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Effects of Pre-Exposure to Object and Label During Word Learning

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Infants learn novel word-object pairings better when they have prior familiarity with either the label (Swingley, 2007; Graf Estes et al., 2007) or the object (Fennell, 2012; Kucker & Samuelson, 2012). This suggests that infants encode information about labels and objects, even when they do not know what they refer to or how they are labelled, and that they can use this knowledge for later word learning. The present study examines whether mere exposure to object and label facilitates word learning or whether consistency of co-occurrence between label and object also matters. We familiarized German 15- to 17-month-old infants with a novel object and a novel label in an animated story without explicitly associating the two with each other. Object and label merely co-occurred in the story. Subsequently, the infants participated in a word learning task. Results show that infants only showed evidence of word learning when the label and object presented in the story were also paired in the word learning task, suggesting that mere exposure to label and object has only limited effects on word learning and that infants readily use co-occurrence information to form label-object associations.

1. Introduction

Word learning is not a trivial task. In order to learn a word, the child has to master at least three tasks: she has to recognize a novel word in the speech input and encode information about its phonological form, she has to isolate the corresponding referent and encode information about its identity, and she has to integrate this information about form and meaning. Unsurprisingly, previous familiarity with the phonological form or the referent of a novel word can facilitate word learning.

Graf Estes et al. (2007) investigated whether 17-month-olds could use information from speech segmentation for later word learning. They exposed the infants to an artificial language speech stream, in which transitional probabilities

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between syllables indicated word boundaries. Subsequently, the infants were presented with a word learning task. The novel label was either a word or a part-word from the previously presented artificial language stream. In other words, had the infant correctly segmented the speech stream, the novel label was either familiar or unfamiliar. Results show that infants successfully learned the novel word when it was familiar but not when it was unfamiliar, suggesting that infants can use information from fluent speech for later word learning (see Hay et al. (2011) for similar results using natural, foreign speech).

Similarly, Swingley (2007) shows that previous familiarity with a label allows children to better encode phonological detail during word learning. He exposed 19-month-olds to an animated story in which a novel label (but not a novel referent) was presented several times. Subsequently, the toddlers were presented with a word learning task and tested on their ability to spot mispronunciations in the newly learned words. Results show that toddlers were able to spot distant mispronunciations regardless of whether they had been pre-exposed to the novel word or not, but that subtle one-feature mispronunciations were only spotted for those words that the children had already heard in the story before.

Fennell (2012) expands these findings by showing that familiarity with an object also enhances word learning. He presented 14-month-olds with a word learning task. Half the infants had the opportunity to play with a novel stuffed toy that served as novel object in the word learning task prior to the experiment. Results show that only those infants who had played with the toy before, i.e., that were familiar with the object, learned the novel label and succeeded to discriminate it from a minimally different word.

Going a step further, Kucker and Samuelson (2012) compare the influence of previous exposure to word and object. They pre-exposed 24-month-olds to either objects or labels before they participated in a word learning task. Toddlers performed above chance in the word learning task when tested immediately after pre-exposure, regardless of whether they had been pre-exposed to the label or the object (as would have been expected based on the previous studies). However, only those children who had been pre-exposed to the object performed above chance after a five-minute delay, suggesting that familiarity with a phonological form and familiarity with a referent have different effects on word learning. Since this is beyond the scope of the current paper, we will not consider possible sources of this difference, but instead refer to the discussion in Kucker and Samuelson (2012).

Taken together, the above studies inform us that previous familiarization with either the word or the object can support word learning. However, in natural learning situations, the child will probably be exposed to various objects when hearing a novel label and to various labels when seeing a novel referent – infants are not always exposed to objects and their labels simultaneously (Gleitman, 1990). Does pre-exposure to either object or label similarly aid later word learning when the object has been previously presented in the context of other labels or when the label has been presented in the presence of other

objects? Put differently, is the consistency with which a phonological form and a referent co-occur before word learning important for later correctly associating the word with the intended referent?

Using a similar design as Swingley (2007) the current study addresses this issue by testing infant's word learning following pre-exposure to a story that familiarizes the infant with a novel label and a novel object. The object and the label are not explicitly mapped to each other in the story, i.e., the child is not told that the novel label refers to the novel object. Instead, they merely co-occur, i.e., the label is embedded in the story and the object is one of several objects depicted in the visual scenes that accompanied the narrative. The pre-exposure phase is followed by a word-learning task in which children have to learn and later recognize two novel label-object pairings. Crucially, co-occurrence during the pre-exposure phase is either consistent or inconsistent with the learning phase (see Table 1 for a schematic of the experimental procedure).

