Laying the Foundation: Extracting Partial Meanings of Hard Nouns via Observational Contexts

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Abstract

A key aspect of understanding how children learn the meanings of words involves understanding how they mine different sources of information (e.g., observational, linguistic) in the service of learning. According to one dominant view, there exists a class of words (i.e., "hard words"; Gleitman et al., 2005) for which learning their meaning requires access to information beyond the observational contexts in which those words occur. Building upon previous work on this topic that employed the Human Simulation Paradigm, a paradigm commonly used for investigating vocabulary learning, the current study revisits the role of observational contexts for the acquisition of one class of hard words: nouns that denote non-basic level object categories (or "hard nouns"; see Kako, 2005). These data reveal that although observational contexts may not be sufficient to yield learning of precise hard noun meanings, they allow learners to extract systematic partial knowledge, knowledge that may lay a critical foundation for meaning acquisition.

Keywords: word learning; abstract concepts; language acquisition; conceptual development

Introduction

Abstract concepts have long piqued the interest of cognitive scientists for multiple reasons, including the structure of their representations (e.g., Borghi et al., 2017), the nature of their neural underpinnings (e.g., Binder, 2016), and the ways in which they are codified linguistically (see Majid et al., 2018). These concepts are of special interest to scholars of conceptual development because although young toddlers appear to have learned some more abstract terms (e.g., "friend", Fenson et al., 2007), many of the purported learning mechanisms available early in development seem ill-equipped for learning such words (see Gleitman et al., 2005). Thus, understanding the mechanisms by which young toddlers learn these more abstract words is thought to provide unique insight into the nature of word learning.

The current study builds upon previous research that has utilized the Human Simulation Paradigm (HSP) in service of investigating the acquisition of different kinds of word meanings (see Gillette et al., 1999; Gleitman et al., 2005; Kako, 2005; Medina et al., 2011; Snedeker & Gleitman, 2004; Piccin & Waxman, 2007). In the HSP, adult learners are presented with different learning conditions meant to simulate the different kinds of information that may be available at different points in development. For example, to simulate learning words from observational contexts alone, participants might view a muted video vignette of parent-child interactions around the moments particular target words (e.g., "ball", "toy") are heard (see Figure 1). In a different condition simulating learning words from the syntactic input, participants might view the syntactic context containing those target words in child-directed speech (e.g., "mo enz a RENCK" for the actual heard sentence "it's a ball"). In each condition, participants' task is to identify the target word's identity. The logic of the HSP is that the relative ease with which participants identify the mystery word across conditions speaks to the informativity of the different kinds of input for acquiring the meaning of those words.

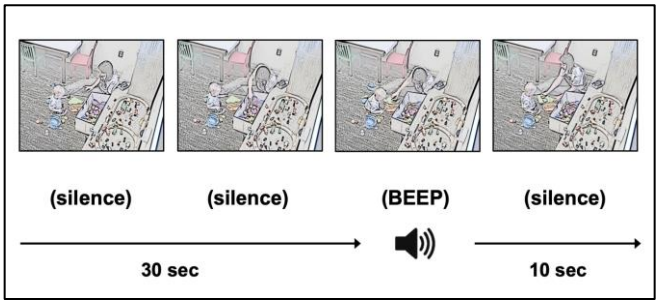

Figure 1. Schematic of a trial in the Human Simulation Paradigm: participants view a muted video vignette except for a beep that is played at the exact moment parents uttered a target word of interest; participants' task is to guess the word at the end of the trial.

Of particular interest to the current discussion is Kako's (2005) study which employed the HSP revealing that the informativity of different types of input varied across different noun types. More specifically, although participants readily used the non-linguistic observational contexts to identify nouns denoting the more concrete, basic-level object category (BLOC) terms (e.g., "ball", "hat"), they struggled to do so for nouns denoting the more abstract, non-basic level object (NBLOC) category terms (e.g., "music", "toy"). Kako found that successful identification of NBLOC nouns required access to their *linguistic* contexts. Kako's data are consistent with a broader theoretical perspective that there exist a class of "hard words" for which learning their meanings requires access to information beyond the observational contexts in which those words occur (see Gleitman et al., 2005; Gleitman & Trueswell, 2020; Piccin & Waxman, 2007; Snedeker & Gleitman, 2004).

