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The Acquisition of Abstract Words by Young Infants

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Abstract

Young infants' learning of words for abstract concepts like 'all gone' and 'eat,' in contrast to their learning of more concrete words like 'apple' and 'shoe,' may follow a relatively protracted developmental course. We examined whether infants know such abstract words. Parents named one of two events shown in side-by-side videos while their 6-16-month-old infants (n=98) watched. On average, infants successfully looked at the named video by 10 months, but not earlier, and infants' looking at the named referent increased robustly at around 14 months. 6-month-olds already understand concrete words in this task (Bergelson & Swingley, 2012). A video-corpus analysis of unscripted mother-infant interaction showed that mothers used the tested abstract words less often in the presence of their referent events than they used concrete words in the presence of their referent objects. We suggest that referential uncertainty in abstract words' teaching conditions may explain the later acquisition of abstract than concrete words, and we discuss the possible role of changes in social-cognitive abilities over the 6—14 month period.

Keywords

language acquisition; word learning; cognitive development; infancy; psycholinguistics

1. Introduction

To learn their native language, children must learn words. And to learn words, children must identify words in speech, and grasp what others mean when they talk. The predominant hypothesis about the course of language learning has long been that development proceeds first with speech signal analysis, and only later with discovery of word meaning. This perspective is motivated by demonstrations of precocious phonetic learning between 6 and 10 months (e.g., Jusczyk & Hohne, 1997; Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992; Polka & Werker, 1994), subsequent advances in social cognition (e.g., Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998), and finally the onset of referential communication at about 11 months, when infants first produce meaningful speech and gesture (e.g., Bates, Camaioni, & Volterra, 1975; Camaioni, Perucchini, Bellagamba, & Colonnesi, 2004). According to this view, the typical 10-month-old knows the auditory forms of dozens of words, but has yet to invest them with meaning (e.g., Jusczyk, 1997; Swingley, 2005), perhaps pending a better understanding of humans as intentional agents.

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The notion that development in social cognition is a prerequisite for learning words follows from the premise that the typical conditions under which infants encounter words are insufficient for infants' making the connection between the words and their denotations using perceptual association mechanisms alone (Gleitman & Gleitman, 1992). If a parent says "I'll go get a *spoon*" in the absence of a spoon, this "teaching trial" is misleading for the simple associative learner who perceives "spoon" and some spoonless applesauce, but is potentially helpful to the intention-reading child who tracks the parent's goals until he returns with the spoon. Not all researchers agree about this premise, however, maintaining that whatever social cognitive skills infants may or may not have, words and their referents co-occur with sufficient reliability to be learnable by infants using domain-general cognitive capacities for perceptual association. Thus, there is debate about whether intention-reading skills are necessary for young children's learning of all words (Tomasello, 2001; Waxman & Gelman, 2009), perhaps just "hard", more abstract words (Gleitman, Cassidy, Nappa, Papafragou, & Trueswell, 2005), or no early words at all (Colunga & Smith, 2005).

One empirical approach to characterizing the mechanisms of early word learning is to test lexical knowledge in children who have only very rudimentary social cognitive skills. Indeed, young infants' early intention-reading and joint attention skills are limited. For example, at 6–7 months, infants can follow a person's gaze to an object, but do not appear to understand that gaze implies object-directed interests or goals (Woodward, 2003). Such infants do not yet engage in true "triadic" interactions where they knowingly share attention to an object with another person (Carpenter & Liebal, 2011); the ability to appreciate gaze as both social and goal-directed does not appear until around 9-10 months (Beier & Spelke, 2012). On the other hand, more basic goal attribution and belief computation has been shown in social cognition research around 6-7 months (Csibra, 2008; Kovacs, Teglas, & Endress, 2010).

Despite 6–7-month-olds' apparent lack of sophistication in recognizing others' intentions, two recent studies have shown that 6-7 month olds know some object word meanings, including words referring to body parts, e.g. *hand*, and foods, e.g. *banana* (Bergelson & Swingley, 2012; Tincoff & Jusczyk, 2012). Word understanding at this age implies either that rich intention-reading skills are not necessary for learning all words, or that such skills have been underestimated in 6-month-olds.[1]

Given the theoretical possibility that these object words may have been learned by infants using generic mechanisms of perceptual association and categorization, here we examined more abstract words, such as "eat," "wet," and "hi," whose referents in the child's experience are, visually speaking, more diverse from instance to instance. Moreover, while concrete words are often used in the presence of the objects they refer to (Gogate, Bahrick, & Watson, 2000), abstract words such as action verbs have denotations that are often transient by nature, and instances of such words may not be as closely linked in time to their referents (Tomasello & Kruger, 1992) . Learning such words may thus be more challenging for younger infants.

