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Word processing at 19 months and its relation to language performance at 30 months: A retrospective analysis of data from German learning children

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Abstract

Recent research has shown that the early lexical representations children establish in their second year of life already seem to be phonologically detailed enough to allow differentiation from very similar forms. In contrast to these findings children with specific language impairment show problems in discriminating phonologically similar word forms up to school age. In our study we investigated the question whether there would be differences in the processing of phonological details in normally developing and in children with low language performance in the second year of life. This was done by a retrospective study in which in the processing of phonological details was tested by a preferential looking experiment when the children were 19 months old. At the age of 30 months children were tested with a standardized German test of language comprehension and production (SETK2). The preferential looking data at 19 months revealed an opposite reaction pattern for the two groups: while the children scoring normally in the SETK2 increase their fixations of a pictured object only when it was named with the correct word, children with later low language performance did so only when presented with a phonologically slightly deviant mispronunciation. We suggest that this pattern does not point to a specific deficit in processing phonological information in these children but might be related to an instability of early phonological representations, and/or a generalized problem of information processing as compared to typically developing children.

Keywords: *Word processing, late talker, early indicators for SLI, processing of phonological details.*

Introduction

One of the main features of first language acquisition in the second year of life is a fast growth of the lexicon. Results from parental questionnaires suggest that the typically developing 12-month-old has an average productive vocabulary of about 6 words while the typically developing 24-month-old has an average repertoire of around 310 words (e.g., Bates et al., 1994). Generally speaking, learning a word means to form an association between a phonological form and a meaning and to establish a representation of this association in the long term memory, i.e., the mental lexicon. Despite intensive research in this field the exact nature of these mental representations is still unclear. There is evidence that children start with rather unspecific phonological and semantic representations (e.g., Ferguson & Farwell, 1975; Walley, 1993). This may give rise to overgeneralizations of words to concepts they do not refer to in the target language (Clark, 1973) and to confusions of phonologically similar forms in word recognition (e.g., Barton, 1980; Eilers & Oller, 1976; Gerken, Murphy & Aslin, 1995; Metsala, 1997; Walley, 1988).

The observation that young children confuse newly learned phonologically similar minimal pairs is not new (Shvachkin, 1973; Garnica, 1973), but the recent findings on infants' impressive discrimination abilities for all sorts of phonetic contrasts (for a review see Jusczyk, 1997) suggests that these confusions are not due to perceptual problems. Seminal work by Stager and Werker (1997) has shown that confusions between phonologically similar words do not show up in tasks that only involve general perceptual processes but are specific to the situation of word learning. This finding has been extended and replicated in further studies (Nazzi, 2005; Pater, Stager, & Werker, 2004; Werker, Fennell, Corcoran, & Stager, 2002). The results of all of these studies suggest that, when learning a new word, 14-month-olds do not have access to the fine phonetic differences between minimal pairs which older children have.

On the other hand, children as young as 14 months have demonstrated the ability for detailed phonetic discrimination of words they are familiar with (e.g., *ball* vs. *doll*) or between a familiar word and a phonologically slightly deviating mispronunciation of the same word (Ballem & Plunkett, 2005; Fennell & Werker, 2003; Mani & Plunkett, to appear; Swingley, 2003; Swingley & Aslin, 2000, 2002). According to these studies the representations of words that are already established in the 14-month-olds' lexicon seem to be phonologically specified on a level detailed enough to allow the differentiation between minimally different forms. These results are at odds with the assumption that early phonological representations are only minimally specified and that they become more detailed only under the pressure of the growing lexicon that forces a higher degree of phonological differentiation to keep entries apart (Charles-Luce & Luce, 1995; Metsala, 1997).

