The impact of verbal cues on 14- and 24-month-olds' visual action anticipation

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Abstract

When infants and caregivers interact with each other, a lot of information in the language and the action domain is shared between them. Past research shows that from the first year of life, infants' abilities to process language and action information develop significantly. However, a lot of the research focussed on the language and the action domain in isolation, without investigating in which ways these two domains might inform each other. A growing body of research suggests that verbal information can hinder or facilitate childrens' goal anticipation, but the mechanisms involved are not yet completely understood. The current study investigated the impact of different verbal information in the form of nouns, verbs, or unspecific information, on 14- and 24- month-olds' goal anticipation during observation of a human grasping action. There was no differential effect of language cues on goal anticipation, and also no hindering or facilitating effect could be found in either age group. The results are discussed with respect to current literature and address the need of further fine-grained analyses of the impact of language cues on early action processing.

The impact of language cues on 14- and 24-month olds' visual action anticipation

1. Introduction

When caregivers and their children interact with each other, a lot of information from different domains is shared and exchanged. For example, new actions are demonstrated, so that the child can learn how to use and interact with different objects. Caregivers also talk to their children and expose them to new labels for objects or actions to give them a better understanding of the world and help them learn the words they need when they grow up. Therefore, the best way for children to strategically learn about the world they live in is to make optimal use of the information given to them by experienced adults in the different domains of action and word learning.

Past research on action processing has shown that, starting around 6 months of age, infants are able to visually anticipate the goal-position of a human grasp [1], and with 12 months, the goal of manual containment actions [2]. Around their first birthday, infants already integrate multifaceted contextual information such as statistical regularities [3], goal salience [4,5], or behavioral cues [6–9] into their reasoning about action goals.

Then, at the beginning of the second year of life, children's ability to form associations between actions, objects, and action effects develops drastically [10,11]. For example, Elsner and Aschersleben [10] found that 9-month-olds did not learn action-effect relations from observing an adult who performed two actions on the same object, with each action producing a specific effect (e.g., pressing--sound, pulling--light). In contrast, 12-month-olds learned that effects could be produced by action performance, and 15-month-olds transferred the specific associations between each action and the respective effect to their own actions. Taken together, these results suggest that from very early on, infants start to decode the goal-directed nature of actions in increasingly complex and quickly developing ways.

In the interaction with their caregivers, infants are often presented with verbal and action information in temporal synchrony [12]. For example, parents may say the word "rabbit" while they present a toy rabbit hopping around, or may demonstrate how to act on an object and verbally comment on the steps that need to be done. Children's vocabulary develops quickly with the beginning of lexical comprehension at around nine months [13], and the first spoken words around the first birthday [14], culminating in an expressive vocabulary of about 300 words already at 24 months of age [15]. Furthermore, studies suggest that 2-year-old children show more robust learning of nouns compared to verbs, a bias that seems to be especially pronounced in English, Italian, and Spanish [16].

However, early action perception and word learning have been investigated mainly in isolation, without examining whether and how the two domains may interact with each other. A growing body of evidence suggests that linguistic and non-linguistic information might inform each other in meaningful ways. For example, in experimental play-situations with their 6- and 8-month-old infants, mothers tend to use certain movements such as forward/downward and shaking movements more frequently in temporal synchrony with spoken words than upward or- backward motions, and the use of shaking motions also seems to help the infants to learn the word-object associations [17]. Interestingly, various types of object motion seem to have differential effects on object-word mapping in 8-month-old infants. When infants were presented with toy animals and an according label for the animal, shaking and looming actions, but not upward and sideways actions, facilitated infants' learning of the association between word and object [18]. This suggests an influence of the non-linguistic movements on the linguistic word processing, with a specific importance of object motions that mothers tend to use naturally in play situations [17]. Werker, Cohen, Lloyd, Casasola, and Stager [19] even

found that 14-month-olds were only able to learn word-object associations when the objects were moving.