We tested children ranging from 6 to 16 months. This served three goals. First, if 6-9 month olds fail with abstract words, it may indicate that learning concrete and abstract words requires different skills with different developmental courses, or that the learning conditions for abstract words are less favorable. In contrast, if infants succeed, it would suggest that even perceptually diverse categories can be learned and linked to words by children without

[1]A third possible response is to stipulate that the 6-month-olds have learned associations, not words, *because* such infants do not understand reference. We make the contrary stipulation that knowing what a word means begins when infants connect the sound form to a significant, representative aspect of its denotation.

fully-developed intention-reading skills. Second, if children start to succeed between 10 and 12 months, it will suggest that learning abstract words, unlike concrete words, emerges in parallel with important advances in social cognition (though it would not show that this developmental link is a causal one). Third, if word-understanding performance improves significantly at around 14 months, as Bergelson and Swingley (2012) found for more concrete words, it will provide further evidence for a change in language-relevant cognitive or social abilities in children, including perhaps a deeper understanding of joint attention (Carpenter & Call, in press), a better grip on the conventional nature of words (Buresh & Woodward, 2007), or improvement in appreciating the nature of the experimental task.

To better interpret developmental features of our word-understanding results, we also conducted a series of video-corpus analyses of the contexts in which parents use the concrete and abstract words tested in our studies. Coders annotated a range of interactional features in all instances of these words in 20 recording sessions from the Providence corpus (Demuth, Culbertson, & Alter, 2006). These data were supplemented with analyses of word frequencies in the Brent and Siskind (2001) corpus.

2. Material and Methods

2.1 Participants

Three age groups were tested: 34 6-9 month-olds (M=8.37mo., R=6.24-9.79mo., 19 girls); 46 10-13 month-olds (M=11.96mo., R=10.02-13.99mo., 26 girls); 18 14-16 month-olds (M=14.99mo., R=14.03-16.52mo., 11 girls). 48 infants were excluded due to fussiness (39), technical problems (3), failure to meet language or health criteria (2), or parental influence (4). Infants were recruited from the Philadelphia area by mail, email, phone, and in person. All were healthy, carried full-term, heard >75% English at home, and had no history of chronic ear infections.

2.2 Materials

Infants were presented with 14 5s videos organized into 7 yoked pairs: *all-gone–hi*, *eat–hug*, *dance–kiss*, *more–splash*, *drink–smile*, *bye–uh-oh*, and *sleeping–wet*. Videos (each 12×16 cm) were displayed side-by-side on a 34.7×26.0-cm LCD screen (see Fig. 1 and supplementary videos available online).

Items were selected as the most common picturable words, excluding object labels, in young children's environment based on frequency in a corpus of 16 mothers speaking to their infants (Brent & Siskind, 2001), and based on a database of parental reports indicating which words parents believed their children understood or said (MCDI, Fenson, et al., 1994). Each word appeared in 37-100% of the 16 Brent mothers' speech, and had a corpus $\log_{(10)}$ frequency ranging from 1.5-3.1. Each word was reportedly understood by 38-99% of 16 month olds in the MCDI database.

2.3 Apparatus and Procedure

Visual fixation data were collected using an Eyelink CL computer (SR Research), with a reported accuracy of .5°, sampling monocularly at 500Hz. The eyetracker operated using a camera just below the computer screen, and required no head-restraint. A sticker with a high-contrast pattern, which aided the eyetracking mechanism, was placed on the infant's forehead.

Before the experiment began, the procedure was explained to parents, who gave informed consent. Parents completed a vocabulary checklist and a word exposure survey estimating how often their child hears our test words in daily life. Then, parent and child were led to the dimly-lit testing room where the infant sat on the parent's lap facing a computer display. Parents wore an opaque visor preventing them from seeing the screen, and headphones over which they were prompted with the target sentence.

Each of the 7 yoked pairs of videos was presented four times, resulting in 28 test trials. On each test trial, parents spoke a single sentence to their child, repeating a prerecorded utterance that they heard over headphones. The sentences had been recorded by a native English-speaking woman talking at a moderate speed, with slightly exaggerated intonation. Each sentence followed the format "Look! X, X!" where X stands for the target word. The recorded sentences were 3.5s in duration and were presented at about 34dB, audible only to the parent. The exact timing of parental sentences varied across trials, but the onset of the target word was recorded; the videos played for ~3s after the parent's utterance ended.

