



# Bye-bye mummy – Word comprehension in 9-month-old infants

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From the little research that exists on the onset of word learning in infants under the age of 1 year, the evidence suggests an idiosyncratic comprehensive vocabulary is developing. To further this field, we tested 49 nine-month-old infants by pre-assessing their vocabularies using a UK version of the MacArthur-Bates Communicative Developmental Inventory. Intermodal preferential looking (IPL) was then used to examine word comprehension including: (a) words parents reported as understood, (b) words infants are expected to understand according to age-related frequency data, and (c) words parents had reported infants not to understand. Assuming parents are good assessors of their infant's early word knowledge, we expected a naming effect with IPL in condition (a), but not condition (c). As language research uses standard samples of words, we expected a discernible naming effect in condition (b). Results show clear IPL evidence of word comprehension for those words that parents reported their infants to understand (condition a). This agreement between methods demonstrates the usefulness of parental communicative developmental inventory in conjunction with IPL to assess infant's individual word knowledge. No naming effects were found for condition (c) and the lack of naming effects in (b) shows that pre-established word lists may not give a sufficiently clear picture of infant's true vocabulary – an important insight for researchers and practitioners alike.

## Statement of contribution

### *What is already known on this subject?*

- Most word comprehension research is mainly based on older infants (12, 15, or 18 months of age to 2–3 years and older).
- Some evidence of word comprehension for common and novel nouns in 6- to 10-month-olds.
- Existing evidence uses either only specific word groups or nouns combined with specific training and/or repetition procedures.

### *What does this study add?*

- Nine-month-olds display word knowledge independent of context and without repetitions of words.
- First words encompass not only nouns, but a range of other word classes.
- Parents are good at indicating which words their infants do and do not understand.

While there is a wide range of studies on word learning in infants over the age of 1 year, very little research exists on the *onset* of word comprehension in infants under 1 year. As

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investigating the very beginnings of word comprehension is a challenging task given infants' verbal and attentional limitations, most word comprehension research tests mainly older infants, starting from 12- 15- or 18 months of age to 2–3 years and older (Fernald, Perfors, & Marchman, 2006; Houston-Price, Mather, & Sakkalou, 2007; Schafer & Plunkett, 1998; Werker, Cohen, Lloyd, Casasola, & Stager, 1998). Very few studies have investigated word comprehension in infants under 12 months of age. However, as we know that infants around 12 months can already understand a range of words, for example, proper nouns, nouns, and socio-pragmatic words (e.g., Schafer, 2005; Syrnyk, 2008), there must be an earlier point in time when we can observe the onset of their word learning abilities. Studies with 12- and 15-month-old children have shown that they can match nouns and prepositions to previously unseen, typical exemplars, but they cannot extend these words to less typical (e.g., Meints, Plunkett, & Harris, 1999; Meints, Plunkett, Harris, & Dimmock, 2002; Poulin-Dubois & Sissons, 2002; Southgate & Meints, 2000) or broken exemplars (Meints & Jones, 2004) as children and adults can. Thus, young infants' word comprehension is not just lacking in size, but also lacking in maturity when compared with older children and adults. It follows that early comprehension is often interpreted as a continuum of initial associative learning, also described as word–object associations (Werker *et al.*, 1998) or recognition comprehension (Oviatt, 1982) which is not equal to full-fledged word learning. More mature word learning comprises a fuller extent of word-to-object mappings and follows different timings in the different word classes (see Meints, Plunkett, & Harris, 2008 for discussion).

### ***Evidence of early word learning in infants under 12 months: Head-turn preference procedure and intermodal preferential looking***

Using the head-turn preference procedure, Mandel, Jusczyk, and Pisoni (1995) were able to provide evidence of very early recognition of proper names as infants as young as 4.5 months of age were found to recognize their own names. Around 6 months of age infants can use familiar names to help them segment the speech stream into word units (Bortfeld, Morgan, Golinkoff, & Rathbun, 2005). It has been shown that infants from 6 to 12 months of age can link consistent speech sounds and conceptual knowledge before learning labels (Balaban & Waxman, 1997; Fulkerson & Waxman, 2007; Waxman & Braun, 2005; Waxman & Markow, 1995) as well as use visual (facial) displays to categorize speech sounds (Teinonen, Aslin, Alku, & Csibra, 2008) and vice versa (Yeung & Werker, 2009). However, while there is a large range of studies in infants' sound, speech, and word segmentation abilities under the age of 1 year, there remains little research on the onset of whole-word comprehension at this young age.