Several studies have also investigated the influence of linguistic input on infants' and toddlers' action processing. For example, accompanying an action by socio-emotional cues such as smiling, vocalization, and eye contact supports 14-month-olds' imitation of that action [20]. Furthermore, 14- and 18-month-olds are twice as likely to imitate an action sequence when the demonstrator comments the action with a "there!" (indicating intentional performance), as compared to when she comments it with an "oops!" (accidental performance) [21]. There is rich evidence that children's performance in imitation tasks is usually enhanced by the addition of verbal information [22–24], showing the impressive influence of verbal information on action processing already from 12 months on. However, 15-month-olds' imitative performance was hindered when infants had to transfer information from a 3D to a 2D source and were provided with additional verbal information in the form of an object label and a verb [25]. Therefore, verbal information on the one hand is able to highlight important aspects of actions and objects to a child [26], but on the other hand, this information can also pose high cognitive demands [25] and therefore interfere with children's learning, in particular when the children's cognitive capacities are still limited, or when the tasks are inherently difficult, such as when they include several objects, actions, and/or labels.

Further evidence on hindering and facilitating effects of language on early action-processing comes from recent eye-tracking studies that investigated the impact of verbal information on infants' production of goal-directed gaze shifts during the observation of human actions. Here, the infants' age seems to be important. For example, 14-month-olds' action-goal anticipation during a simple human grasping action was hindered by the addition of the words "I am taking the ball" compared to conditions without sound or

with a sine-wave sound [27]. In line with this, Gampe and Daum [28] found that the addition of action verbs interfered with 12-month-olds', but facilitated 24-month-olds' anticipatory gaze-behavior during observation of a goal-directed reach. This effect, however, was only present for verbs that were already part of the 24-month-olds' productive vocabulary. Hence, linguistic and non-linguistic representations seem to start informing each other already at the end of the first year of life. Contrary to these findings, Paulus, Schuwerk, Sodian, and Ganglmayer [29] did not find a facilitative impact of verbal information on anticipatory eye movements in children younger than 3.5 years of age.

A potential explanation for this mixed evidence comes from differences in the applied methods and procedures: First, the timing of the verbal-cue presentation as well as the cues itself varied notably between studies. For example, Sciutti et al. [27] presented the verbal cue during the action demonstration with an elongated pronunciation of the word "take" to match the hand's grasping movement. In contrast, Gampe and Daum [28] and Paulus et al. [29] presented the verbal cue before the start of the movement, and without any elongation of the words. Due to the high cognitive demands of processing verbal information [25], this probably creates an important difference, because in Sciutti et al.'s study, infants had to process the verbal and action information at the same time, whereas in the other two studies, infants could process the information from different domains in succession. Furthermore, Sciutti et al. as well as Paulus et al. used nouns and verbs as cues, whereas Gampe and Daum used verbs. And last, each study operationalized the dependent measure 'action anticipation' in a different way, making a direct comparison between studies very difficult.

The aim of the present study was to investigate the effect of different kinds of verbal information on action processing in 14- and 24-month-olds in more detail, by using goal

anticipation and looking-times as dependent measures in a single paradigm. Looking-times are frequently used in studies investigating early action processing [30] and can provide additional insight when used in combination with anticipation measures [31].

Infants watched repeated videos displaying how a human hand approached and grasped one of two objects, and then performed a specific action with each object (e.g., shaking the teddy, pushing the car back-and-forth; Fig 1). We measured infants' goal-directed gaze behavior during the hand's approach of the object, and measured their looking-times during the presentation of the verbal cue and during a still frame after the performance of the action on the object. In the first 8 trials (familiarization period), each object was combined with a specific action, and the last 8 trials (test period) presented the two familiar action-object associations intermixed with violations (i.e., performing the other action on an object). In three familiarization conditions, infants heard verbal cues that signified specific aspects of the subsequent goal-directed action in the form of nouns for the goal objects (*teddy*, *car*), verbs for the actions (*shaking*, *pushing*), or unspecific information (*look!*), before the hand started to move. With this procedure, a fine-grained analysis of the impact of verbal cues on action processing was possible without the confounds of timing, type of verbal cue, or differing definitions of goal anticipation.