Table 1: Schematic of the experimental procedure.

	Consistent pairing		**Inconsistent pairing**	
Pre-exposure	 *"Fubo"*			
Learning	 *"This is a fubo"* **Familiar pair**	 *"This is a tibie"* **Unfamiliar pair**	 *"This is a tibie"* **Object familiar**	 *"This is a fubo"* **Word familiar**
Test	  *"Where is the tibie/fubo?"*			

In the consistent condition the child has seen the object and heard the label in the story that form one of the label-object pairs, while the other label-object pair is completely unfamiliar. Since previous studies have shown that familiarity promotes learning, we expect that learning will be better for the familiar than for the unfamiliar pair. In the inconsistent condition the child has heard the label of one of the label-object pairings, but seen the object of the other label-object pairing in the story. Thus, the co-occurrence of label and object in the story is inconsistent with the pairing in the learning phase. Since for one pair the object is familiar, while for the other pair the label is familiar, we expect no differences in learning performance for both pairs based on previous familiarity if label and

object familiarity have similar effects on learning. Alternatively, if object familiarity is more salient, we expect better performance for the object familiar pair. Importantly, if consistency during pre-exposure and not only mere familiarity matters, we expect better learning in the consistent compared to the inconsistent condition.

2. Method

2.1. Participants

Sixteen German 15- to 17-month-olds (6 boys) participated in the experiment. Their ages ranged from 15;03 (months; days) to 16;20; mean age 15;23. Seven additional children were tested (one boy) but excluded because they did not provide data for correctly and mispronounced test trials of both words (1), because they did not complete the experiment (4) or because of equipment failure (2). Participants came from a sample of families who responded to an invitation letter sent to all families with infants living in the area. Participants were rewarded with a book or a t-shirt.

2.2. Stimuli

Visual stimuli of the pre-exposure phase included images of six different scenes. All scenes presented a dog on a meadow against a blue sky. The scenes additionally included an unknown object, other individuals and landscape features, such as the sun, a bush, a tree, flowers or a lake. The unknown object was either a red round or a blue sticky stuffed microbe (athlete's foot and penicillin, see www.giantmicrobes.com). The other individuals included a cat, a doll, a bird and a duck. The images were created from photographs and measured 900 by 1200 pixels. Visual stimuli of the learning and test phase included photographs of the red round and the blue sticky stuffed microbe, which served as learning items, and images of filler items displayed against a grey background. Filler items included a car, a ball, a banana, a bed, a book, a bottle, a cookie and a spoon. Learning and test images measured 600 by 800 pixels.

Audio stimuli of the pre-exposure phase included a narrative describing the quest of the dog for a novel object. On his quest the dog encounters different individuals and asks them whether they had seen the sought-after object (usually presented on-screen hidden from both protagonists). None of them have, so the story ends without the dog finding the object. Audio stimuli of the learning phase included sentences labelling the learning items, such as *Das ist ein Tibie. Gefällt dir das Tibie?* 'This is a tibie. Do you like the tibie?' and *Das ist ein Fubo. Siehst du das Fubo?* 'This is a fubo. Do you see the fubo?' Audio stimuli of the test phase included sentences asking the child to look at one of the presented pictures, such as *Wo ist das Tibie?* 'Where is the tibie?' Filler items were always labelled correctly, while learning items were either labelled correctly or with an initial mispronunciation. Mispronunciations included a

close one-feature change in the place of articulation of the initial consonant, changing *tibie* into *kibie* and *fubo* into *gubo*, and a distant change that changed the initial consonant into a consonant cluster, turning *tibie* into *kwibie* and *fubo* into *grubo*. Audio stimuli were spoken by a female native speaker of German, using child directed speech. Audio stimuli were recorded in a quiet room with a sampling rate of 44100 Hz and volume matched after recording using audio editing software.

