The Recognition of the Prosodic Focus Position in German-learning Infants from 4 to 14 Months*

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The aim of the present study was to elucidate in a study with 4-, 6-, 8-, and 14-month-old German-learning children, when and how they may acquire the regularities which underlie Focus-to-Stress Alignment (FSA) in the target language, that is, how prosody is associated with specific communicative functions. Our findings suggest, that 14-month-olds have already found out that German allows for variable focus positions, after having gone through a development which goes from a predominantly prosodically driven processing of the input to a processing where prosody interacts more and more with the growing lexical and syntactic knowledge of the child.

Keywords: prosodic focus, HTP, infants

1 Introduction

Children do not only have to learn how to express and to interpret the propositional content of a sentence, but also what is supposed to be common knowledge for the interlocutors and what is new, that is, focused information. There are basically three ways for a language to mark the focus of an utterance: prosodically, lexically, and syntactically. With respect to prosodic focus marking it is generally assumed that there is a systematic relation between the informational focus of the sentence and its intonation, in the sense that the prosodic prominence (nuclear accent) has to be assigned to the rightmost element of the focused constituent, a principle called Focus-to-Stress Alignment

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(FSA) by Nespor and Guasti (2002) following Jackendoff (1972). This principle predicts that in the case of broad focus, that is, when the whole utterance constitutes new information, the nuclear accent should fall on the rightmost constituent of the sentence. This seems to be the case universally[1]. We may thus consider the way FSA is realized in the case of broad focus as the default, or unmarked case.

But languages vary in how they realise FSA in case of narrow focus, that is, when only a part of the sentence, for instance the subject or the object, is new information. They may basically be differentiated with respect to whether they tend to maintain either the unmarked, canonical prosodic structure as in the case of broad focus, by choosing a word order that places the focused element at the right edge of the clause, where nuclear accent is assigned according to the regular stress rule, as for example in Italian and Spanish. Alternatively, they may assign the nuclear accent to the focused element in its syntactic position, thus abandoning the unmarked, canonical prosodic structure, as for example in English (Büring & Gutiérrez-Bravo, 2001; Nespor & Guasti, 2002; Samek-Lodovici, 2005; Vallduví, 1993). This division basically corresponds to the traditional distinction between free and fixed word-order languages. Languages like German in which both word order and the position of nuclear accent are relatively flexible, occupy an intermediate position. These different strategies are illustrated by the following examples from English, Italian, and German:

(1) a. Who bought a car? JOHN bought a car. vs. * bought a car JOHN.

b. Chi comprò una machina? (Una machina,) la comprò GIOVANNI.

[1] Kiss (p.c.) challenges the claim that broad focus is marked universally on the rightmost phonological phrase, as this does not seem to hold in Hungarian.

c. Wer kaufte ein Auto? PETER kaufte ein Auto. Or: Ein Auto kaufte PETER.

Thus in English, the FSA is satisfied by stress movement (Type A language), in Italian by syntactic movement, for instance by movement of the subject from the canonical to the post-verbal, final position where nuclear accent is assigned according to the regular stress rule (Type B language), whereas German has both options (Type C language). But in German, these options, from the point of view of language usage, are not equivalent. The most frequently realised prosodic pattern in the case of narrow focus is the one with final nuclear stress, corresponding to the constituent order SVO which has to be considered the canonical word order, with the preverbal subject constituting old, that is, topic information, and the postverbal object new, that is, focus information. Given that this is also the stress pattern in the case of broad focus, it is the most common in German overall. Thus, we may assume that the interaction of broad and final narrow focus stress should result in a strengthening of the unmarked case of nuclear stress.

In order for the child to find out to which type of FSA the target language belongs, that is, how prosody is associated with specific communicative functions, she has first to be able to discriminate between different stress patterns which implies the recognition of different stress positions. The child’s growing ability to syntactically and semantically analyse the speech elements occupying these positions should then lead the child to infer the principles which determine the association of focused, that is, new information with prosodic prominence, possibly based on a distributional analysis of the co-occurrence patterns of these elements in the input.

The aim of the present study was to investigate the initial phases of this developmental process in a cross-sectional study starting at the age of 4 months.