Intermodal preferential looking (IPL) has enhanced our understanding of language comprehension (e.g., Fernald *et al.*, 2006; Tincoff & Jusczyk, 1999, 2012), word learning, categorization (e.g., Meints *et al.*, 1999, 2008), and grammar (e.g., Chan, Meints, Lieven, & Tomasello, 2010). Contemporary versions of IPL (e.g., Meints & Woodford, 2008) benefit from automated data processing, improved efficiency, precision and reliability of testing procedures through the use of computer-aided presentation, recording, and scoring as well as computerized data analysis. IPL may also offer a more sensitive means of gauging early knowledge than other methods (Chan *et al.*, 2010). Indeed, using IPL with infants under 12 months, Tincoff and Jusczyk (1999, 2012) found that 6-month-old infants look significantly longer at images of familiar people ('Mommy' and 'Daddy') and objects ('hands' and 'feet') when presented with the relevant words. More recently, Bergelson and Swingle (2012) found 6–9 month-olds demonstrated word comprehension for

common nouns from the categories of ‘food’ and ‘body’ (e.g., hair, banana). Repetition was key to testing as each of the 16 target words was tested three times, once in a multi-object still image and twice as paired still image displays. Other studies have found evidence that 10-month-old infants can learn novel nouns for a highly salient object after five repetitions (Pruden, Hirsh-Pasek, Golinkoff, & Hennon, 2006) and that from 9- to 12-month infants can learn nouns after repeated prior exposure (four times per week over 12 weeks) (Schafer, 2005). Although these studies provide us with a sense that young children are indeed on their way towards learning and understanding words, researchers have used either highly specific word groups (e.g., Mommy, Daddy) or nouns only combined with specific training and/or repetition procedures before testing infants’ knowledge. Thus, little remains known about the extent of infants’ naturally occurring word knowledge in the first year of life. To our knowledge, no further experimental research exists in this area, despite improved testing techniques.

### **Further evidence of early word learning: MCDIs**

The MacArthur-Bates Communicative Developmental Inventories (MCDIs; Fenson *et al.*, 1994, 2003), a parental report measure of early receptive and productive language, suggests that infants as young as 10 months understand approximately 10 words (Fenson *et al.*, 1994). Application of the MCDI is widespread as it has been found to display good validity and reliability outcomes; good correlations with similar checklists, with structured and naturalistic assessments (e.g., Dale, Bates, Reznick, & Morriset, 1989); to show similar developmental growth patterns as that of laboratory measures (Jahn-Samilo, Goodman, Bates, & Sweet, 2000); and to be applicable to atypical populations (Miller, Sedey, & Miolo, 1995). There are currently over 40 different language versions of the CDI worldwide, with normed UK data being introduced in 2016 (Alcock *et al.*, 2016) (for overview, see CDI Advisory Board, 2011). These are used as general language screening tools (Bleses, Vach, Jorgensen, & Worm, 2010) to help identify very young children with language delay (see also ELFRA 2 – Grimm & Doil, 2000; Sachse & Von Suchodoletz, 2008), or in identifying older children with language delay (e.g., Heilmann, Weismer, Evans, & Hollar, 2005), as well as to monitor language delay longitudinally (Thal, O’Hanlon, Clemmons, & Fralen, 1999) and in large-scale projects (e.g., Bleses *et al.*, 2008, 2010).

Communicative developmental inventory data are used by language researchers in several ways: (1) Overall norms and frequency data (i.e., American MCDI norms, Fenson *et al.*, 1994) are used to choose age-appropriate stimuli for testing and have frequently been used also for young children learning UK English (e.g., Schafer, 2005; Styles & Plunkett, 2009), due to a lack of valid UK vocabulary norms; (2) to measure young children’s overall knowledge gain in word learning (e.g., Schafer, 2005); (3) to measure young children’s vocabulary size as a background measure to compare groups or select subgroups (e.g., Pruden *et al.*, 2006); or (4) to assess individual knowledge by administering, for example, UK adaptations of the MCDI before testing and hand-tailoring stimuli to choose only those stimuli for which parents confirm word knowledge in either comprehension and/or production (e.g., Meints *et al.*, 1999, 2008).

However, parental reports such as the CDI have also been confronted with criticism when addressing the large and consistent amount of variation observed in data collected from vocabulary checklists (Feldman *et al.*, 2000; Fenson *et al.*, 1994, 2003; Tomasello & Mervis, 1994). Some have addressed this variation in reporting during the first year by questioning the validity of the CDI’s measure of word comprehension itself (Tomasello &

Mervis, 1994) and suggest vocabulary reports of younger children may not be consistent (Yoder, Warren, & Biggar, 1997) as parents find it difficult to comply with the CDI's instructions for reporting words believed to be understood.