Each test trial began with a beeping, spinning star that drew children's attention to the screen's center. Once the child fixated it (or after 10s), the pair of test videos was shown twice, accompanied only by music. This familiarized children to the videos and their locations. Then the videos were shown again, twice, with the mother being prompted to name one of the videos during the first of these two presentations.

Each participant was randomly assigned to one of two pseudorandomized trial orders, with target side counterbalanced. All children were tested on all 14 items. The experiment lasted about 20 minutes. Families were compensated with a choice of two children's books or $20. The entire visit lasted about 45 minutes.

3. Corpus Analyses

We examined mothers' use of the words tested here as well as the words tested in Bergelson and Swingley (2012) in both the Brent Corpus (an audio corpus of 16 mothers interacting with their 9-15 month old infants), and in 20 videos of the Providence Video Corpus (5 mothers interacting with their young children; we selected a subset in which children ranged from 11 to 18 months). In the Brent Corpus we compared frequency counts in isolation (i.e., in one-word utterances) and overall. In the Providence corpus we extracted 919 utterances in which both the mother and child were clearly visible, and in which one of our words of interest was said. These utterances were coded for a number of features, including whether the referent of the word was present (e.g. is there an apple when 'apple' is said, is someone eating when 'eat' is said, etc.), what the parent was looking at/touching, what the child was looking at/touching, the situation the word was used in, what (if anything) was moving, whether the word was said before, during, or after attention to the relevant referent transpired, and what was present in the room. In the case of bodyparts, which were evidently always "present" during every interaction, coders noted "presence" only when the relevant part was, in any important sense, involved in the interaction: for example, if the mother was feeding a child who had yogurt all over her mouth and said, gazing at her, "look at your messy face!" this counted as "presence" of the word "face"; in contrast, if the child was crying and the mother was holding and hugging him while singing "if you're happy and you know it clap your hands", this did not count as an instance in which "hands" were considered "present".

4. Results

4.1 Results from Eyetracking Study

To measure whether infants fixated the named event more upon hearing it named, we computed a difference in fixation proportions: how much infants looked at one video when it was the target, minus their proportion of looking to it when it was the distracter. This computation, which corrects for bias due to preferences for one video over the other (Bergelson & Swingley, 2012), yields one score for each item-pair. For instance, with the pair *kiss–dance* an infant's performance was given as how much he looked at 'kiss' when it was said by his parent, relative to his looking at 'kiss' when 'dance' was said. Positive difference scores indicate word understanding.

We measured performance in the window from 367-4000ms after the onset of the spoken target word (e.g. the beginning of the first 'hi' in "Look! Hi, hi."). Fixation responses earlier than 367ms are unlikely to be responses to the speech signal (Swingley, 2009). The 4000ms window offset is used here, rather than the 2000ms offset typically used with children over 18 months, because younger children take longer to demonstrate word recognition (Fernald, Pinto, Swingley, Weinberg, & McRoberts, 1998).

Analyses of children's fixations revealed no indication that 6–9 month olds understood the words we tested. 19/34 infants showed a positive proportion of target looking (see Fig. 2; Mdn=.020, p=.47 all Wilcoxon tests unless noted otherwise). Performance on 4/7 item-pairs was positive (see Fig. 3; Mdn=.027, p=.77). By contrast, 10–13-month-olds looked at named targets significantly above chance levels, both over subjects and item-pairs. 32 out of 46 infants showed a positive proportion of target looking (Mdn=.075, p=.002, binomial p=.011). These infants showed positive performance on 6/7 item pairs (Mdn=.060, p=.02). Finally, 14–16 month olds showed consistently high levels of performance. 15/18 infants showed positive increases in target looking (Mdn=.12, p=.0017; by binomial test p=.0075.), with positive performance on all 7 item-pairs (Mdn=.14, p=.0078).

A correlational analysis found no relation between children's performance and the total number of words parents reported that children understood or said, except in the eldest group, as determined by the MacArthur-Bates Communicative Development Inventory (CDI; τ=.43, p=.012; all other p>.1 by Spearman (nonparametric) correlation test). Considering parental report of children's knowledge of the specific words tested in the study, again only in the eldest age group was this vocabulary knowledge correlated with gaze performance (τ=.17, p=.016; all other p>.10).