The documented abilities for a detailed phonetic analysis and the ability to establish long term phonological representation with a sufficient phonological detailedness surely contribute to the fast lexical growth we see during the second year of life and might even be a necessary basis for this. But already in these early phases of language acquisition we see variation between children. Not all children show a comparable fast expansion of the lexicon at this age. According to Rescorla (1989) children with an estimated vocabulary below 50 words at the age of 2 years, so called late talkers, bear a high risk of being language impaired. Detailed research has shown that as a group, late talkers still show lower language performance than average in different domains of language over the next years of life (e.g., Rescorla, Dahlsgaard, & Roberts, 2000; Rescorla, Mirak, & Singh, 2000). An above average number of children with a history of being a late talker as compared to typically developing children show language performance suggesting a developmental language impairment in later testing.

Problems in acquiring and processing words are among the core features of developmental language disorders (e.g., Leonard, 1998). Almost all children diagnosed with specific language impairment (SLI) show poorer performance in word production and word comprehension than age-matched children with normally developing language skills. It has been suggested that these lexical problems are related to an impairment of processing phonological information, leading to less detailed or more holistic phonological representations than in children with typical language development (Bishop, 1997; Edwards & Lahey, 1998).

Recently, the ability of children with SLI to differentiate between phonologically similar strings has been investigated more closely. Criddle and Durkin (2001) showed that 5–7-year-old children with SLI still confuse newly learned forms with phonologically similar forms especially when they differed only in the first phoneme. Similar results were obtained in a study by Maillart, Schelstraete and Hupet (2004) using an auditory lexical decision task. Besides correct French words they presented pseudowords that were created by the addition or deletion of the initial, a medial or the final phoneme from existing words. Six- to 12-year-old children with SLI made significantly more errors in rejecting the pseudowords than typically developing children, matched to the children with SLI on the basis of their receptive vocabulary. Both groups made more errors in pseudowords that retained the syllable number of the original word. The performance of the children with SLI was most clearly below that of the typically developing children with respect to pseudowords with an initial or final phoneme change that retained the syllable number. Maillart and colleagues interpret their results as indicating that the phonological representations of children with SLI are phonologically less defined than those of typically developing children with a comparable lexical inventory. Their results support the idea of more holistic representations that code global phonological features like the number of syllables but contain fewer phonetic details concerning individual segments. If this is the case, children with SLI would still be in a developmental phase typically developing children might already have left during their second year of life.

The aim of our study was to investigate whether children at risk for specific language impairment by showing low language performance at the age of 30 months differ already in their first steps into the lexicon in their lexical processing skills from normally developing children. The participants of our study were participants in a longitudinal study on German language development (http://www.glad-study.de). In analogy to the studies by Swingley and Aslin (2000, 2002) reported above we used the intermodal preferential looking paradigm and presented correct word forms and mispronunciations deviating in one phoneme from the correct word to a group of 19-month-old children. At the age of 30 months the children's language performance was checked by a German standardized language production and comprehension test (SETK2; Grimm, Aktas, & Frevert, 2001). According to their performance in this test, children were grouped as low language performers and normal language performers. The data from the experiment with the intermodal preferential looking paradigm were then analysed for these two groups of children separately.

Method

Participants

Eighty-six children (44 girls and 42 boys)—all participants of a longitudinal study on German language development (GLaD Study)—were

successfully tested with the intermodal preferential looking paradigm when they were around 19-months-old. All children were healthy full term infants from monolingual German-speaking homes. They had a normal course of pregnancy, were somatically healthy and passed hearing screening with otoacoustic emissions. Only 71 of these children were still available for SEKT2 testing at 30 months. In the following only the data of these 71 children are reported. The mean age of this group was 579 days (range: 569–604, SD = 7.6) which corresponds to 19 months and 3 days when tested with the intermodal preferential looking paradigm.

Materials

Six monosyllabic common German nouns which were supposed to be familiar to 19-month-olds were selected as target stimuli. The words were *Tisch* "table", *Kamm* "comb", *Po* "bottom", *Kuh* "cow", *Schaf* "sheep", and *Fisch* "fish". The mispronunciations were arrived at by changing the place of articulation of the initial consonant (*Tisch* > *kisch*, *Kamm* > *tamm*, *Po* > *ko*, *Kuh* > *pu*, *Schaf* > *saf*, *Fisch* > *sisch*). None of the mispronuciations corresponded to an existing German word. To achieve more variability during the experiment, four additional nouns were selected as filler items: *Reh* "deer", *Maus* "mouse", *Huhn* "chicken", and *Bett* "bed".