First attempts have been made to use IPL to measure the validity of parental CDI judgements. As far as older children are concerned, there is conflicting evidence of both agreement and disagreement between parental reports and IPL performance. For example, using both IPL and a British version of the CDI, Houston-Price *et al.* (2007) used individual parent reports of comprehension (or lack of comprehension) to randomly select a collection of 'known' and 'unknown' nouns at 15-, 18-, and 21 months. In addition, these nouns had also been reported by parents to be familiar to their child. Houston-Price *et al.* found that children of all ages showed understanding for known and unknown words. That is, children showed evidence of comprehension for words their parents believed the child not to understand, although the child was familiar with the referent. The authors' explanations for this unexpected finding included parental underestimation and/or inaccuracy for reporting their children's word knowledge and the suggestion that IPL and CDI measurements capture differing degrees of early word comprehension. This latter explanation has been considered elsewhere (Syrnyk, 2008) and it has been suggested that infants harbour different degrees of comprehension throughout development for different words (Hirsh-Pasek & Golinkoff, 1996; Hollich *et al.*, 2000). In an effort to clarify the potential discrepancy between IPL and CDI methodologies, Styles and Plunkett (2009) also collected 18-month-olds' parental reports using the Oxford CDI (Hamilton, Plunkett, & Schafer, 2000) and tested chosen known and unknown words using IPL. In contrast to Houston-Price *et al.*, they found that parental report did predict individual IPL performance. However, the contrasting findings may also be attributed to the details surrounding stimulus combination and presentation. Unlike Houston-Price *et al.*, Styles and Plunkett employed a one-shot IPL design that prevented the repetition of tested words, and also controlled for pairings of stimuli within the same semantic category. By showing support for the accuracy of the CDIs using IPL's measurement of comprehension at the item level, Styles and Plunkett's study demonstrates that parents could be capable interpreters of their children's language in the 2nd year of life.

In the current study, we have tried to find a way to assess infants' earliest word knowledge using IPL as a direct method of assessment of infants' ability to link the target word with the depicted item in combination with using parental judgements with UK-adapted CDIs. We use IPL in combination with parental questionnaires in three ways: (a) with words parents reported their infants to understand, (b) with words infants are expected to understand according to age-related frequency data, and (c) with words parents reported their infants not to understand. If parents are good assessors of their infant's early word knowledge, then we should find a naming effect with IPL in condition (a) and no effect in condition (c). Condition (b) was tested as standardized language and speech tests (e.g., the Reynell Developmental Language Scales III, Edwards *et al.*, 1997), as well as some language research, use standard samples of words that infants are expected to understand. If such standardized lists fit the vocabulary well, then we should expect a discernible naming effect in IPL.

In contrast to other studies, we do not limit ourselves to nouns or proper nouns, but instead test a range of words from various word classes that make up infant's early vocabulary (e.g., socio-pragmatic words, words for routines, nouns, verbs) and reflect a large range of objects and situations they encounter (see Appendix S1). As there is evidence that the noun bias may not be as strong in initial word learning as later in

development (e.g., Bloom, Tinker, & Margulis, 1993; for a review, see Clark, 2003) and may depend on the input language (cf. Dhillon, 2010), this study can therefore begin to shed light on whether the noun bias found in older English-speaking children is already visible in 9-month-old English-speaking infants.

In addition, we tested separate experimental groups – one longitudinal and one cross-sectional group. This allowed us to see whether parental accuracy would be heightened if parents knew that they were coming back for further testing at later points in time, thus improving the validity of the data set.