Similarly, an analysis examining parents' estimates of the frequency with which a their child hears the study's words in his or her daily life (on a 0-4 scale ranging from 'never' to 'several times a day') found no relationship between this measure and children's word-recognition, except in the eldest group (τ=.20, p=.006). Descriptively, most parents in all age groups said their children heard all of our test words 'several times a day'; this response was more frequent than all of the others combined (M=3.3, SD=1.06)).

4.2 Concrete and Abstract Word Comparisons

As a further comparison with previous research on concrete nouns (Bergelson and Swingley 2012), we statistically compared subject means in that work and in the current experiment, for each age group. 6-9 month olds did significantly better on concrete words than on abstract words, with 26/33 infants achieving positive subject means, compared to 18/34 here (estimated difference=.064, p=.012 by Wilcoxon test, Chi Square=3.88, p=.049). 10-13 month olds did not show significantly different performance on the two word types, with 20/30 infants achieving positive subject means, compared to 34/46 here (estimated difference=.0096, p=.83 by Wilcoxon test, Chi Square=.18, p=.67). 14-16 month olds showed marginally different performance, with 7/7 attaining positive subject means, compared with 15/18 here (estimated difference =.17, p=.055, Chi Square=.22, p=.64).

Additionally, a series of analyses was conducted to test whether the difference in performance between abstract words (shown here) and more concrete words (Bergelson &

Swingley, 2012) might be due to higher frequency of the concrete words rather than something more fundamental about the words' meanings. Frequency was estimated using the Brent corpus (Brent & Siskind, 2001). There was not a significant difference in the frequency of the abstract and concrete words. Descriptively, concrete words occurred 45-562 (M=262, Mdn= 244) times within the corpus while abstract words occurred 33-1292 (M=453, Mdn= 219) times. Across each set of words, the total number of usages did not vary significantly (244 versus 219, p=.98 by Wilcoxon test). Given that previous research supports a link between word learning and frequency of isolated word tokens (Brent & Siskind, 2001), we also examined this variable here. The sets of words were not differentially likely to occur in isolation (in single-word utterances) either: concrete words occurred 2-92 (M=26) times and abstract words occurred 0-1091 times (M=152); this difference was not significant (concrete Mdn=19, abstract Mdn=11; p=.95 by Wilcoxon test.).

Analyses of the Providence Corpus(Demuth, et al., 2006) revealed that there too, our abstract and concrete words occurred with similar frequency: abstract words occurred 1-94 times (M=37, Mdn=23), there were 523 abstract-word tokens total. Concrete words occurred 5-46 times (M=21, Mdn=19), with 396 concrete-word tokens total (estimated difference per word type: 7 words; p=.29 by Wilcoxon test over words). Similarly, abstract and concrete words as a group did not differ in number of isolated occurrences (72 isolated abstract-word tokens total, R=1-7 over words; 35 isolated concrete-word tokens total, R=1-3 over words; estimated difference 1.8 words; p=.13 by Wilcoxon test over words).

Hand-coding of interactional features during parental use of the tested words revealed a large word-type (object versus action) difference in whether the referent of the word was present as part of the interaction. Abstract words were said much more often than concrete words when their referent was not present—e.g., saying "hi!" when no-one was newly on the scene, or "kiss" when there were no evident attempts at kissing. By contrast, concrete words ("a banana!") were more often spoken in the presence of the referent (an actual banana, or a picture of one). For abstract words the referent was not present 39% of the time; for concrete words, 15%. This pattern held for 5/5 children in the corpus, and was significant over words (estimated difference =.24, p<.012 by Wilcoxon test over words).

No significant differences between abstract and concrete words was found in what mothers or children were touching or looking at, the number of situation-types that the word occurred in (e.g. playing, eating, interacting, book-reading), what in the scene was moving (e.g. child or mom, their hands, other objects, etc), whether the word was said before, during, or after attention to the relevant referent transpired, nor what was present in the room (all ps>.05 by Wilcoxon tests, and not significant predictors in logistic regressions of word-type). In short, on most coded variables, abstract and concrete words did not differ in various features of the learning environment.

4. Discussion

These findings enrich our understanding of the early stages of language acquisition, showing that by 10-13 months, but not earlier, infants linked several common abstract words to their referents. This in turn suggests that the word-learning mechanisms and social/cognitive abilities that are needed to learn abstract words under ordinary daily-life conditions are in place approximately half a year earlier than previous laboratory tests had indicated (Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987). At the same time, the results are consistent with diary and other observational studies of children of 10 months and older. Such studies have found that a wide range of word types is present in children's early comprehension vocabularies (e.g., Bloom, 1993; Dewey, 1894; Nelson, 1973). For example, Benedict (1979) found that when infants appeared to know 10 words, at around 10 months, among those words were nominals, action words, and various social words. The present research substantiates these claims using a controlled, replicable experimental procedure. Recognition of words in our study is particularly remarkable because it required that infants generalize the words they knew from their individual life experience to new instantiations involving actors and events previously unseen by the infant.