2.3. Procedure

Participants were seated on their parent's lap in a dimly lit, quiet experimental room, facing a 92 cm wide and 50 cm high TV screen at a distance of 100 cm from the screen. Two cameras mounted directly above where the images would appear on the TV screen recorded children's eye-movements during the experiment. Synchronized signals from the cameras were routed via a digital splitter to record two separate time-locked images of the child. Auditory stimuli were presented via loudspeakers that were located above the screen. Stimuli were presented using the Look software (Meints & Woodford, 2008). Parents wore headphones playing music intermixed with speech during the experiment and were instructed to interact as little as possible with their child and to avoid pointing to the screen or naming the objects.

Pre-exposure phase

Each child was first presented with the narrative and the corresponding images depicting scenes of the story. The pre-exposure phase lasted for approximately 100 seconds. The child saw a novel object (either the red or the blue stuffed microbe) six times and heard a novel label (either *tibie* or *fubo*) twelve times in the course of the audio-visual story. Label and object were not explicitly associated in the story, i.e., children were not told that the object was a *tibie* or a *fubo*. Instead label and object merely co-occurred, i.e., the novel word was mentioned in the story while the object was present on the screen (amongst the other objects). It was counterbalanced across children which novel label and which novel object was presented in the story.

Learning phase

The story was followed by a learning phase in which children were presented with two novel label-object pairings, i.e., the novel labels *tibie* and *fubo* were explicitly presented as labels for the red and blue microbe objects. Infants had been presented with one of the objects and one of the labels during the story while the other object and label were unfamiliar to the child. Each object-label pair was presented 4 times to the child, adding up to 8 learning trials. Each trial lasted for 4 seconds displaying the image of one of the novel objects on the screen while the corresponding label was presented twice in sentence context, i.e., the child heard each label 8 times in the course of the learning phase. Trials began only when the child fixated the screen. In between

trials the screen remained blank or the picture of a bell accompanied by a ringing sound was presented to redirect children's attention to the screen. Trial order was randomized.

The learning phase was identical across children given consistent or inconsistent pre-exposure. The label-object pairings presented in the learning phase were consistent with the pre-exposure phase for half the children, e.g., half the children saw the red microbe and heard *fubo* in the story and, in the learning phase, were told that *fubo* was the name of the red microbe. In the consistent condition both label and object were familiar for one of the label-object pairs as they were both presented during pre-exposure (familiar pair), while for the other pair both label and object were unfamiliar (unfamiliar pair). The label-object pairings presented in the learning phase were inconsistent with the pre-exposure phase for the other half of the children, e.g., the children saw the red microbe and heard the word *tibie* in the story and, in the learning phase, like the children who received consistent learning input, were told that *fubo* was the name of the red microbe. In the inconsistent condition the label was familiar for one label-object pair (e.g., *tibie*; word familiar), while the object was familiar for the other pair (e.g., the red microbe; object familiar).

Test phase

After the learning phase, children's recognition of the novel words *tibie* and *fubo* was tested. Each trial presented the child with the two images side-by-side, of which one was labelled. Trials lasted for 4 seconds. Labelling was timed so that the target word onset occurred 2 seconds into the trial, splitting the trial in a 2 second pre-naming and a 2 second post-naming phase. Each child was presented with 16 trials. Eight trials were filler trials in which both target and distracter were familiar to the child. Eight trials were test trials. Each novel word was correctly pronounced in two trials and mispronounced in two trials. Half of the mispronunciations were close mispronunciations (*kibie* and *gubo*), the other half were more distant mispronunciations (*kwibie* and *grubo*). Trials began only when the child fixated the screen. In between trials the screen remained blank or the picture of a bell accompanied by a ringing sound was presented to redirect children's attention to the screen. Trial order was randomized.

2.4. Data analysis

We analyzed the amount of time children looked at the target image before and after naming in correctly and mispronounced trials as a measure of word recognition. Children's looking behaviour was analyzed using a digital video scoring system. A trained coder indicated for each 40 ms frame of the video whether the child was looking to the left, to the right, in the middle or away from the screen. The coder was blind to target location and trial type. The coding output was aligned with information about side of target, target word onset and trial type. This enabled us to determine the amount of time that children spent looking at the target (T) and at the distracter (D) throughout test

trials. For each test trial the proportion of target looking, PTL = T/(T+D), was calculated for both the pre- and a post-naming window. The pre-naming window lasted until 2000 ms into the trial, i.e., until target word onset; the post-naming window lasted from 360ms to 2000 ms after target word onset. A delay of 360 ms before start of the post-naming window is standard in the infant literature, since eye movements before 360 ms are not likely to be made in response to the auditory perception of the target word (e.g., Swingley, 2009). For each trial, we estimated the size of the naming effect by calculating the increase in target looking after naming, $PTL_{postnaming} - PTL_{prenaming}$. Only those trials were included in the analysis in which children looked at the screen at least once in the pre- and in the post-naming phase. One child was excluded because he did not provide data for correctly and mispronounced trials of both words. The final dataset contained data from 8 children for the inconsistent condition and 8 children for the consistent condition.