## Method

### Participants

Forty-nine British 9-month-olds were tested. Of these, 23 (10 girls and 13 boys) were tested cross-sectionally ( $M = 0; 09.04$  [0; 07.23 to 0; 09.17]), and 26 infants (nine girls and 17 boys) were tested longitudinally ( $M = 0; 09.06$  [0; 08.11 to 0; 09.28]). These data were part of a larger, related study consisting of longitudinal and cross-sectional groups. The longitudinal group took part in further studies on word learning and vocabulary development and was seen at 9, 12, 18, and 24 months of age. In testing the cross-sectional group, one child was excluded due to excessive fussiness. Similarly, data from one child were not included in the final longitudinal group, due to poor video recording quality. All infants were recruited from local nurseries in the United Kingdom, and all were reported by parents to have normal hearing and vision, and to be monolingual, native speakers of British English with no history of language delay or disorder and no exposure to additional languages. Only 11 of the participating families wished to report their combined income of which the average annual income was £36,000 (£0–130,000) (average annual full-time income according to UK 2011 census data was £32,837). Parents provided their informed consent prior to testing. Each child's receptive and productive vocabulary was assessed by their parents using a British version of the MCDI (Fenson *et al.*, 2003) and the Lincoln Communicative Developmental Inventory (LCDI) (2000). Completed LCDIs were retrieved approximately 1 week prior to testing, so that individual stimuli could be prepared in time for testing (see Table S1, for an overview of reported vocabulary).

### Stimuli

#### Visual stimuli

Each child was presented with stimuli representing typical nouns and non-nouns (see Appendices S1 and S2) in the following three conditions: (a) words parents had reported infants to understand 'known words', (b) words infants are expected to understand according to age-related frequency data 'standard words', and (c) words infant's parents had reported them not to understand 'unknown words'.

For standard words (b), 18 items were included which infants of 9 months age could be expected to understand according to general CDI frequency data available at the time of testing and obtained from American and British parental report data (MCDI: Fenson *et al.*, 1994; Oxford CDI: Hamilton *et al.*, 2000) on the basis that they had a reported average frequency of approximately 50% or higher (for similar practice Schafer, 2005; Styles & Plunkett, 2009). As the normed MCDI data only provided a limited amount of items reported to be understood by 50% of infants at this young age, items selected for

inclusion were extrapolated from ages 9 to 13 months. As there is considerable variation in the amount of words children are reported to understand at young ages (e.g., Barrett, 1986; Fenson *et al.*, 1994) and as some may be more advanced than others, we broadened the age range up to 13 months when selecting words. In retrospect, this choice was justified given the range of words reported to be understood in this sample as there was indeed considerable variation. Words included 10 nouns as well as eight other familiar words from different categories (e.g., one action label and four routines, one negation, and two parent names). These 18 items 'expected to be understood' were also best-matched according to setting, size, colouring, and semantic category to form the following item pairs: *cat-dog*, *ball-book*, *bottle-telephone*, *banana-teddy*, *car-duck*, *no-bye-bye*, *kiss-peekaboo*, *batb-night night*, and *mummy-daddy*. In all, infants were tested on a maximum of 26 items. Of these, 18 were shown to all infants as they were 'expected to be understood'. Up to eight additional items were shown if they were reported to be understood by their caregivers. This was done to increase the possible number of trials and to make sure words understood by children were tested. For condition (a), we examined infants' looking behaviour towards the standards items they were reported to understand (condition b) along with up to eight additional items, all of which were reported to be understood by their caregivers (see Table S2 for examples). The number of items was dependent on individual LCDI reports. These items were best-matched according to setting, size, colouring, and where possible, semantic category, although noun items were paired with noun items and non-noun items paired alike. For condition (c), we specifically examined those items in the standard set that infants were reported not to understand in order to measure whether parental assessments of words infants do not know are correct.

All images and videos were either derived from an existing item library and had been previously rated to confirm their typicality (Meints *et al.*, 1999), or produced as needed. Videos were captured and edited from digital 8-mm tape to become 382 × 288 pixel in a manner which best presented the action or situation of interest (see Appendix S3). All stimuli were assessed by carrying out additional typicality ratings with adults. Only items that yielded a score 2.5 or less on a 7-point Likert typicality scale (1 = very good example, 7 = very poor example) were used as stimulus items.

Images were edited and presented against a 5% grey background, while video files were produced to best represent the non-noun items – bar the item pair of *mummy-daddy*. For this item pair, digital photographs of each parent were obtained prior to testing. Parent images were edited to remove all background imagery, were presented against a 5% neutral grey background, and were each individually edited to only include the upper body and head of the parent.

#### *Auditory stimuli*

For each item, an auditory stimulus was recorded in a female, infant-directed voice and formatted as 22.05 kHz, signed, 16-bit digital audio files which were normalized for amplitude at 80% with all head and tail clicks removed. The female speaker was not known to any of the infants tested. When presented with images, infants heard the target item named as follows: 'Look, look at the (object)!' Videos were presented as 'Look! (action) ing!' For all other items, despite different word classes, the same procedure was adapted to keep stimuli as similar as possible. Stimuli were produced, videoed, and edited with best presentation ability and stimulus unambiguity in mind. For consistency purposes, the same initial 'Look!' was copied and used for all audio files.