Furthermore, this design allowed us to test whether infants notice the specific semantic reference of the noun cues, which signify the to-be-grasped object, and/or the verb cues, which signify the to-be-performed action. We tested 14- and 24-month-olds because the younger children were at an age where verbal cues should hinder their goal anticipation, whereas the older children should benefit from the addition of verbal cues [27,28], in particular of target-signifying nouns, compared to a condition without specific information. Furthermore, older children should be especially sensitive to violations of expectation (as indicated in higher looking times) regarding the to-be-grasped goal

object when they get information about nouns, but to violations regarding the to-be-performed action when they get verb information. These effects should not occur in the younger age group. Finally, during labeling, we expected the infants to look at the correct object above chance when a noun is announced, but should look at both objects equally long when the verb is announced or no specific information is given. However, if the domains of action and language do not start informing each other before the age of 3.5 years [29], we should not find any condition differences in the goal-directed gaze behavior or in the looking-times to the labeled object or to violations of expectation in either age group.

2. Method

2.1. Participants

We tested forty-two 14-month-olds ($n = 14$ per condition; M age = 14.0, $SD = 0.28$; 20 girls) and forty-two 24-month-olds ($n = 14$ per condition; M age = 23.9, $SD = 0.32$; 19 girls). Data of additional 14-month-olds (noun condition: $n = 1$, verb condition $n = 1$) and 24-four-month-olds (verb condition: $n = 2$, unspecific condition: $n = 1$) had to be excluded due to a lack of valid trials (criteria see below). The toddlers' parents were invited by phone and received 7,50 € and a certificate with a photo of their child as reimbursement for their participation.

2.2. Stimuli and Apparatus

The experiment consisted of a familiarization period and a test period with 8 videos each. In the familiarization videos, two white cubes were presented in the top left and top right corner of the screen (see Fig 1), filmed from above on a black background. A brown teddy bear was depicted on one of the cubes, and a blue car on the other cube. The left/right position of the objects was randomized across participants. Each video started

with a labeling phase (duration: 5500 ms), in which a still frame of the two objects was displayed and a verbal cue was presented (see below). Then, a human hand entered the scene from the middle of the lower part of the screen, approached screen center in a linear upward motion (duration: approx. 1100 ms), changed its trajectory, approached one of the two objects, and grasped it (duration: approx. 1600 ms). The hand then either shook the object or pushed it back and forth, and put it back in its original position (duration: approx. 2500 ms, both actions were accompanied by the sound of a toy bell). After the action, a still frame depicting the hand grasping the object was inserted (duration: 2000 ms in familiarization videos), resulting in a total video runtime of about 12700 ms. The specific actions performed on the objects were counterbalanced across participants, that is, half of the participants saw *teddy--shaking* and *car--pushing* in 4 familiarization trials each, and the other half of participants was familiarized to *teddy--pushing* and *car--shaking*. The presentation order of the 8 trials was randomized across participants.

For the familiarization part, each infant was assigned to one out of three experimental conditions that differed with regard to the verbal cues inserted during the initial still frame (i.e., during the first 5500 ms of each video). In the noun condition, a female voice announced "Schau mal, Teddy!" ("look, teddy!", duration approx. 2600 ms) or "Schau mal, Auto!" ("look, car!"), respectively, always correctly announcing the goal object that was subsequently grasped by the hand in this video. In the verb condition, the female voice announced either "Schau mal, wackeln!" ("look, shaking!") or "Schau mal, schieben!" ("look, pushing!"), respectively, always correctly announcing the action that was subsequently performed on the goal object in this video. In the unspecific condition, the voice announced "Schau mal, was zeigen!" ("look, showing something!") in all 8 videos. The verbal cues started at a video runtime of approximately 170 ms and lasted

until 2770 ms (nouns, verbs) or until 3470 ms (unspecific), resulting in a pause of about 2730 ms or 2030 ms, respectively, before the hand entered the scene at 5500 ms.

Figure 1. Still frames of the stimulus videos. The position of the goal objects as well as the specific actions performed on each object were counterbalanced across participants. The labels given during the first 5500 ms were determined by the conditions; this example presents the noun condition. The lower right picture shows an example of the AOIs used, the markings were not visible during testing.

The 8 videos of the test period were similar to the familiarization videos, with three important changes. First, to allow the measurement of looking times, the duration of the

final still frame was 6000 ms, resulting in a total video runtime of about 16700 ms.