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The goal of the current study is to revisit the role of the non-linguistic, observational context in the acquisition of NBLOC nouns. The hypothesis that undergirds the current study is that the key dependent variable in the HSP (i.e., identifying the *exact* word uttered by a parent) may fail to capture systematic partial word meaning that can be gleaned from observational contexts. Uncovering with more precision the elements of word meaning that can and cannot be acquired via observational contexts has implications not only for understanding the informativity of the observational world for word learning, but also for understanding the ways in which linguistic information may bolster learning.

Several lines of research support the possibility that Kako's HSP results may indeed have underestimated the role of observational contexts for NBLOC noun learning. First, a long history of studies suggests that task differences or measurement differences within tasks can lead to differences in estimates of word learning (e.g., Bergelson & Aslin, 2017; Hendrickson et al., 2015; Horst & Samuelson, 2008; Yurovsky et al., 2013). Second, several word learning scholars have construed word learning as a multi-process system, whereby in-the-moment referent identification (arguably what is most likely captured by the dependent variable in the HSP) can be dissociated from the process of aggregating lexicosemantic knowledge (Clerkin & Smith, 2022; McMurray et al., 2012; Wojcik et al., 2022). Finally, research on the acquisition trajectories of words denoting colors (Pitchford & Mullen, 2003; Sandhofer & Smith, 1999; Wagner et al., 2013), emotions (Ogren & Sandhofer, 2022; Widen & Russell, 2003), durations of time (Shatz et al., 2010; Tillman & Barner, 2015), and body parts (Waugh & Brownell, 2015; Witt et al., 1990), among others, all suggest that word learners go through stages of partial learning, leaving open the distinct possibility that observational contexts play a key role in shaping that partial knowledge.

In the current study, we designed a novel word learning experiment that deviates from the HSP design in several ways to reexamine the role of the observational contexts for learning NBLOC nouns. First, we implemented a category learning task (e.g., Kalra et al., 2019) in which participants were presented with both vignettes that did and did not contain the mystery word and were then asked to categorize whether or not each vignette contained the mystery word. Second, although, like Kako (2005), we asked participants to identify the mystery word at the end of the study, we also analyzed the nature of participants' errors. Finally, after participants offered their guess for the identity of the mystery word, we presented participants with a semantic ratings task whereby participants saw a set of NBLOC nouns (including the mystery word) and had to rate the similarity in meaning of the mystery word to each NBLOC noun (Lazaridou et al., 2017). This design (i.e., categorization task, error analyses, semantic rating task), allowed us to examine whether participants extracted systematic partial knowledge of NBLOC word meanings from their observational contexts even when they failed to identify the exact NBLOC word meaning.

Methods

Participants

120 adults participated in this study which was conducted entirely online. Sixty participants were paid participants recruited through Prolific (https://www.prolific.co). The other sixty participants were undergraduate students enrolled in psychology courses at the University of Connecticut; These students received course credit for their participation.

Stimuli

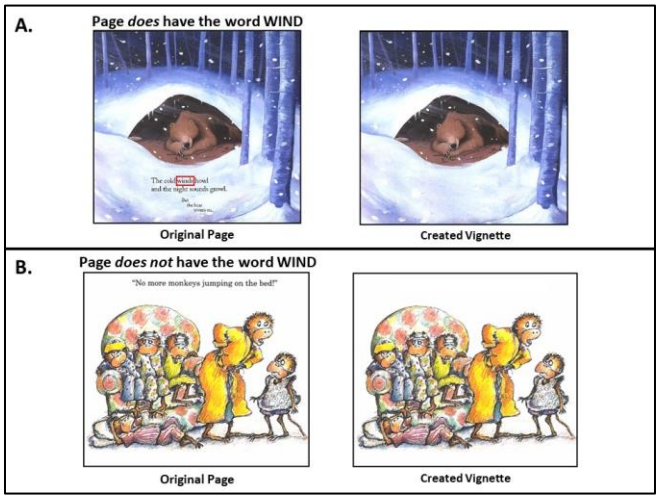

Figure 2. Example vignettes used in the current study. (A) a target vignette for the word "wind" (left side: the page as it appeared in the book; right side: the textless scene presented to participants); (B) a distractor vignette for "wind".