All words and mispronunciations were recorded by a female native speaker of German. In addition, three sentence frames for the critical items were recorded: *Wo ist der/die/das . . . ?* "Where is the . . . ?". The critical words were spliced into one of these frames so that their gender matched the form of the article. For use as a second acoustic stimulus another six sentences that referred to the object by means of a pronoun were recorded: *Siehst Du ihn/sie?* "Do you see it?", *Kannst Du ihn/es finden?* "Can you find it?", and *Gefällt sie/er dir?* "Do you like it?".

For each of the words a simple coloured line drawing showing only the referent of the word was prepared and digitized. For presentation during the experiment the drawings were combined into fixed pairs. Within the set of critical items these were *Tisch-Kamm*, *Po-Schaf* and *Fisch-Kuh*. The fillers consisted of the pairs *Bett-Maus* and *Reh-Huhn*.

Procedure and apparatus

The experiment consisted of two experimental blocks which only differed with respect to the order of the trials. Each experimental picture pair was presented four times in each experimental block. Twice it was combined with one of the corresponding correct words and twice with the corresponding mispronunciations. For example, the picture pair *Tisch-Kamm* was presented once with the word *Tisch*, once with the word *Kamm*, once with the mispronunciation *kisch* and once with the mispronunciation

tamm. Half of the pictures were first presented together with a correct word and half were first presented with a mispronunciation. The left-right arrangement of the two objects/animals was counterbalanced across the four presentations as well as the position of the object/animal corresponding to the acoustic stimulus. The filler pictures were only presented once during each experimental block. Within the first experimental block *Maus* and *Huhn* were used as target words, during the second block *Bett* and *Reh*. Each block consisted of 14 trials and started with a filler item.

For the experiment the intermodal preferential looking paradigm (cf. Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987) was used. During the experiment the children were sitting on their parents' lap in the centre of a sound-proof testing booth approximately 1.50 m before a silver screen on which the pictures were presented by an LCD-projector. The parents were presented with loud music by closely fitting headphones to avoid a systematic influence on the child's looking behaviour. The two objects of a pair were presented on separate pictures with the same background colour simultaneously side by side with a distance of 10 cm between them. Each picture measured approximately 45 × 35 cm.

An experimental trial was built up as follows: At the beginning a small girl jumping up and down was presented at the centre of the screen to attract the child's attention and initiate a fixation to the screen. When the child looked at this animation the experimenter pressed a button which stopped the animation and started the presentation of one of the picture pairs. Each picture pair was first presented silently for 3000 ms. This period served to establish a baseline of preference for one of the two pictures. After this silent period the first stimulus sentence with the target noun as its final word was presented automatically by one loudspeaker located centrally behind the silver screen. After the end of the target sentence there was again a silent period of 3000 ms. Then one of the sentences referring to the object only by a pronoun was presented and again the reaction of the child was observed for 3000 ms. Each experimental trial consisted of three phases of silent periods with a total duration of 9000 ms and together with the two presentations of the acoustic stimuli this resulted in an overall trial time of about 10 s. After a blank screen of 1 s the animation was presented again until the next trial was started. The whole experimental session was video-recorded by a video camera through a small hole in the centre of the silver screen between the two pictures.

Data analysis and scoring

Each recording was coded offline by one of two highly trained coders blind to the different conditions run in the experiment. The coder decided for each video frame whether the child was looking at the

right picture, at the left picture or at neither of the two pictures and coded his decision by pushing one of three predefined keys. The fixation time for each picture during each trial was finally calculated by adding the number of frames during which the child had fixated the critical picture and multiplying this amount by the duration of a single frame (20 ms). For the analysis the looking time at the picture corresponding to the acoustic stimulus, proportional to the overall looking time at the two pictures, was used. This score was calculated separately for all three experimental phases of 3000 ms: before the start of the acoustic stimulus, after the first presentation of the first stimulus sentence including the critical word, and after the presentation of the second stimulus sentence.

