw input: while there are a plethora of phonological rules, many of which simply vary on a given parameter (e.g. assimilation can be for various kinds of place features as well as for laryngeal postures) if you look crosslinguistically, there are certain systematic gaps in what kinds of patterns apply to what kinds of phonetic elements.

Previous work on rule naturalness and its relationship to learnability has provided mixed results. Some evidence that learners are biased towards attested patterns comes from Berent *et al* (2008), who found that adult Korean speakers prefer 'bl' onsets to 'lb' onsets, even though neither onset type is attested in Korean. This preference reflects general linguistic universals. Other evidence, however, such as Seidl and Buckley (2005) has shown that infants find some 'unnatural' rules just as learnable as natural ones.

Recently, Gerken and Bollt (2008), following up on work showing that multiple exemplars make it easier for infants to generalize phonetic rules, found that 9 month olds were unable to learn an unnatural rule (stress syllables starting with 't'), but 7.5 month olds were able to learn this rule, arguing that perhaps ability to learn unnatural kinds of rule alters over development.

Given the mixed results of previous work, we sought to test the relationship between learnability and the attestation of phonological rules in the world's languages. We tested 8-month-old infants and adults on rules that occur