### **Procedure**

Testing was conducted in a purpose built IPL suite. Infants sat on their parent's knees at a distance of approximately 70 cm from a large viewing screen. Parents were asked to keep their eyes closed during the testing while listening to a recording over headphones. This recording reminded the parents to keep their eyes closed and to keep still during the experiment and was recorded against white noise and set at a volume that shielded them from the experimental auditory stimuli. During each trial, infants were presented with two images or actions (the item pair) which were equidistant from the centre of the viewing screen. A loudspeaker located centrally above the screen emitted the acoustic stimuli, naming one of the images. Prior to the onset of the trial, infants' gaze was centred using a large red dot which appeared midway between the images on the screen. If a child looked away from the screen between trials, the dot, accompanied by a sound, was played to return the child's attention to the screen. A new trial did not begin until the child's attention was manually centred. All trials were separated by a minimum of 0.5 s and were controlled via computer in an adjacent room. Each trial was 6,000 ms in duration. The target word was delivered 2,500 ms after the onset of the trial and the visual stimulus. The period during the trial before the target was named is referred to as the pre-naming period (0–2,500 ms), and the period after the target onset is referred to as the post-naming period (2,500–6,000 ms). During testing, each item pair was presented twice, so that each item within a pair acted as the named target during the initial presentation and as the distracter in the repeated presentation. Therefore, infants were presented with a maximum of 26 trials. To avoid looking biases, item pairs were counterbalanced between left and right target positions between the initial and repeated presentations and between participants. In addition, the order of item pairs presented during testing was pseudo-randomized by computer.

### **Data analysis**

In order to assess direction of eye gaze, infant's looking behaviour was recorded with video cameras hidden directly above the screen. A button-box system, applied in tandem with a data registration program synchronized with the recordings, was used to score the videos which were played back at standard speed. Videos were scored twice for the infant gazing to the left side and twice for looking to the right. The experimenter scoring the videos was blind to the target location in all instances. Left- and right-looking scores were averaged to yield two distinct measures of direction of gaze during each trial. Inter- and intrarater reliability yielded agreement of  $\geq 90\%$ . Looking behaviour was analysed using the dependent measures of *longest look and total looking*. The longest look measure is considered to be a more sensitive measure than total looking for younger children (see Schafer & Plunkett, 1998). The difference in target and distracter looking ( $t-d$ ) before and after the onset of the target word in both the pre-naming and post-naming periods was calculated. For total looking, the proportion of looking to the target over the distracter was calculated ( $t/t+d$ ) before and after the onset of the target word. For both measures, a significant increase in target looking after naming is referred to as a 'naming effect'.

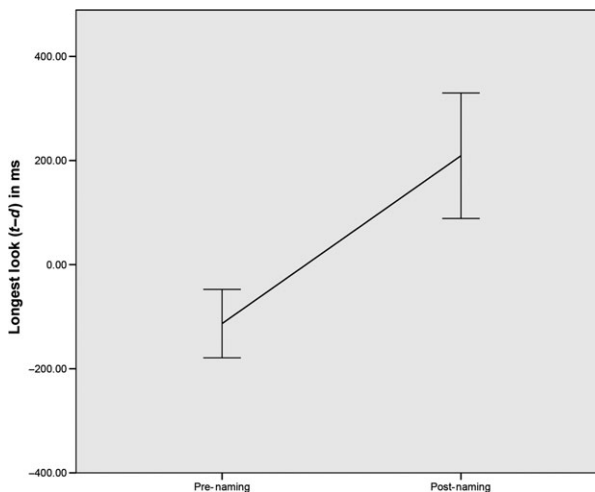
It should be noted that individual trials had to be omitted from analysis if the child did not look at both images during the pre-naming period (to avoid biases and to make sure the infant had seen both images). Furthermore, as analyses (a) and (c) are dependent on parental reports, not all infants contributed to these analyses.

## Results

### Known words

To investigate words parents reported infants to understand (condition a), we analysed only item pairs in agreement with individual parental reports. A  $2 \times 2$  mixed repeated measures ANOVA with Cohort (longitudinal vs. cross-sectional) as between-group factor and Naming Period (pre- vs. post-naming) as the repeated measure was calculated for longest and total looking measures. A significant main effect for Naming Period was found for the longest look measure,  $F(1, 39) = 7.51, p = .009, \eta_p^2 = .162$ , showing a significant increase in looking towards the target after naming has occurred (pre-naming:  $M = -126$  ms,  $SE = 65$ , post-naming:  $M = 212$  ms,  $SE = 123$ ) (See Figure 1 below). Consistent with this, the total looking measure yields a similar result,  $F(1, 39) = 6.99, p = .012, \eta_p^2 = .152$ .