This age was chosen on the basis of recent findings that children between 6-12 weeks of age are able to discriminate between languages which differ with respect to the position of prosodic prominence within the phonological phrase (Christophe et al., 2003). This should allow us to find out whether German-learning children would treat sentences with initial and final stressed narrow focus differently. Two possible reasons for why the child may show an initial bias for final nuclear stress are, first, that this is, as mentioned above, the most frequent narrow focus position in German, and second, that it coincides with the universally preferred position for nuclear stress in the case of broad focus. If there was a bias for one position that would mean that later in development the child would have to overcome this bias in order to realise that there are multiple focus positions in German. Only then prosodic prominence could be used by the child in the process of sentence interpretation as a reliable indicator of the (semantic) focus of the sentence. Three additional groups of 6-, 8-, and 14-month-olds where tested with the same material. The age of 6 months was chosen because this is the age at which the first open class lexical items are selectively segmented from continuous speech (Jusczyk, 1997), and there is evidence that they distinguish between sentences containing clauses with pauses in natural and unnatural positions (Hirsh-Pasek et al., 1987; Schmitz, Höhle & Weissenborn, in prep.). At 8 months German-learning children are able to recognise closed-class lexical items in continuous speech (Höhle & Weissenborn, 2003), and at 14 months they have discrete lexical representations for closed-class, functional elements, like determiners which are a prerequisite for the analysis of noun phrases in the speech input (Höhle et al., 2004).

We predicted that these developmental changes in the linguistic processing abilities of the child should be reflected in changing reaction patterns to the prosodically and segmentally identical test sentences at the different ages.

2 The Study

2.1 Experiment with 4-month-old infants

2.1.1 Participants

Twenty-four German-learning infants from the Potsdam area participated in this experiment. Their mean age was 4 months and 20 days, with a range of 4 months and 2 days to 4 months and 30 days. All infants were born full term and have no known hearing deficits (according to a questionnaire filled out by the parents). The data of 5 additionally tested infants could not be included in the analysis due to parent intervention (1), falling asleep during the experiment (2), crying (1) and problems with the technical equipment (1). Of the remaining 24 subjects, 14 were girls and 10 boys.

2.1.2 Stimuli

The sentences we used during the experiment were all sentences with canonical word order, that is, SVO, consisting of a single Intonation Phrase. All in all, 56 sentences of the type NP1 AUX NP2 PART (e.g., *Das Auto hat Reifen gebraucht*; the car has tyres needed; ‘the car needed tyres’) were constructed.

In order to obtain test sentences in which nuclear stress naturally, that is, according to the FSA rule holding for German, falls on the first or the second NP, we recorded the test sentences in a Narrow Focus question-answer context, as in:

(2) Q: Wer hat Flöte gespielt?
Target: Der ENKEL hat Flöte gespielt[2].
Who has played the flute? The GRANDSON has played the flute.
‘Who played the flute? The grandson played the flute’.

[2] In this paper capital letters are used to indicate prosodic focus marking.

(3) Q: Was hat der Enkel gespielt?
Target: Der Enkel hat FLÖTE[3] gespielt.
What has the grandson played? The grandson has played the FLUTE.
'What did the grandson play? The grandson played the flute'.

The stimuli were recorded by a female native speaker of German.[4] She was instructed to read both the question and the answer in a friendly child-directed manner.

After the digital recording, the target sentences were extracted, and prepared for use in the experiment. For that, 16 blocks of seven sentences each were constructed, eight blocks containing sentences with the prosodically highlighted first NP (e.g., *Der ENKEL hat Flöte gespielt*) and the other eight blocks containing the corresponding sentences with prosodically highlighted second NP (e.g., *Der Enkel hat FLÖTE gespielt*). Between the sentences of a given block a pause of 900 ms was inserted. The mean duration of the sentences blocks with focused NP1 was 18.5 s (Range: 17.5 s to 18.9 s) and the mean duration for blocks with focused NP2 was 18.8 s (range: 18.1 s to 19.3 s).

The sentences were analysed using the Praat program (Boersma & Weenink, 1992-2005)[5]. The mean-F0 features of the noun in NP1 (e.g., *Enkel*) had an average value of 339 Hz in the condition when it is focused, and 224 Hz in the condition when it is not focused. This difference is statistically significant: $t_{(55)} = 18.20$; $p < 0.01$. Comparably, the data for the nouns in NP2 (e.g., *Flöte*) had an average value of 333 Hz, when it was focused and 195 Hz when it was not focused. Again, this difference is statistically significant: $t_{(55)} = 22.74$; $p < 0.01$.