The failure of the 6–9 month olds to evince recognition of non-object labels contrasts with performance of 6–9 month olds in other studies testing understanding of object words. Those studies used similar fixation-based methods (Bergelson & Swingley, 2012; Tincoff & Jusczyk, 2012) or event-related potentials (Parise & Csibra, 2012), so it is unlikely that minor methodological differences between this study and prior studies account for the difference. Nor is lexical frequency likely to be responsible, given results of the corpus analyses described above.

A more likely possibility is that the developmental difference concerns the requirements for learning more abstract words, for which the connection between the uses of the words in conversation and the concepts to which they refer is more difficult to establish through observation (Gillette, Gleitman, Gleitman, & Lederer, 1999). This hypothesis has two versions. One is that the same learning machinery is at work in learning concrete and abstract words, but the statistics of abstract words are more complex and therefore demand more data to resolve, which is manifested here in the later age at which evidence of learning is found. The other is that learning abstract words demands skills that do not begin to emerge until around 10 months, such as the capacity for reading others' intentions. For example, between nine and ten months, infants improve in their ability to analyze the gaze of others as social, goal-directed action (Beier & Spelke, 2012; Brooks & Meltzoff, 2005). This ability could prove more useful for understanding abstract words than concrete words, because abstract words may have fewer correlated perceptual features. That is, shape, size, color, movement, and texture range less freely for things called 'juice' than for situations called 'all gone!' or 'uh-oh.' While our task does not itself require gaze-following, abstract words are, to a greater degree, expressions of the parent's perspective, and as such their learning might depend more on skills of intention-reading.

Moreover, concrete words and referents are more easily subject to joint *visual* attention in a way that abstract words may not be: objects are often present in the environment before, during, and after the words labeling them are uttered, and thus reading others' visual attention is helpful when linking object words to referents. In contrast, many common verbs toddlers hear are transient. Indeed, previous research has found that common verbs are usually said before the relevant action occurs. Because these verbs do not co-occur with the action they denote, it has been suggested that to learn their meanings "children must find cues other than ostensive gestures to determine the adult's attentional focus" (p.313, Tomasello & Kruger, 1992).

On the other hand, the data-driven account of development may gain support in our finding that abstract words are less likely to be said when the referent is evident in the context of the interaction. In principle, this could make learning abstract words harder even if they are learned through the same mechanism as concrete words.

A related explanation for the delay, in keeping with the data-driven hypothesis, is that infants first attempt to interpret words as names for concrete objects, and only upon failing this do they attempt to link them to actions, or other more abstract concepts, a misstep that lengthens the process of learning abstract words. Of course, this presupposes the existence of an object bias, and at present there is no evidence that speaks to this issue in 6-9 month olds.

Our results do not show which of these hypotheses is correct, but they do indicate a developmental change that requires explanation.

Infants' performance in the task improved substantially at around 14 months, just as in Bergelson and Swingley (2012). This change, which is evidently independent of whether the tested words are abstract or concrete, might be due to increases in basic cognitive capacities. As discussed in Carpenter and Call (in press), a mature form of joint attention in which an infant tracks not just what she knows, or an adult knows, but what they both know together, emerges around 14 months; joint attention demonstrations prior to this age may lack this "knowing together" element (p. 7, Carpenter & Call, in press). Additionally, infants around this age, but not around 9 months, are able to track *both* (a) that an individual reaching for something likes it, though this preference does not necessarily apply to others, and (b) that if an individual uses a label for an object, another individual is likely to mean that object by that label as well (Buresh & Woodward, 2007). Both mature joint attention and insight about word-label generalization may be among the skills that improve around 14 months and that lead infants to perform better in word comprehension tasks with both concrete and abstract words.

Parental reports of infants' vocabulary knowledge did not correlate with infants' gaze performance, just as in Bergelson & Swingley (2012). This might be attributable to the difficulty parents have in assessing their infants' vocabulary knowledge before children begin to talk and while children's responses to language may be quite ambiguous. This assessment on the part of parents may be particularly difficult when considering words that do not refer to objects.