3. Results

Children had different degrees of familiarity with the label and object depending on condition, i.e., familiarity varies non-uniformly across children given consistent and inconsistent pre-exposure (consistent condition: label and object familiar for one pair and unfamiliar for the other pair; inconsistent condition: label familiar for one pair, object familiar for the other pair). Therefore, separate ANOVAs investigated the impact of familiarity on children's sensitivity to mispronunciations in children given consistent and inconsistent pre-exposure.

For the consistent condition, a repeated measures ANOVA with familiarity (familiar pair, unfamiliar pair) and pronunciation type (correct, mispronunciation) as a within-subjects factor, revealed a significant interaction between pronunciation*familiarity ($F1,7)=10.107$, $p=.016$) and a trend for a main effect of pronunciation ($F(1,7)=4.413$, $p=.074$) For the inconsistent condition, no main effects or interactions approached significance ($p>.2$). This suggests that children's looking behaviour in the consistent condition was modulated by pronunciation, i.e., whether the target was correctly pronounced or mispronounced, and by familiarity, i.e., whether label and object were presented in the pre-exposure phase or not. In the inconsistent condition, however, neither pronunciation nor familiarity seems to have influenced children's looking behaviour.

To investigate if children had learned the label-object pairings successfully, we compared children's increase in target looking after naming to chance, i.e., 0. If infants recognized the association between the label and the target object, target looking should increase after naming. Results show that children in the consistent showed a trend for a naming effect for the familiar pair, i.e., the pair whose label and object had been presented in the story, when the label was correctly pronounced ($t(7)=2.227$, $p=.061$), but not when the label was mispronounced ($t(7)= -0.666$, $p=.527$). A paired t-test confirmed that target

looking was significantly higher in correctly pronounced than in mispronounced trials (t(7)=3.975, p=.005). Children did not show a naming effect for the unfamiliar pair though, i.e., the pair for which neither the object nor the label had been presented in the story (correct pronunciation: t(7)= -0.847, p=.425; mispronunciation: t(7)=.0.863, p=.417) and their target looking did not differ between correctly and mispronounced trials (t(7)= -1.508, p=.175). This suggests that children only successfully learned the label-object association for the familiar pair.

Children in the inconsistent condition showed no evidence of target recognition at all. They neither showed a naming effect for the label familiar pair, i.e., the pair for which the label had been presented in the story (correct pronunciation: t(7)= -1.455, p=.189; mispronunciation: t(7)= -0.596, p=.570), nor for the object familiar pair, i.e., the pair for which the object had been presented in the story (correct pronunciation: t(7)=0.490, p=.639; mispronunciation: t(11)=0.274, p=.792). Target looking did not significantly differ between correctly and mispronounced trials neither for the label familiar pair (t(7)= -0.703, p=.505) nor the object familiar pair (t(7)=0.043, p=.967). Figure 1 illustrates the naming effect by displaying the increase in proportion of target looking from pre- to post-naming for trials in which the target was correctly pronounced (CP) and for trials in which the target was mispronounced (MP). Data for the different word pairs are displayed separately with data from the consistent condition on the left and data from the inconsistent condition on the right.