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3 Under the assumption that the main prominence or nuclear stress is supposed to fall on the rightmost element, one would expect the participle to carry nuclear stress. We assume, following Büring (2005, footnote 10) that due to a prosodic integration process, the participle is prosodically incorporated into the direct object, which in turn gets the nuclear accent.

4 Many thanks to Ulrike Kölsch for being "The Voice".

5 We want to thank Ruben van de Vijver for providing the Praat script for the analysis.

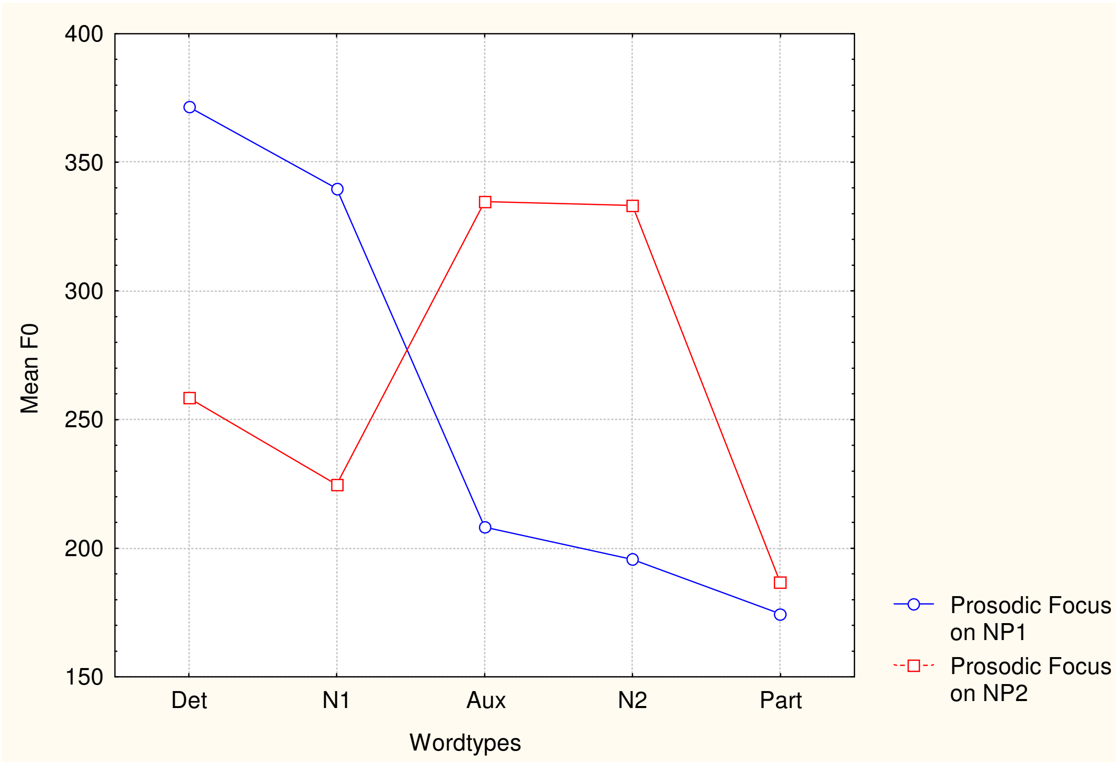

Figure 1: Mean pitch of the words in each focus condition

Also, the duration of the nouns was significantly longer in the focused condition than in the unfocused condition: 517 ms vs. 422 ms for the first NP, $t_{(55)} = 11.79$; $p < 0.01$; and 502 ms vs. 392 ms for the second NP, $t_{(55)} = 18.22$; $p < 0.01$, respectively. Thus, a noun has a significantly longer duration and a higher pitch when focused compared to the same noun in unfocused condition (for comparable findings see van de Vijver, Sennema & Zimmer-Stahl, this volume).

2.1.3 Method and procedure

A variant of the head turn preference paradigm was used (Kemler Nelson et al., 1995). To test 4-months-olds we made a slight modification in the procedure: as infants that young still have problems to move their heads to left and right in order to fixate the side lamps at the 90° angle, the lamps for testing the infants were all mounted at the back panel of the testing booth. The green lamp is placed in the centre beneath the hole for the camera lens. The red side lamps were mounted at the same height as the green lamp, each in a corner of the back panel. The loudspeakers were mounted immediately besides the red lamps outside the booth.