4.1 Conclusions

The current findings contribute to the litera ture on language acquisition in several ways. We showed that infants as young as 10 months old identify novel referents of common words that do not refer to concrete objects, but younger infants do not. Thus, the acquisition of abstract and concrete words differs ontogenetically, and may require skills with differing developmental trajectories. The beginnings of abstract word learning, but not concrete word learning, appear to occur in parallel with the major advances in social cognition documented in prior research (e.g., Carpenter, et al., 1998), though word-referent consistency likely plays a role in the more protracted timeline of abstract word learning as well. Furthermore, we replicated with abstract words what has been shown with more concrete words: that at around 14 months infants' word-learning or word-recognition abilities improve greatly. This improvement too coincides with important improvements in social cognition found in the literature (e.g., Buresh & Woodward, 2007). Taken together, these findings show that infants' early word learning comprises various types of words; involves generalization over prior experience in non-obvious ways; and is characterized by two developmental shifts: one around 10 months, and one around 14 months.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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- Infants 10 mo. & older show understanding of abstract words like “uh-oh” and “eat”
- 6-9 month-olds do not, in contrast to their performance with concrete nouns
- At 14 months, infants show more robust abstract word-meaning knowledge
- Corpus analyses show abstract words are used less reliably with their referents

Fig. 1.
Sample stills from video stimuli. The left still is from a trial with videos depicting ‘hi’ and ‘all gone’; the right still is from a trial with videos depicting ‘eat’ and ‘hug’ (left to right, respectively, for each). Video stimuli were in color.

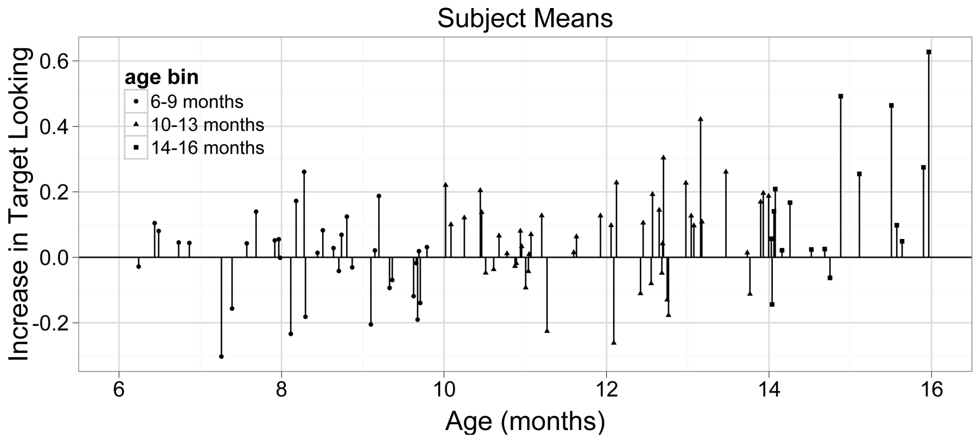

Fig. 2.

Target looking performance in each infant. Data are subject mean difference scores calculated over the 367-4000ms window. These were calculated by averaging the 7 item-pair mean difference scores for each subject. Symbols indicate the age bins used for statistical analyses; see text for details.

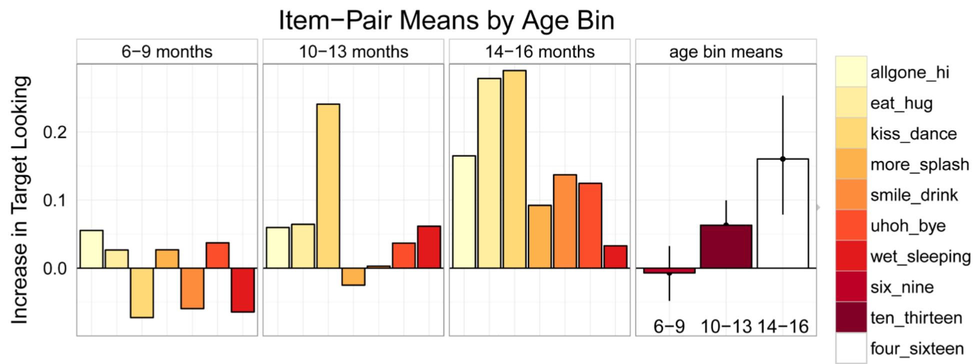

Fig. 3.
Item-pair mean difference scores within each age bin (three left panels), and subject means by age group (right panel). Error bars for subject means represent bootstrapped nonparametric 95% confidence intervals.