Second, regardless of the infant's familiarization condition, 4 of the 8 test videos were noun videos, and the other 4 videos were verb videos. Third, each infant watched 4 no-violation trials (2 with noun cues, 2 with verb cues), 2 violation-of-target trials (with verb cues), and 2 violation-of-action trials (with noun cues), all of which were presented in a randomized order (see Table 1). In the no-violation trials, infants saw the hand's goal approach and the same two action-object associations as during familiarization, one video each with the correct noun cue *teddy* and *car*, and one video each with the correct verb cue *pushing* and *shaking*, respectively. In the 2 violation-of-target trials, the voice announced a verb (*pushing* in one trial and *shaking* in the other trial), and the hand then moved to and performed this action on the other object than during familiarization, resulting in a violation of the expectation regarding the to-be-approached object (see Table 1). Accordingly, in the 2 violation-of-action trials, the voice announced a noun (*teddy* in one trial and *car* in the other trial), and the hand then moved to this object, but performed the other action than during familiarization, resulting in a violation of the expectation regarding the to-be-performed action (see Table 1). It is important to note that in all test trials, the voice always correctly announced what was about to happen, and that the violations occurred only with regard to the respective non-verbalized part of the familiarized action-object association.

Table 1. Example for the operationalization of the types of test trials for an infant who had been familiarized to 'teddy--shaking' and 'car--pushing'. Regardless of the familiarization condition, each infant watched all of the 8 videos in randomized order, and only the information given during familiarization established which video was considered as no violation, violation of target, or violation of action.

Infant familiarized to " teddy-shaking " and " car-pushing "		
Test period:		
Verbal Cue	Action presented	Violation of Expectation
"Look, teddy!"	Hand shakes teddy	No violation
"Look, pushing!"	Hand pushes teddy	Violation of target
"Look, shaking!"	Hand shakes car	Violation of target
"Look, car!"	Hand pushes car	No violation
"Look, teddy!"	Hand pushes teddy	Violation of action
"Look, shaking!"	Hand shakes teddy	No violation
"Look, car!"	Hand shakes car	Violation of action
"Look, pushing!"	Hand pushes car	No violation

We recorded participants' gaze behavior with an SMI RED 250 eyetracker mounted to a 22-inch monitor, with a sampling rate of 250 Hz. At the beginning of the experiment, a 5-point calibration with fast calibration speed and manual point acceptance was used, followed by a validation procedure.

2.3. Procedure

When the parents arrived at the babylab with their child, they were guided to a room where they could sit down and play for a moment to get familiar with the premises. The experimenter then sat down with the child and started a 5-min play session during which the two wooden objects were presented and each of the labels, *teddy* and *car*, was used 6 times. The experimenter also presented random toys from the play room and performed shaking and pushing motions with them while using the according labels, *shaking* and *pushing*, 6 times. Therefore, all of the children heard all of the relevant words at least 6 times prior to testing. The experimenter never performed any of the actions on the teddy

or the car to ensure that no associations between the actions and the objects could be formed before the familiarization began. The parents were then guided to the eye-tracking room and seated on a chair with the infant on their lap in front of the stimulus monitor at a distance of approximately 60 cm. They were instructed to not interact with their child during the experiment unless the child needed soothing. The experiment started with the calibration procedure, followed by a validation. Then, the video presentation began and the 16 trials were presented. Attention getters were inserted between every trial to redirect the children's attention to the center of the screen at the beginning of every trial. The participants and their parents spent approximately 30 minutes in the babylab, with an experiment runtime of about 8 minutes.

2.4. Data Handling

In the familiarization videos, we created a moving AOI for the hand and two static AOIs for the goal objects (see Fig 1). Then, to extract gaze-arrival times, we subtracted the time when the participants shifted their gaze from the hand to the goal object from the time when the hand entered the goal AOI. Therefore, positive gaze-arrival times indicate that the participants shifted their gaze to the goal before the hand arrived there, a value of zero indicates gaze arrival at the same time as the hand, and negative values indicate gaze arrival at the goal after the hand arrived there. When the mean gaze-arrival time across the 8 trials was significantly above, not different from, or below the value of 0 ms, the gaze behavior was regarded as predictive, tracking, or reactive, respectively. A trial was considered valid when the participants first fixated the hand for at least 200 ms and subsequently shifted their gaze to the goal object. All gaze-arrival times of -1000 ms or less were considered invalid, and a participant had to have at least 3 valid trials to be included in the final sample. The mean number of valid familiarization trials per

participant was $M = 6.2$, $SD = 1.6$, with no significant differences between conditions or age groups, all $ps > .34$.