The infant was seated on a caregivers' lap who was instructed to keep the infant in a reclining position. The caregiver wore headphones during the experiment over which masking music was played, so that the caregiver could not influence the infants' reactions to the stimuli in a systematic way. The experimenter sat in the adjoining room and coded the infants' looking behaviour with a push-button box. The loudspeaker of the monitor was silent, so that the experimenter was blind to the condition the infants listened to and thereby was prevented from influencing the experiment results.

Each experimental trial started with the blinking of the green centre lamp. When the infant orientated towards the lamp, one of the red side lamps started to blink. When the infant looked towards this lamp, the experimenter started the auditory stimulus. The dependent variable in this kind of experiment is the so-called orientation time (OT), that is, the amount of time the infant spends looking at the blinking lamp, thus listening to the presented auditory stimuli. When the infant looked away for less than two seconds, the presentation of the stimulus continued, but the time was excluded. When the infant looked away for more than two seconds the experimental trial was suspended (time-out) and the next trial started with the blinking of the green centre lamp. The first four trials (two sentence blocks with focused NP1 and the corresponding two blocks with focused NP2) were used to make the infant familiar with the auditory material and the experimental procedure, that is, to ensure that the infant learned that the auditory stimulus will be played as long as the infant is looking towards the blinking lamp and thereby being able to influence the amount of time the stimulus can be heard. These first four trials were excluded from the statistical analysis, only the remaining 12 blocks were subject to analysis.

The material was presented in four different randomised orders of presentation. Each infant was randomly assigned to one of these randomisations. In each order the number of girls and boys was balanced.

2.1.4 Results

The time each infant spent listening to the stimuli of both conditions was calculated. Then the data was pooled and statistically analysed. The analysis of the data of the 24 infants revealed no preference for either the condition with focused NP1 or focused NP2. The mean orientation time towards the sentence blocks with prosodically focused NP1 was 9606 ms (SD = 3274 ms) and for the sentence blocks with stressed NP2 9389 ms (SD = 3132 ms). This difference is statistically not significant: $t_{(23)} = 0.62$; $p = 0.54$.

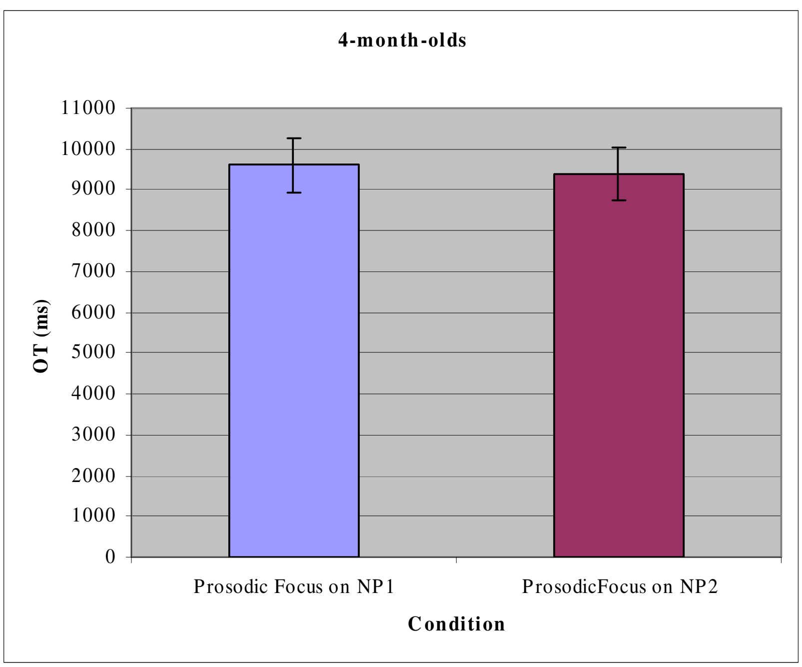

Figure 2: Mean orientation time of the 4-month-old infants

2.1.5 Discussion

These results show that infants of 4 months of age do not react differently to sentences with focused NP1 and focused NP2. The nearly identical orientation times towards each condition suggest that the infants either did not perceive the different prosodic focus structures or that they accept both types of sentence in the same way, showing no preference for one prosodic structure over the other.

2.2 Experiment with 6-month-old infants

2.2.1 Participants

Thirty-two 6-month-old infants participated in this experiment. The mean age of this group was 6 months and 13 days, with a range from 6 months 1 day to 6 months 30 days. The selection criteria were the same as in the first experiment. Again, the infants were randomly assigned to one of the experiment versions, yielding 8 infants per randomisation.