As the lack of a cohort effect confirmed that the variance was consistent between groups, we examined the data further by investigating the differences between all items understood versus all items not understood. A  $2 \times 2$  repeated measures ANOVA of Comprehension of Items (comprehension vs. no comprehension) and Naming Period (pre- vs. post-naming) was calculated for both longest and total looking. The ANOVA showed a significant effect for Naming Period with increased looking towards the target after it was named for both measures: longest look,  $F(1, 32) = 5.947, p = .020, \eta_p^2 = .157$ , and total looking,  $F(1, 32) = 3.984, p = .054, \eta_p^2 = .055$ . An interaction effect was found for longest look,  $F(1, 32) = 4.78, p = .036, \eta_p^2 = .130$ , and for total looking,  $F(1, 32) = 8.85, p = .005, \eta_p^2 = .217$ . Planned comparisons for the longest look interaction show a significant naming effect for comprehended items,  $F(1, 32) = 13.608, p < .001$ , but not for no comprehension items ( $p = 0.944$ ). Planned comparisons for the total looking measure showed similar results, with the comprehended items showing a significant naming effect,  $F(1, 32) = 20.29, p < .001$ , but not the no comprehension items ( $p = .331$ ).



**Figure 1.** Mean longest looking times ( $t-d$ ) in ms for items understood (condition c) before and after naming.



### **Standard words**

For age-related frequency words (condition b), looking behaviour was measured for those words infants are expected to understand according to age-related frequency data. To examine for significant differences here, a  $2 \times 2$  mixed repeated measures ANOVA of Cohort (longitudinal vs. cross-sectional), the between-group factor, by Naming Period (pre- vs. post-naming), the repeated measure, was calculated. For both the longest look and total looking measures, only a significant main effect for Naming Period was found,  $F(1, 47) = 4.55, p = .038, \eta_p^2 = .088$ ;  $F(1, 47) = 7.30, p = .010, \eta_p^2 = .134$ , respectively. Regarding mean longest looking time to the target in the pre-naming phase was  $M = 37$  ms ( $SE = 27$ ) and the post-naming phase  $M = -117$  ( $SE = 71$ ), suggesting that infants spent more time looking towards the distracter after the target had been named. However, some item pairs consisted of known and unknown items, making it likely that the distracter effect was due to infants' unequal knowledge of these items. To examine this further, we sorted the data into item pairs in which either both items were known or both items in the pair were unknown to the infants. This time the same ANOVA analysis showed no significant effect for Naming Period ( $p = .171$  for longest look,  $p = .196$  for total looking), or any other effects. Thus, it can be concluded that the distracter effect was an artefact due to unequal pairs. This is an important insight for other studies, too, as distracter effects are not infrequent in IPL experiments (cf. Houston-Price & Nakai, 2004) and as studies often do not control for knowledge of both words in a displayed pair.

### **Unknown words**

For words parents reported as unknown (condition c), we analysed those words which infants' parents had reported them not to understand. To avoid biases in looking, we took the precaution of only including data where both items in a pair were unknown to the infants. Using a  $2 \times 2$  mixed repeated measures ANOVA with Cohort (longitudinal vs. cross-sectional) as between-group factor and Naming Period (pre- vs. post-naming) as the repeated measure, we carried out this analysis for longest and total looking measures. No significant effects were found.

### **Further analysis of word classes**

Age-related frequency words included five socio-pragmatic words and one verb (see Appendix S2). As the presentation of verbs and socio-pragmatic words involved moving images, these were combined to form one category of investigation: 'non-nouns'. On average, infants were presented with approximately 70% nouns (this included proper nouns) and 30% non-nouns. As a limited amount of non-nouns were included in individual parent files, analyses of non-nouns were conducted using the standard set only. For the sake of clarity, the following analyses only use the longest look measure.

#### *Nouns*

Two-tailed paired *t*-tests of pre- versus post-naming for standard set nouns or parent set nouns did not yield naming effects (see Table S3). As before, we sorted the looking data into item pairs in which either both items were known or both items in the pair were unknown to the infants. Again, no naming effect was found for standard set nouns or standard set nouns reported to be not understood. However, while infants' looking to the target increased after naming for standard set nouns reported to be understood, this did

not reach significance. Finally, no naming effect was found for nouns after combining the standard and parent sets.