We also extracted proportional looking-times to the two goal objects during the labeling phase at the beginning of each familiarization video. First, the relevant time frame was defined as the duration of the verbal cue plus an additional 2 seconds, to ensure that the participants had enough time to process the verbal cue. The resulting time frame was 1985-4740 ms for "Schau mal, Teddy!" (*teddy*), 1985-4844 ms for "Schau mal, Auto" (*car*), 1900-4856 ms for "Schau mal, wackeln!" (*shaking*), and 1920-4856 ms for "Schau mal, schieben!" (*pushing*). During these time frames, dwell-times on the goal AOIs were evaluated and summed up across trials for each individual goal object. Then, we calculated proportional looking-times by dividing the time the participants looked to the labeled object (noun condition), or to the object that was associated with the labeled action (verb condition), or to one of the two objects (unspecific condition) by the time they looked at both objects.

For each test video, we created a full-screen static AOI and captured dwell-times to the screen during the last 6000 ms, that is, when the final still frame was presented. We then calculated accumulated dwell-times for the 4 no-violation trials, the 2 violation-of-target trials, and the 2 violation-of-action trials. To be included in the analysis of the respective looking-time score, the participant had to have at least one fixation longer than 200 ms in one of the test trials that belonged to the respective variation.

In our analyses, we first conducted ANOVAs to compare the mean gaze-arrival times in the familiarization videos between conditions and age groups, to analyze the impact of the verbal cues on infants' goal-directed gaze behavior. We used one-sample t -tests on mean gaze-arrival times against the threshold of 0 ms to determine if the gaze behavior was predictive, tracking, or reactive. To examine if the infants were able to map the

labels to the correct goal object, we analyzed the proportional looking-time scores during the labeling phase of the familiarization videos for the noun and the verb condition in each age group, using individual one-sample *t*-tests against the chance level of 50%. For the unspecific condition, where no specific labels were presented, we conducted the same analyses for the looking-times to each of the two objects to ensure that the toddlers did not have a visual preference for one of the objects. Finally, to study how the infants learned the familiarized action-object-associations in the different conditions, we compared looking-times to the final still frame of the different types of test videos between the familiarization conditions and age groups using repeated measures ANOVAs.

3. Results

3.1. Familiarization Period

The ANOVA on mean gaze-arrival time with condition and age group as between-subject factors yielded a significant main effect of age group, $F(1,78) = 29.86$, $p < .001$, $\eta^2 = .28$. Across conditions, the 24-month-olds shifted their gaze to the goal faster than the 14-month-olds (see Fig 2). There was no significant main effect of condition and no significant interaction, all $ps > .25$. The *t*-tests on mean gaze-arrival times against the threshold of 0 ms revealed that in all conditions and age groups, the mean gaze-arrival times were above zero and therefore considered predictive, all $ps < .01$: The infants' gaze arrived at the goal AOI before the hand arrived there.

Figure 2. Mean gaze-arrival times in the 8 familiarization trials for the 14- and 24-month-olds. Positive values indicate predictive gaze shifts, error bars represent standard errors.

For the labeling phase of the familiarization videos in the noun and verb conditions, the t -tests on the proportional looking-time scores against the 50% chance level revealed that only the 24-month-olds in the noun condition looked at the labeled object above chance, $t(13) = 2.3, p < .05, r = .54$. In all other groups, participants looked at the two objects equally long, all $ps > .48$ (see Fig 3). In the unspecific condition, both age groups looked at the two objects for the same amount of time (14-month-olds: car $M = 47\%$, $SE = 4.6$, teddy $M = 53\%$, $SE = 4.6$; 24-month-olds: car $M = 49\%$, $SE = 4.2$, teddy $M = 51\%$, $SE = 4.2$), all $ps > .58$, suggesting no visual preference for one of the objects.

Figure 3. Proportional looking-time to the labeled object (noun condition) or to the object with which the action had been combined (verb condition) during the initial labeling phase of the familiarization videos for the 14- and 24-month-olds. Error bars represent standard errors.