The data of an additionally tested 8 infants could not be included into the analysis for the following reasons: technical problems (3), infants' crying (4), and one child had a strong preference for one of the presentation sides, ignoring the other side completely. We therefore decided to exclude her data from the analysis. The remaining group comprised 16 girls and 16 boys.

2.2.2 Stimuli

The same stimuli as in the previous experiment were used.

2.2.3 Method and procedure

We used the basically same method as in the first experiment. One change was made with respect to the head turn preference procedure: as infants from 6 months are freer in their head motion and are able to look to the left and right, we returned to the original method by placing the red side lamps at the sides of the test booth in 90° angle from the centre green lamp. The loudspeakers were mounted outside of the booth immediately behind the red side lamps as in the original design described by Kemler Nelson et al. (1995).

The procedure used was identical to the first experiment.

2.2.4 Results

The time each infant spent listening to the stimuli of either condition was calculated. Then the data was pooled and statistically analysed. The result shows that the 6-month-olds, as the 4-month-olds, give no indication of preferring either one of the experimental conditions. The mean orientation time towards the sentences with focused NP1 was 8404 ms (SD = 3310 ms), whereas the mean orientation time for the sentences with the focused NP2 was 7951 ms (SD = 3000 ms). This difference is statistically not significant: $t_{(31)} = 1.23$; $p = 0.23$.

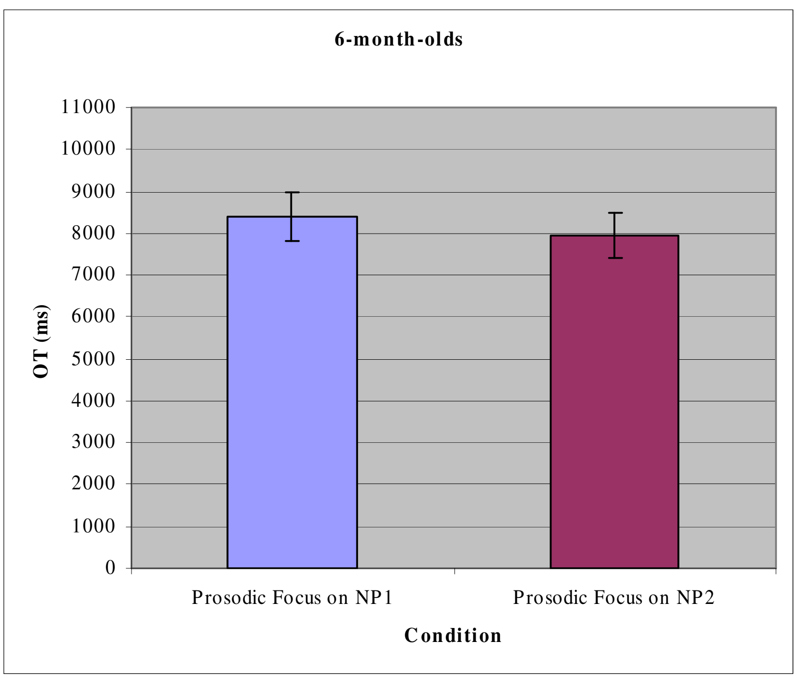

Figure 3: Mean orientation time of the 6-month-old infants

2.2.5 Discussion

In this experiment, again, we did not find a significant preference for either of the different prosodic structures, although the infants showed a slight tendency to listen longer to the condition in which the first NP was prosodically highlighted. This tendency could possibly be interpreted as a novelty effect for the more infrequent, thus marked, sentence initial prosodic prominence. If this were the case, we would expect an even clearer novelty effect for older infants, who would have had a longer experience with the unmarked structures. It would hardly be plausible to interpret the performance of the 6-month-olds as due to an insensitivity to prosodically marked linguistic properties of the input language, as infants from 6 months on have been shown to be sensitive to different kinds of prosodic features within sentences (Hirsh-Pasek et al., 1987; Schmitz et al., in prep.). It may rather be the case that, like possibly for the 4-month-olds, the prosodic wellformedness of both of the test sentences lead to this result.

2.3 Experiment with 8-month-old infants

2.3.1 Participants

Thirty-two 8-month-old infants participated in this experiment. The mean age of these infants was 8 months and 15 days (range: 8 months 1 day to 8 months 28 days). The criteria for inclusion were the same as before. As before, each infant was randomly assigned to one of the four experiment versions.