### *Non-nouns*

Using paired *t*-tests of pre- versus post-naming, no naming effect was found for standard set non-nouns. After again sorting the data into item pairs, no naming effects were found for standard set non-nouns, standard set non-nouns reported to be understood or not understood.

## **Discussion**

The present findings show that by 9 months of age, infants demonstrate comprehension for those words their parents report them to understand (condition a). These results support previous research that finds evidence for word understanding in the first year of life (Bergelson & Swingley, 2012), emphasizes the individual nature of the developing lexicon (e.g., Harris & Chasin, 1999), and also agrees with studies suggesting that parents play an important role in assessing and predicting their own infant's lexical development (Styles & Plunkett, 2009; see also Meints *et al.*, 1999, 2002, 2008 for word comprehension tailored from individualized word lists). We therefore conclude that the CDI can be used well in an individualized fashion even at a young age.

In addition, this study is the first to show the wider range of words young children understand – these are not only nouns, but also words for daily routines like bath time or going to sleep (e.g., 'night night'), games (e.g., 'peekaboo'), greetings ('hello'), negation ('no'), and an action (to kiss). This contributes new data to the empirical base of child development, it corroborates observational research with older infants, and it mirrors research on older children's first word productions (e.g., Waxman & Leddon, 2011; for a summary) and on young children's vocabulary growth (e.g., Caselli *et al.*, 1995). We can therefore now show a transition in early learning from comprehension of infants' own names at 4.5 months (Mandel *et al.*, 1995) to names for parents, body parts, and certain food items from 6 months (Bergelson & Swingley, 2012; Tincoff & Jusczyk, 1999, 2012), to a range of words in different word classes that are in use at 9 months of age.

Second, as predicted for condition (c), parents seem to know what their infants do not understand: 9-month-olds did not display comprehension for words that they were reported not to understand. Instead, they only demonstrated comprehension for words their parents reported them to understand (condition a). Furthermore, we found that infants do not display comprehension for words they might be expected to know from respective CDI frequency data (condition b). This is an important finding as standard lists are used in research and also (often with older children) in language research (e.g., Schafer, 2005). Using IPL, Schafer found evidence of decontextualized word learning in 12-month-olds who had received explicit training on a set of items the names of which were expected to be understood. Although infants showed evidence of understanding the words for which they had been specifically trained, the control group of infants who received no prior training could not link words to images they were expected to know. This fits well with our results on condition (b) – expected word knowledge as derived from standard lists does not overlap well with an individual infant's word knowledge, and can therefore explain the missing naming effect in Schafer's control group.

Intriguingly, while our results suggest that parents may be very good reporters of their *own* child's early word knowledge, they question more general *expectations* made about children's word knowledge in the first year of life as 9-month-olds did not display evidence of comprehension for words extrapolated from frequency data. This suggests that investigations of word knowledge, especially at such an early age, profit from individual parental report, while general frequency data do not seem to coincide well with the actual word knowledge of an individual child. Bergelson and Swingle's (2012) study suggests that children may comprehend these expected items; however, there are alternative explanations to their findings. For example, six out of the eight single still item pairs contained strong frequency differences based on both infant comprehension and production data (Fenson *et al.*, 1994, 2003). To illustrate, the item 'banana' is a high-frequency item in early child language, while its pair 'hair' is of low frequency, particularly for children of this young age. It could be that in this case the item with greater frequency works as an anchor for children's fast mapping. In addition, as the items were repeated, this may have consolidated such fast mapping but may not necessarily be sufficient evidence of word comprehension. Thus, no relation to parental report information would be expected with such a design. In contrast, our findings show that individual parental reports agree with infants' early word knowledge. This is important as standardized language measures usually do not rely on individual report but employ expected word knowledge frequency data. For example, the Reynell Development Language Scales III (Edwards *et al.*, 1997), a standardized language assessment tool, measures language development using a specific set of items infants might be expected to understand at certain ages. The results from this study suggest that a child's real word comprehension is better evidenced when based on individual parents' judgments for their own child – as opposed to expectations based on frequency data of the kind that standardized tests use.