3.2. Test Period

For the analyses of the test period, $n=3$ additional 14-month-olds in the noun condition and $n=1$ additional 14-month-old from the verb condition had to be excluded because of a lack of valid data points.

The repeated-measures ANOVA with looking-time as dependent measure and the within-subject factor test-trial type (no violation, violation of target, violation of action) and the between-subject factors age group and condition yielded no significant main effect of test-trial type and no significant interaction, all $ps > .12$, see Fig 4. The main effects of age group, $F(1,74) = 3.04$, $p = .085$, $\eta^2 = .04$, and of condition, $F(2,74) = 2.56$, $p = .084$, $\eta^2 = .07$, approached significance. The 24-month-olds tended to look slightly longer at the still frame than the 14-month-olds, but the effect of condition was not

corroborated by a multiple comparisons post-hoc *t*-test that revealed no differences between the conditions, all *ps* > .14.

Figure 4. Looking-times to the full-screen AOI during the final still frame (6000 ms) of the test videos for no-violation trials (NoV), violation-of-target trials (VoT), and violation-of-action trials (VoA) in the noun-, verb-, and unspecific familiarization condition for the 14- and 24-month-olds. Error bars represent standard errors.

4. Discussion

The aim of the present study was to examine potential differential effects of different verbal cues on 14- and 24-month-olds' processing of a manual grasping action and on infants' learning of presented specific actions that were performed on each of two visible goal objects. Depending on the condition, we presented toddlers with an verbal cue in the form of a noun, an action verb, or unspecific information, followed by the presentation of a hand that approached and grasped one of two goal objects and then performed a specific action on the object, as had been announced by the verbal cue. Based on Sciutti et al. [27] and Gampe and Daum [28], we hypothesized that the 14-month-olds should be hindered in their goal anticipation when verbal information is presented, whereas the 24-month-olds should show faster goal anticipation. During labeling, we expected the infants in the noun condition to look at the correct goal object above chance, and infants in the verb- and unspecific condition to look at both objects at chance level. Furthermore, 24-month-olds in the noun condition should be sensitive to the goal of the action and therefore be surprised when expectations about the goal object are violated, whereas toddlers in the verb condition should be surprised when expectations about the action are violated. If the domains of action and language start informing each other no earlier than at the age of 3.5 years [29], then no differences between conditions should be found.

We first analyzed gaze-arrival times in the first 8 trials of the experiment and found that the 24-month-olds shifted their gaze to the goal object significantly faster than the 14-month-olds. This result is in line with other studies that show how children's goal anticipations tend to get faster with increasing age [1]. We also found predictive gaze shifts for every condition in both age groups, so all children were able to successfully predict the hand's goal. Interestingly, there was no differential effect of the verbal cues, that is, in all conditions the children anticipated the goal equally fast. This result is

interesting in two ways. First, the 24-month-olds did not benefit from additional verbal information, which probably indicates that they were able to infer the hand's goal by using kinematic information, as can be seen in the unspecific condition where no information about the goal was given. Second, the 14-month-old children were not hindered in their goal anticipation, because in all conditions, their gaze systematically arrived at the goal object before the hand got there. Gampe and Daum [28] also found goal anticipations for all action types in all age groups, but were able to use a baseline difference as dependent measure, which then revealed a facilitative effect (for 24-month-olds) or a hindering effect (for 12-month-olds) of action verbs on goal anticipation in comparison to a within-subject baseline without verbal cues. In the present study, a between-subjects design was used, and no baseline difference could be calculated, which might explain the missing effect of verbal information. Furthermore, the hand's trajectory in our stimuli was longer than in the study by Gampe and Daum [28], giving the children more time to process the action and therefore possibly rendering the availability of verbal information irrelevant.