The stimuli for the current study deviated from most Human Simulation Paradigm studies (e.g., Gillette et al., 1999; Medina et al., 2011) that use brief video clips of child-directed speech as the vignettes from which participants must learn. The vignettes for the current study were static scenes taken from children's picture books (see Figure 2) and consisted of 160 *target vignettes* and 320 *distractor vignettes*. The target vignettes belonged to one of ten target nouns (16 vignettes per target noun) denoting a NBLOC noun (see Table 1). Following Kako (2005), NBLOC nouns are those that meet at least one of the following criteria: (1) they do not label a whole object, (2) they are situationally dependent, and (3) their referents are not similar in shape. The NBLOC nouns used in this study were selected to represent different types of NBLOC nouns that are known to be acquired early in development.

Table 1: Target Nouns and their Age of Acquisition

Target Noun	Age of Acquisition[1]	Target Noun	Age of Acquisition
Dinner	.86	Story	.84
Friend	.78	Tomorrow	.59
Hand	.95	Toy	.96
Morning	.76	Water	.98
School	.91	Wind	.76

Vignette Selection and Construction. All target vignettes contained the target NBLOC noun in its original text. These vignettes were randomly selected from a corpus of over 300 children's picture books, with each target vignette of a target noun coming from a unique picture book. Picture book pages were considered candidate target vignettes if the target noun was: (1) the head noun of the phrase, (2) used in its predominant meaning (e.g., "school of fish" would not have been considered as a target vignette for "school"), and (3) not used in an expression (e.g., "quick as the wind" would not have been considered as a target vignette for "wind"). Both singular and plural forms of the target noun (e.g., "toy", "toys") were considered acceptable target vignettes. For both "morning" and "tomorrow", some of the vignettes were in adverbial form[2].

Vignettes were created by scanning the page and removing its text (see Figure 2). For each target vignette, two separate "distractors" were created for the purpose of creating two Category Learning Task lists. Picture book pages were considered candidate distractor vignettes if they did not contain the target noun, were from a book in the same age range as that used for the target vignette and were not from a book that had already been used for a target vignette or a distractor vignette within the same experimental list.

Experimental Lists. For each target noun, two lists of 32 vignettes were created. The two lists differed only in their 16 distractor vignettes. In all, there were 20 experimental lists and each participant completed one list.

Experimental Design

The experimental design consisted of a Category Learning Task, a Word Identity Test, and a Semantic Relatedness Test. The experiment was constructed and hosted online on Gorilla Experiment Builder (https://gorilla.sc; Anwyl-Irvine et al., 2019).

Category Learning Task. For each trial of the Category Learning Task (see Figure 3), participants were presented with either a target or distractor vignette. Three seconds after the vignette appeared on the screen, participants were asked to indicate whether they thought the vignette had contained the mystery word in its original text (i.e., whether the vignette was a target or distractor vignette). Prior to the experiment, participants were told that the mystery word would go by the meaningless code name "MODI". Thus, participants were prompted to indicate by pressing one of two buttons whether they thought the scene "had the word 'MODI'". Immediately following participants' guess, they received feedback on whether their guess was correct or incorrect. The Category Learning Task consisted of 32 trials (16 target trials and 16 distractor trials) presented in a semi-random order[3]. By presenting participants with both scenes that did and did not contain the mystery word, this design simulates children's experience of hearing particular words in some contexts and not others.