The data of 11 additionally tested infants could not be included into the analysis for the following reasons: crying, etc. (4), fussiness (4), and overall too short orientation time (3). The remaining group of 32 children consisted of 16 girls and 16 boys.

2.3.2 Stimuli

The same material as in the previous experiments was used.

2.3.3 Method and procedure

The same method and procedure as in experiment 2 were used.

2.3.4 Results

The time the infants spent listening to the stimuli of each condition was calculated and the data were subjected to a statistical analysis.

The orientation time data of the infants show a significant difference between the sentences with NP1 focus, which was 7386 ms (SD = 2166 ms), and the sentences with NP2 focus, which was 6276 ms (SD = 2133 ms; $t_{(31)} = 2.98$; $p < 0.01$).

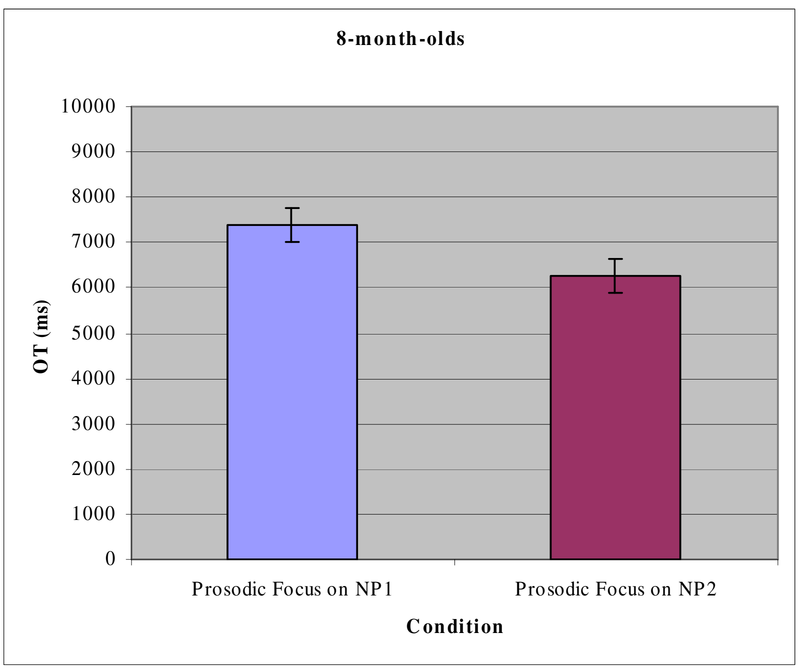

Figure 4: Mean orientation time of the 8-month-old infants

2.3.5 Discussion

This result thus seems to support our prediction, based on the slight preference of the 6-month-olds for the more uncommon prosodic pattern with nuclear stress on the first NP, that the reaction of the infants might be interpreted as a kind of "novelty effect"[6]: instead of preferring the more frequent prosodic pattern, the infants listen longer to the prosodic pattern which is more uncommon in their native language (cf. the assumptions about the default structure of focus prosody in German sentences (Büring & Gutiérrez-Bravo, 2001, p. 16f)).[7]

2.4 Experiment with 14-month-old infants

2.4.1 Participants

Twenty-seven infants have been tested so far. The mean age of the infants is 14 months and 15 days (range: 14 months and 0 days to 15 months 0 days). The criteria for the selection of the infants were the same as before. Seventeen additionally tested infants had to be excluded from the data analysis for the following reasons: not completing the experimental session (6), fussiness (3), technical problems (3), and an overall too short orientation time to one of the experimental conditions (5). The remaining group of 27 children consisted of 20 boys and 7 girls, and as before, the children were randomly assigned to one of the four experiment versions.

2.4.2 Stimuli

The same stimuli as in the previous experiments were used.

2.4.3 Method and procedure

The same method and procedure as in experiment 2 were used.

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[6] This kind of surprise reaction to an unexpected event has currently been observed in infants in linguistic and non-linguistic tasks (e.g., Höhle et al., 2004; Saffran, Aslin & Newport, 1996).

[7] We can not discuss here how the proposal of (Büring & Gutiérrez-Bravo, 2001, p. 16f) concerning the default structure of focus prosody in German sentences fairs with the assumption of Féry (1993), that the pitch of sentences containing narrow subject focus in initial position is more comparable with the overall pitch contour of neutral sentences, in which the sentence initial element carries the highest pitch, even when not focused, due to the fact that a relative decline towards the end of the sentence must be ensured.