SETK2

The SETK2 comprises four different subtests: word comprehension, word production, sentence comprehension and sentence production. Comprehension is tested by a word/picture and a sentence/picture matching task. Word production is tested by naming of real objects and pictures. Sentence production is tested by naming of depicted situations and actions.

Results

SETK2 data

Children scoring below 1 SD from the mean of the norming sample in at least two subtests were considered as children with low language performance for this study. According to this criterion 21 children (eight girls) show language performance below their age average while 40 children (23 girls) scored within their normal age range. These groups were considered as the low language performers and the average language performer in the following.

Preferential looking data

Since not all children finished the second presentation block and the overall looking times at the pictures decreased dramatically within this block, only the results of the first block are reported. Furthermore, given the 3000 ms period after the presentation of the second sentence with the pronominal reference to the target picture did not show any effects, only the comparisons of target fixation before the acoustic stimulus and within the 3000 ms silent period after the presentation of the first sentence containing the target word are reported.[1] For these periods the proportions of looking time at the target picture from the overall fixations for both pictures were calculated.

The proportions of looking time at the target picture before and after word or mispronunciation presentation were subject to a $2 \times 2 \times 2$ factorial ANOVA including the factors experimental phase (before/after acoustic stimulus), word form (correct word/mispronunciation) and group (children with low SETK2 performance/children with average SETK2 performance). This analysis revealed a significant main effect for the experimental phase ($F(1,59) = 12.25$; $p < .001$) and a significant three-way interaction between all three factors ($F(1,59) = 13.81$; $p < .001$). The remaining main effects as well as all two-way interactions failed to reach the significance level (word form: $F(1,59) < 1$; group: $F(1,59) < 1$; word $\times$ group $F(1,59) = 2.98$; $p = .09$; experimental phase $\times$ group $F(1,89) < 1$; experimental phase $\times$ word $F(1,59) = 1.46$; $p = .23$).

To track the source of the significant three-way interaction the data were then analysed separately for the correct word and the mispronunciation presentations by 2×2 factorial ANOVAs with group as a between-subjects and experimental phase as a within-subjects factor. The analysis for the correct words (see Figure 1) showed a significant main effect for the factor experimental phase ($F(1,59) = 10.06$; $p < .01$), no effect for group ($F(1,59) = 1.96$; $p = .16$) but a significant interaction between the two factors ($F(1,39) = 17.61$; $p < .001$). Pair-wise comparisons with t-tests revealed that the increase in target fixation after word presentation was significant for the average language performers ($t(40) = 4.59$; $p < .001$) but not for the low language performers ($t(20) = 0.47$; $p = .64$).

The 2×2 ANOVA for the mispronunciations (see Figure 2) also showed a significant effect for the experimental phase ($F(1,59) = 5.16$; $p < .05$) and a significant interaction ($F(1,59) = 4.34$; $p < .05$) but no group effect ($F(1,59) = 1.32$; $p = .25$). Paired t-test revealed that the average language performers did not show any differences in target fixations before and after presentation of a mispronunciation ($t(40) = .17$; $p = .86$). In contrast, the low language performers showed a significant increase of target fixations after the presentation of the mispronunciations ($t(20) = 2.44$; $p < .05$).