Using an combination of the methods of IPL and CDI questionnaires, we were able to show that 9-month-olds have the ability to associate a range of labels with the appropriate, typical, referents. As our study tested infants on a larger variety of words, we can confirm that their comprehension is well on the way around 9 months of age. Next to providing much needed objective evidence for the earliest stages of infants' word comprehension, which has long only been estimated or based solely on parental reports, or tested only a very small subselection of specific nouns, the current research provides a broader perspective of young infants' word knowledge by testing a wide range of words from other word classes. We have shown that to tap into infants' very early vocabulary, research need not be limited to exploring nouns, but should include a wider range of vocabulary to give a fuller picture of infants' and young children's word knowledge. Our results agree with previous, questionnaire-based research on children's early word learning by Bloom *et al.* (1993) and Caselli *et al.* (1995) who suggest that instead of an initial noun bias, children start to learn words in a different, more distributed way, including words for routines first.

The fact that infants looked longer towards the named target indicates that their knowledge was robust enough to identify the correct word–referent mappings. As interpretations of IPL rely on the logic that longer looking to the target, as opposed to the distracter, after naming, is an index of word understanding or at least of successful word–referent mappings (e.g., Meints *et al.*, 1999; Schafer & Plunkett, 1998; Tincoff & Jusczyk, 1999, 2012), our results show evidence of this as early as 9 months of age. This has important theoretical and practical implications: As Yeung and Werker (2009) have shown successfully that 9-month-olds can use cross-modal associations to link objects consistently to sounds to help them to learn native speech sounds before they learn *novel*

words, our results show that infants must do this before 9 months of age for those words which they already understand by 9 months of age. Note also that the visual representations of all items in our study were typical, but that they were also all novel (i.e., previously unseen) to the infants. As young children have been shown to employ prototypes in categorization from 10 months of age (e.g., Younger & Gotlieb, 1988), and in noun learning from 12 months of age where they are only able to link words to typical referents (e.g., Meints *et al.*, 1999), it is not unlikely that 9-month-olds also use them as reference points in word learning at this early age. Further studies will need to enhance our understanding of these earliest mappings.

### **Conclusion**

This study is among the first to demonstrate that infants under 1 year of age display word knowledge independent of context and without having undergone any repetitions of words during the testing procedure. We have shown that young children's first words encompass not only nouns, but a range of other word classes. Finally, concerning parental judgements, this research demonstrates that parents are good at indicating which words their infants do and do not understand.

Implications of this research suggest that methods of assessing and examining language development should take parental feedback into consideration in order not to undervalue or misjudge individual infants' knowledge of words. This is made all the more important by our findings that suggest that the applicability of general, pooled CDI data to measure an individual child's specific word knowledge is doubtful (see also Houston-Price *et al.*, 2007) and needs further investigation. As our results show significant agreement between IPL and the parental CDI for individual infants, we can now profit from the methodological combination of IPL and parental CDI, especially as IPL is an easy to administer procedure and one of the few able to offer a direct and objective measure of young infant's developing word comprehension. Thus, when assessing word knowledge, it can be advantageous to use IPL and the CDI together. However, since the CDI depends on parent's lexical knowledge in order to infer that of infants', future research should examine whether socio-economic status (SES) of parents has an impact on the degree of agreement between IPL and individual parental CDI reports. SES has been linked to language development from as early as 18 months (Fernald, Marchman & Weisleder, 2013); for example, differences in children's abilities have been shown with lower and higher SES. We tested parents who earn around the average UK salary, suggestive of middle-class status – however, it is possible that SES also played a role here. Further research with children as young as our sample is needed to examine whether SES starts to interfere with children's word learning at these earliest stages.

Finally, to measure children's progress and potentially turn this combination of IPL with CDI into a new method for early language assessment that impacts upon children's and parents' lives, further research is needed to examine how early word mappings develop into word comprehension on the one hand, and how differences in experimental design (i.e., stimulus knowledge, familiarity and frequency, and stimulus presentation and repetition) affect the researcher's assessment of early word learning. Once we have gained a solid base on the finer details of early word learning and how to measure it best, we can move on to develop effective early assessment and intervention tools.

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### Supporting Information

The following supporting information may be found in the online edition of the article:

**Table S1.** Descriptive statistics of 9-month-olds ( $N = 49$ ) vocabulary using the LCDI.

**Table S2.** Examples of parent items and their reported frequency of comprehension at 9 months.

**Table S3.** Looking time data (ms) using longest look and paired  $T$ -tests for the word classes of nouns and non-nouns.

**Appendix S1.** Labelled images of standard list nouns: Cohorts at 9 months.

**Appendix S2.** Description of standard list non-nouns: Cohorts at 9 months.

**Appendix S3.** Example screen captures of non-noun video clips: Cohorts at 9 months.