2.4.4 Results

As the experiment is not yet completed, the results can only be seen as preliminary.

The orientation time for the condition with NP1 focus is 6022 ms (SD = 3283 ms), and for the condition with NP2 focus 5458 ms (SD = 2023 ms). The difference is statistically not significant: $t_{(26)} = 0.95$; $p = 0.35$.

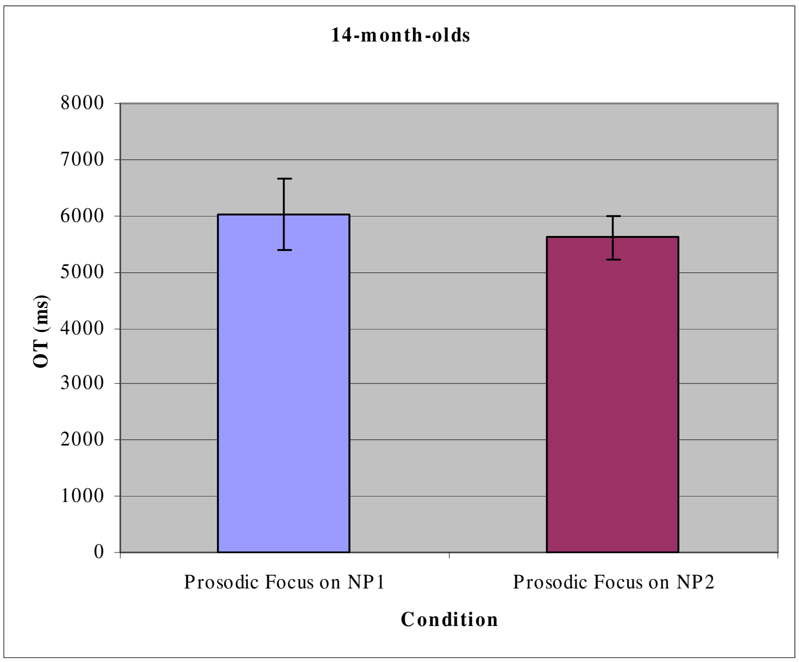

Figure 5: Mean orientation time of the 14-month-old infants

2.4.5 Discussion

Thus, contrary to the results of the 8-months-olds, the 14-month-olds do not seem to make a distinction between both prosodic focus conditions.

The finding that the 14-month-olds behave like the 4- and the 6-month-olds obviously asks for another explanation than the one given for the younger children, that is, that the infants either did not perceive the different prosodic focus structures or that they might not just have recognised the more frequent pattern in their speech input.

As we will argue more in detail in the General Discussion below, we would like to suggest, that the behaviour of the 14-month-olds can most plausibly be accounted for, if we assume that it reflects target language knowledge, in that the infants already have realised that their language belongs to Type C, that is, that it allows for various focus positions, and that they therefore do no longer differentiate between two prosodic patterns solely on the basis of a difference in their frequency of occurrence.

3 General Discussion

The aim of the present study was to elucidate in a cross-sectional study with 4-, 6-, 8-, and 14-month-old German-learning children when and how they may acquire the regularities which underlie Focus-to-Stress Alignment (FSA) in the target language. We assumed that in order for the child to find out to which type of FSA the target language belongs, that is, how prosody is associated with specific communicative functions, she has first to be able to discriminate between different stress patterns which implies the recognition of different stress positions. The child's growing ability to syntactically and semantically analyse the speech elements occupying these positions should then lead the child to infer the principles which determine the association of focused, that is, new information with prosodic prominence, possibly based on a distributional analysis of the co-occurrence patterns of these elements in the input.

More specifically, we predicted that the developmental changes in the linguistic processing abilities of the child, contributing to the acquisition of the FSA rule, should be reflected in the changing reaction patterns to the prosodically and segmentally identical test sentences at the different ages.

The general developmental path we observed may be described as taking the shape of an inverted U-shape development, where the identical reactions of the children to the same stimuli at the age of 4, 6 and 14 months, as we suggested, have to be differently accounted for. The 4- and the 6-month-olds gave no indication of preferring either of the prosodic focus conditions, the orientation times for both conditions were statistically not different. Given that in the light of previous findings, infants already at birth rely on rhythmic patterns to distinguish their native language from a different language (Mehler et al., 1988), and given the findings of Christophe et al. (2003) mentioned above, we rejected the interpretation, that the children did not perceive the different prosodic patterns. Instead, we proposed that they had not yet gathered enough information about the distribution of these different prosodic patterns in their target language (i.e., the difference between the marked structure where the prosodic focus lies on the first NP and the default structure with prosodic focus on the rightmost constituent) to establish a preference for one over the other.