Furthermore, we compared the difference in target fixations after the presentation of the correct word and after the presentation of a mispronunciation in more detail. For this purpose, a difference score (correct – mispronunciation) was calculated by subtracting the proportion of target fixations after the presentation of a mispronunciation from the proportion of target fixations after the presentation of the correct word form for each child and each experimental item.[2] For the children with average SETK2 performance this difference score had an average of $M = .085$ ($SD = .115$) while the children with low SETK2 performance had an average score of $M = -.067$ ($SD = .224$). According to a t-test for independent samples the difference in the average scores between the two groups was significant ($t(59) = 3.53$; $p < .001$). The fact that the means of the two groups have opposite signs reflects that the
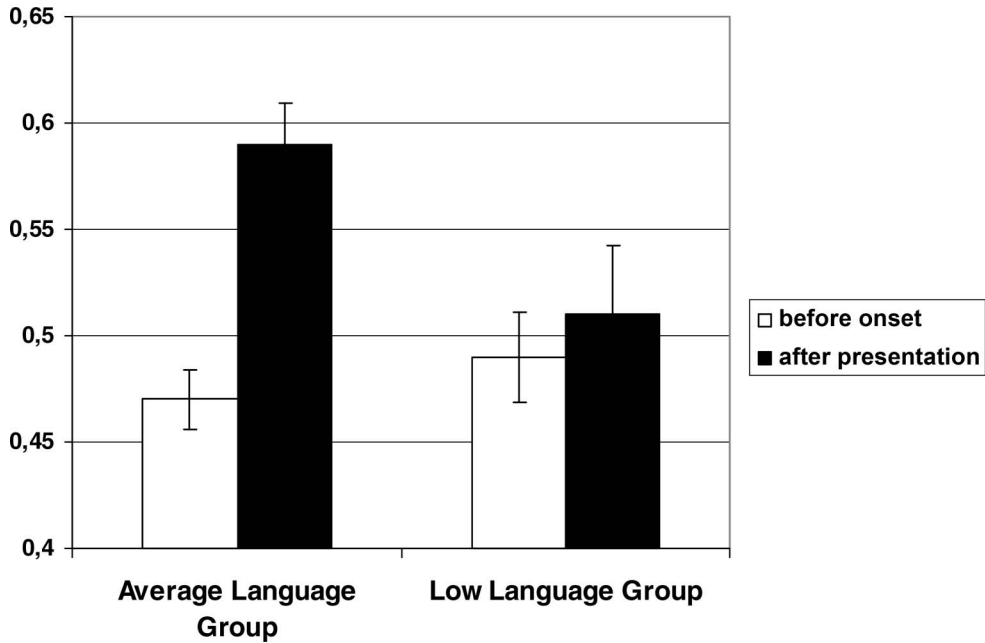
Figure 1. Proportions of target fixations (correct word condition).
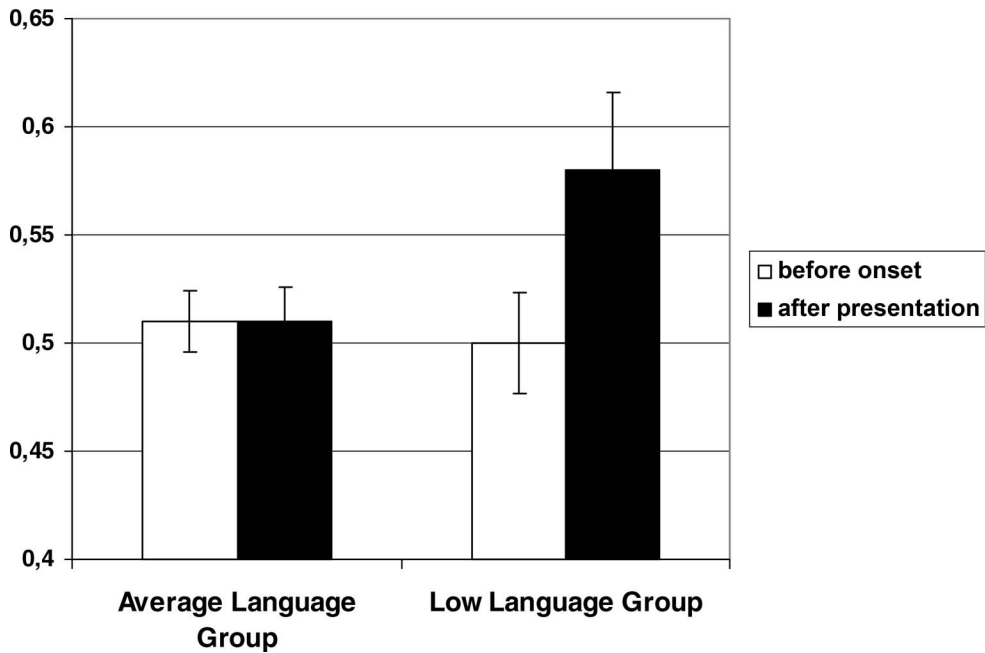