Compared to Sciutti et al. [27], the verbal cues in our study were given prior to the appearance of the hand, not during the action. It seems possible that parallel processing of verbal information and action information was difficult for the 14-month-olds in Sciutti et al., therefore interfering with their goal anticipations due to the high cognitive demands of the task [25]. Paulus et al. [29] did not find a facilitative effect of verbal cues on action anticipation before the age of 3.5 years. At first glance, this result appears at odds with the other eye-tracking studies mentioned above. For one, this could mean that indeed, the domains of language and action do not inform each other before children turn 3.5 years old. On the other hand, this result could also reflect a higher difficulty of anticipating the reappearance of an occluded actor (as used in Paulus et al. [29]), compared to the

extrapolation of an ongoing reaching action. For example, Daum et al. [31] compared childrens' looking times and predictive gaze shifts measured by the expectation of a reappearing, occluded actor. Interestingly, 9-month-olds were able to encode the actor's goal when measured with looking-times, but were not able to do so when measured with predictive gaze shifts. It was not until 3 years of age, that children were able to encode the actor's goal as measured by both looking times and predictive gaze shifts, i.e., at roughly the same age as the children tested in Paulus et al. [29]. Whether this is due to the fact that these measures assess different concepts of infants' goal processing, or if they differ inherently in demands, is as of yet unclear. Therefore, the different measures used across different studies constitute considerable interpretational problems in the domain of action or goal anticipation, making it all the more important to further investigate the impact of these differences in finer detail.

The missing differential effect of verbal cues in the present study does not rule out the possibility of a general influence of language on action anticipation. The socio-emotional cues used in Fukuyama and Yamakoshi [20], for example, were communicative cues devoid of language information, but still significantly impacted children's action imitation. Communicative cues like these possibly complement the pedagogical nature of a situation [26,32], leading to better learning of the information conveyed. In our experiment, the verbal cues in all conditions started with a "Schau mal!" ("Look!"). This cue hinted at the fact that something important was about to happen, which in turn might have led to increased attention regardless of the specific verbal information that followed afterwards. A condition without any verbal information, such as the sine-wave condition in Sciutti et al. [27], would help to see if the results of the present study were due to a general effect of language on children's visual processing of an unfolding action.

During the initial labeling phase of the familiarization videos, the 14-month-olds did not look at the labeled object, or at the object with which the labeled action had been associated, in any of the conditions above chance, suggesting that they did not learn the associations between the words and the objects. This seems surprising when even 6-month-olds are able to map the words "mommy" and "daddy" to the correct person [33]. Then again, the labels for "mommy" and "daddy" might be much more common for the toddlers, and in the present study, the children also had to transfer the words to a painted depiction of a teddy and a car on a wooden cube, which might have rendered the task more difficult. The 24-month-olds, however, looked at the labeled object above chance in the noun-condition, but not in the verb-condition. This suggests that the mapping of a noun to an object was easier for the 24-month-olds than mapping of a verb to a certain action that had been performed on an object. It might also be that the actions presented in the present study were not specific enough to the objects to be processed correctly, because both actions in theory could have been done with either object, and both actions even produced the same sound, probably making it difficult for the children to distinguish them completely. Furthermore, the training for the words in our study was relatively short with only 6 repetitions of every word during the initial play-session. For example, Roseberry, Hirsh-Pasek, and Golinkoff [34] presented 24- to 30-month-olds with unfamiliar verbs, using each verb 12 times during a training phase. Therefore, the task in the present study might have been too difficult for the toddlers to learn the verb-object associations in the given time frame.

The results from the test part revealed no effects of violation of expectation on the 14- and 24-month-olds' looking times to the final still frame of the test videos, suggesting that in neither age group or condition, the children learned the specific action-object associations. It is possible that the two objects and the two actions were too similar to

each other, so that the children found it difficult to differentiate between them and form specific action-object relations. For example, object similarity plays a role for action processing in 6-month-olds [35] and might therefore also be important for older infants in more difficult tasks like in the present study. Furthermore, Gerson, Bekkering, and Hunnius [36] used EEG measures and found that 10-month-olds' action processing was only altered by active motor training and not by passive observational training. In the present study, only observational training was used both prior and during testing, which might have reduced the amount of information the children were able to process during the experiment.

Taken together, we could not find any evidence for a differential effect of verbal cues on goal anticipation and looking-times in 14- and 24-month-olds. Furthermore, we were not able to find further evidence for the hindering [27] or facilitating [28] effect of verbal cues on action processing. This experiment was a first step to ensure that verbal cues as well as dependent measures are used in a way that makes the interpretation of results easier. Hence, further fine-grained analyses with comparable use of verbal cues and comparable measures of action anticipation are needed to get a better understanding of the complex mechanisms involved in the potential interactions of the domains of language and action.

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