In contrast, the 8-month-olds then clearly distinguished between the two prosodic patterns by listening longer to the more infrequent one. We suggested that this finding reflects a growing sensitivity of the children to the different frequency of occurrence of the opposite prosodic patterns in the speech input.
Though the pattern of results we found in the 14-month-olds is on the surface the same as for the 4- and 6-month-olds, it is implausible to apply the same explanation. Due to the fact that 14-month-olds have had much more experience with their ambient language and taking into account our findings for the 8-month-olds, we would like to suggest two possible explanations:

First, it might be that the 14-month-olds have already learned that their target language belongs to the Type C of FSA, in which the mapping of nuclear stress and the focused constituent is realised either through movement of nuclear stress or syntactic movement. The recognition that both types of sentences used in our experiment are possible structures of German could have lead to accepting both to the same agree which is reflected by the same listening times to both conditions in our experiment.

We assume that the target like knowledge of the FSA rule is acquired between 8 and 14 months of age on the basis of the increasing abilities of the children to discern the internal lexical and syntactic structure of sentences. Thus work on German (Höhle et al., 2004) and on English (Shady, Gerken & Jusczyk, 1995) has provided evidence, that infants in the first half of their second year of life may already analyse closed class lexical items like determiners together with the following lexical element as a unit, which corresponds to a NP in the target language. This in consequence might be the basis for the children to recognize that nuclear stress in German is not assigned to a fixed sentence position but is assigned to a focused NP which can stay in its canonical position leading to variable stress patterns in German. Whether this prosodically marked focus is already associated to a semantic focus by 14-month-olds cannot be proved on the basis of our set of experiments and has to be a question for further research.

On the basis of our current data we cannot rule out a second, alternative explanation. It could be the case that the 14-month-olds, in spite of the experience with their native language, did not yet have recognised that German is a Type C language. The results then might be due to the fact that infants during their second year of life do no longer rely mainly on prosodic cues to analyse the input, therefore showing no preference for either of the two sentence types used in our experiment which only differed with respect to their prosodic structure while keeping the lexical content and the syntactic structure constant. This was, for instance, suggested by Hirsh-Pasek and Golinkoff (1996) as well as Hollich and colleagues (Hollich et al., 2000). They claimed that the various types of information existing in the child's speech input are used by the children to a different degree at different stages during the language acquisition process, and, according to their model, the beginning of the second year of life marks a turning point in that children start to increase their reliance on syntactic and lexical information to the detriment of prosodic information, which dominates language processing during the first year of life. Studies by Höhle and Weissenborn (2000) and Jusczyk, Houston and Newsome (1999) provide evidence for this change in language processing: while word segmentation of German and English learners in the first year of life seems mainly be achieved by a metrical segmentation strategy this strategy seems to loose its dominance in favour of the integration of non-prosodic distributional information and lexical top-down mechanism in the recognition of word boundaries at the beginning of the second year of life. The difference we observe in the reactions between the 8- and the 14-month olds of our study might reflect the same change in the domain of sentence prosody.

The data of the German infants alone do not allow us to decide between these two possible explanations for our results. Testing learners of a language with fixed focus position like e.g. Italian, on the other hand, might gain us some insights on the processes going on.

If the Italian infants by 14 months of age have already learned that their language is of the Type B, we would expect the opposite reaction to the one we found in German infants. Having learned that Italian only allows for one focus position at the rightmost edge of the sentence[8] we would expect the Italian infants to clearly distinguish between the sentences with different prosodic focus position when presented with the same stimuli as the German children. If our pattern of results, on the other hand, just reflects a decline on the attention to prosodic information in general, we would expect that the Italian infants also do not make a distinction between both types of stimuli.

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[8] Leaving aside left-periphery phenomena, an option also available in German.

Taken together, our findings provide further evidence for a general developmental path, also observed in other areas of pre-linguistic language development, going from a predominantly prosodically driven processing of the input to a processing where prosody interacts more and more with the growing lexical and syntactic knowledge of the child.

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