Figure 2. Proportions of target fixations (mispronunciation condition).

difference scores of the children with low language performance are not only smaller than those of the children with average language performance but that on the average children with low language performance show higher proportions of target fixation after the presentation of a mispronunciation than after the correct word.

In a next step, we analysed whether children's individual performance in the preferential looking experiment as measured by the difference scores would have any predictive value for the outcomes of the SETK2 testing. Half of the 26 children with negative difference scores in the preferential looking task appeared as children with low language performance in the SETK2. In contrast, only eight out of 35 children with positive difference scores came out as low language performers in the SETK2 test. This relation between the positive or negative value of the difference score and the outcome of the SETK2 was significant ($\chi^2(df = 1) = 4.87$; p < .05). Interestingly,

the nine children with the lowest difference scores in the preferential looking task, i.e., all children scoring below 1SD from the mean of the whole sample's difference scores, showed consistently up as low language performers in the SETK2 testing.

Discussion

To summarize our results: Children who showed normal language comprehension and production skills at 30 months had selectively shown an increase in fixating a referent when its name was presented in the correct phonological form. The presentation of a phonologically similar mispronunciation did not lead to an increase in the fixation of the target picture. In contrast, the children who showed low language performance when tested at 30 months differed from the pattern of the better language performers already at 19 months: they did not show an increase in object fixation when presented with the correct name but in contrast, when presented with a phonologically deviant mispronunciation of the correct word. In addition, all of the children with the strongest amounts of fixating the target after the presentation of a mispronunciation came out as children with low language performance at the age of 30 months.

First, this pattern suggests that German-learning infants who show a typical pattern of language development probably have rather specified phonological representations of at least some familiar words of their target language at 19 months, and are able to differentiate these words from phonological forms that deviate from them in one phonological feature in the initial phoneme. This is in line with previous findings with English and Dutch learning infants (Ballam & Plunkett, 2005; Swingley, 2003; Swingley & Aslin, 2000, 2002), and adds evidence to the assumption that early phonological specificity is a general characteristic of lexical development in any language independent of the specific phonological features. As found in other studies, in these children the presentation of a word leads the child to direct her attentional focus to the word's referent.

The fact that this pattern was not observed for the phonologically deviant mispronunciations suggests that the children did not connect this form to the depictured object or animal, even though there was a high degree of phonological overlap between the correct and the deviant forms. This is in contrast with the findings with English learners who showed a reduced but not eliminated effect of presenting a mispronunciation on their fixations of the target picture at least after a repeated presentation of a stimulus (Swingley & Aslin, 2002; Ballem & Plunkett, 2005). This difference between the findings could be due to the fact that in our study this experimental group did not involve children with later low language performance. This factor has not been considered in the English studies in which the

participants had not been selected according to their general language performance. Thus, it could be the case that the non-reaction to the mispronunciations is a typical feature of children who show good language performance.

The findings for the group of children who have been identified to have low language performance at a later age are harder to interpret than the results for the children with good language performance. Interestingly, these children show an opposite pattern of fixation times for the correct and incorrect word: they only direct their attentional focus to the target picture when presented with a phonological deviant but similar form but not when presented with the correct word. What does this pattern tell us? First of all, the fact that the low language performers show an increase in fixation to the target picture when presented with the mispronunciation shows that they connected the acoustic stimulus to the target picture. This is an important observation, since it contradicts one possible explanation for our results, namely that the children with low language performance simply did not yet know and recognize the words used in our experiment. Second, the different results for the correct words and the mispronunciations indicate that the children must have discriminated the correct word forms from the incorrect ones. This then suggests—given that the correct and the mispronunciation differed only minimally in one phonological feature—that the low language performers in our experiment do not have a specific problem in perceiving and encoding detailed phonetic and/or phonological information during the actual processing of the words in the experiment as has been proposed in several accounts (e.g., Bishop, North, & Dolan, 1996; Edwards & Lahey, 1998; Elliot, Hammer, & Scholl, 1989; Leonard, McGregor, & Allen, 1992; Montgomery, 1995; Sussman, 1993; Tallal & Stark, 1981).