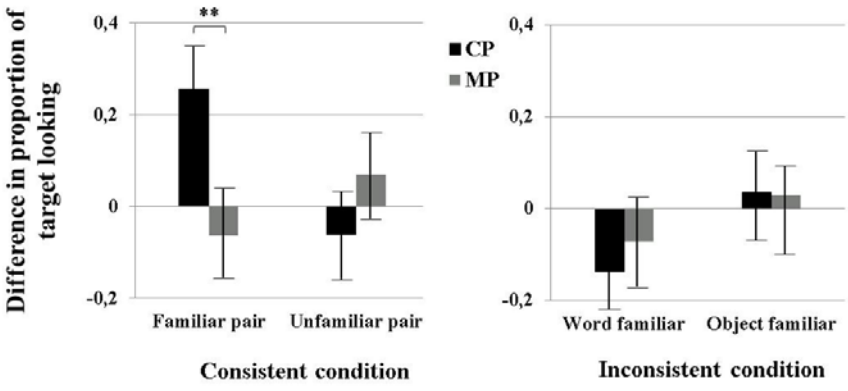

Figure 1: Increase in target looking from pre-to post-naming for the different word pairs in correctly pronounced trials (CP) and mispronounced trials (MP) for the consistent and the inconsistent condition. Error bars represent +/- 1 SE.

4. Discussion

Our results suggest that children in the consistent condition learned the object-label pairing successfully, if they were familiar with both the label and the object. Furthermore, they encoded the novel word with sufficient detail to detect mispronunciations. However, children did not show a naming effect for the unfamiliar pair. This suggests that pre-exposure to object and label helped children to learn the label-object association in the consistent condition. The finding follows our prediction that children should perform better for the familiar than for the unfamiliar pair if familiarity supports learning, and is in line with previous studies showing facilitative effects of pre-exposure to label or object (e.g., Fennell, 2012; Graf-Estes et al., 2007). However, familiarity *per se* does not facilitate learning in our study. In the inconsistent condition the children failed to learn the label-object pairings, although they had been pre-exposed to one of the objects and one of the labels in the story. This follows our prediction that children should perform better in the consistent than in the inconsistent condition if consistency of exposure plays a role.

Remember that the object and the label were never explicitly associated in the story, but that they merely co-occurred. Yet, it might be that children fast-mapped the novel label onto the novel object during the story, given that both were novel while the other content nouns and objects were probably more familiar to the child. Such a mapping might rely on mutual exclusivity (e.g., Markman & Wachtel, 1988) or on children's ability to track statistical co-occurrences between object and label (e.g., Smith & Yu, 2008). Whatever the precise mechanism, it might lead the child to form an initial object-label association throughout the course of the story. If so, the child faces two completely different tasks in the consistent and in the inconsistent condition: In the consistent condition, the previously formed association is strengthened allowing the child to recognize the word later on and to encode the phonological form with sufficient detail to even detect mispronunciation. In the inconsistent condition, the previously formed association has to be eradicated in order to be able to build a new association. Although the initial association might still be fragile (see Kucker & Samuelson, 2012), this is arguably a much harder task.

Note, however, that the children did not perform better for the unfamiliar pair in the consistent condition than for either of the pairs in the inconsistent condition. Put differently, even if the exposure in the story did not conflict with the pairing in the learning phase (as neither the object nor the label of the unfamiliar pair had been presented in the story), children did not show evidence for successful learning of this pair. This might suggest that inconsistency is not more disadvantageous than being not familiar with object or label at all. It can also be taken as evidence that task demands were too high and that only previous (consistent) familiarization with object and label allowed the child to learn a label-object association. Most previous word learning studies with infants younger than 18 months of age used the switch paradigm (Stager & Werker, 1997, and subsequent studies). This paradigm habituates the child with

the label-object associations. In our task, we only presented the pairing four times each. It might, thus, be that the learning phase was not sufficient to learn two new words, and that children only succeeded for the familiar pairs because object and label in this pair were already familiar (but see Ballem and Plunkett (2005) for a study in which 14-month-olds succeeded to learn two novel words using a similar learning procedure).

Our results also suggest that children did not perform differently for the label familiar and the object familiar pair in the inconsistent condition. Kucker and Samuelson (2012) found that previous familiarization with labels and objects have different effects on word learning with more beneficial effects for object familiarity than for label familiarity. However, this beneficial effect was only evident in retention, but not immediately after learning. Since, we did not test infants' retention after a delay, we cannot draw any conclusions on long term effects. Yet, given that the children did not even show evidence for word recognition immediately after learning, it is questionable if they would do so for either pair after a consolidation period.

Taken together, our study provides evidence that previous familiarity *per se* has only limited effects on word learning, but that the consistency of this information with later learning plays a crucial role. This suggests that infants readily use information during familiarization to form label-object associations. The current study therewith provides a starting point for further research on the mechanisms and factors that influence word learning under natural learning circumstances.

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