What we may assume is, that the phonological representations of the low language performers are not yet as stable as those of the average language performers. That is, it may be the case that the low language performers consider the incorrect word as a possible variant of the correct word, and that it is its novelty which leads to the longer fixation times as compared to the ones for the correct word.[3] This raises the question of the origin of this representational instability. One explanation could be, that the low language performers need more time or more instances of a word in their input to establish stable representations, which could point to a memory problem (e.g., Gathercole & Baddeley, 1990; Gathercole, Service, Hitch, Adams, & Martin, 1999; Gathercole, Tiffany, Briscoe, & Thorn, 2005; Rice, Oetting, Marquis, Bode, & Pae, 1994) This would predict that a repetition of our experiment with the same children at a later age should yield a fixation pattern more similar to the one of the good language performers in the present experiment.

Another possibility, which is not necessarily exclusive to the preceding one, is that the low language performers' longer fixation times for the targets in the mispronunciation condition are related to a generalized problem of information processing as compared to typically developing children (Miller, Kail, Leonard & Tomblin, 2001; Schul, Stiles, Wulfeck, & Townsend, 2004; Sininger, Klatzky, & Kirchner, 1989). Less efficient processing might especially show up in our experimental condition in which the child must "reject" a phonologically highly similar incorrect word form as the name for a referent. This might be a harder task than accepting a correct form leading to a longer checking of a possible match between word and picture that is expressed in longer fixations of the target.[4] If our suggestion is correct, our results would support the view that these properties of the information processing in children with language impairment may be one of the sources of the later non-typical language development as has been repeatedly proposed (e.g., Benasich & Tallal, 1996, 2002).

Further research is clearly needed to find an explanation why for the group of low language performers the presentation of the correct word did not lead to a significant increase of the fixation time for the target picture, but that instead this was the case for the presentation of the incorrect word. Our findings however contribute to the growing evidence that there might be indicators for being at risk for a developmental language impairment that can already be detected in tasks looking at perceptual skills and at language processing before the age of 24 months (e.g., Benasich & Tallal, 2002; Trehub & Henderson, 1996; Tsao, Liu, & Kuhl, 2004). This has interesting implications for the development of diagnostic tools for the early detection of children at-risk for specific language impairment.

Acknowledgments

Notes

1 The finding that we did not see any effect in the case of pronominal reference to the target picture is most likely related to the fact, that the children were not able to establish a connection between the pronoun and the nominal antecedent in the preceding sentence. In German, this relation is based on gender and number agreement between the pronominal anaphor and its nominal antecedent. Problems in computing this anaphoric relation may be due to the fact that the child has not yet acquired the gender and number features for the lexical entries of the noun and the pronoun, or to a memory problem, which would render the antecedent of the pronoun unavailable. The most likely explanation is, that the lexical entries for the noun and the pronoun are still missing the gender and number features, as evidenced by the fact that the obligatory use of determiners, which in German agree with nouns for gender and number, does not occur before 20–24 months of age. The intersentential anaphorical use of personal pronouns is observed even much later.

2 One of the reviewers pointed out that this analysis is only valid if there was no difference in looking times before the presentation of the acoustic stimulus which in fact was true for both experimental groups (p > .10 in each case).

3 We would like to thank one of our anonymous reviewers for having pointed this out to us.

4 It is a well-known phenomenon that "no" answers are harder to give than "yes" answers.

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