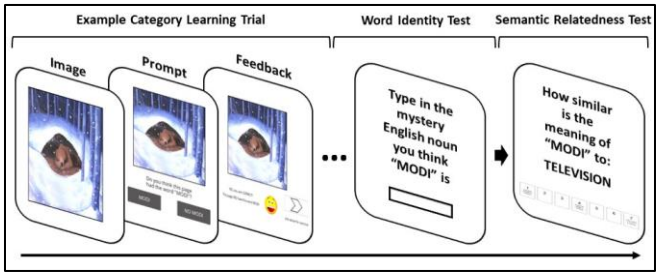

Figure 3. The Experimental Design. Left: example trial structure of the Category Learning Task; Middle: word identity prompt, Right: example trial in the Semantic Relatedness Test.

Word Identity Test. Immediately following the Category Learning Task, participants were asked to guess the identity of the English noun that was represented by the word "MODI" (see Figure 3).

Semantic Relatedness Test. Following the Word Identity Test, participants were asked to rate the similarity of the meaning of "MODI" to that of ten English nouns, including the target noun for that list and the other nine target nouns of this study. On each semantic-relatedness trial, participants saw a single noun and were asked to rate the similarity of "MODI" to that noun on a scale of 1 ("completely unrelated in meaning") to 7 ("highly related / identical in meaning"). To acclimate participants to this task, participants were first asked to rate the similarity of MODI to the word "television". The ten nouns of interest were presented sequentially in random order.

Procedure

Prior to the study, participants completed the informed consent process and a brief demographic questionnaire. Participants were then introduced to the task through two

[1] Age of acquisition scores are based on 30-month-old MCDI production norms (Fenson et al., 2007).

[2] None of the current effects were driven by these two stimuli. If anything, including data from these two stimuli may underestimate our effects.

[3] The 32 trials were divided into four blocks of eight trials (four target and four distractor trials). Trial order within blocks was randomized.

practice sets. Each practice set consisted of ten Category Learning trials (5 target and 5 distractor trials) and the Word Identity Test. The structure of the practice trials was identical to the structure of the experimental trials described above. However, at the end of each practice set, participants were shown the correct answers for both the Category Learning trials and the Word Identity Test. The target nouns for the two practice sets were "cow" and "farm." Following the completion of the practice sets, participants proceeded to the experiment proper, completing the Category Learning Task, the Word Identity Test, and the Semantic Relatedness Test. The entire procedure lasted about 20 minutes.

Results

Performance on Word Identity Test

Following the coding scheme of previous HSP studies (Gillette et al., 1999), participants' guesses in the Word Identity Test were scored as either correct or incorrect. Guesses were coded as correct if they were identical to or shared the same root word as the target noun (e.g., "toys" and "windy" were scored as correct for the target "toy" and "wind"). Any guesses that did not share the root word with the target noun were scored as incorrect, regardless of how close in meaning they were to the target noun (e.g., "stuffed animal" was scored as incorrect for the target "toy"). Overall, 18.3% of participants (range per target noun: 0-75%) identified the correct target noun, a percentage that is remarkably similar to what Kako (2005) found (22.7%) in an HSP study using video vignettes of NBLOC nouns in child-directed speech.

Analysis of Error Patterns. Of particular interest in this study is the partial knowledge participants may have acquired when they failed to learn the target noun. One analysis that speaks to this knowledge is an analysis of the errors participants made. Thus, each target noun – error pair was submitted to a semantic similarity task in which a separate group of participants (n = 110) rated "how closely related in meaning" (on a 7-point scale) the target noun was to the errors produced for that target noun. For comparison, participants also rated the semantic similarity of the target noun to the errors produced for the other set of target nouns. As seen in Figure 4, participants rated errors belonging to a target noun (M = 3.44, SD = 1.63) as being closer in meaning to that noun than errors belonging to the other nine target nouns (M = 2.40, SD = .93), $t(109) = 8.21$, $p < .001$, d = .78. Thus, although the observational context of NBLOC nouns may have been insufficient to lead participants to the *precise* identity of the target noun, it did appear to lead participants to the right semantic neighborhood. For example, participants offered the guesses "storm", "kids", and "play" for the target nouns "wind", "school", and "friend", respectively.

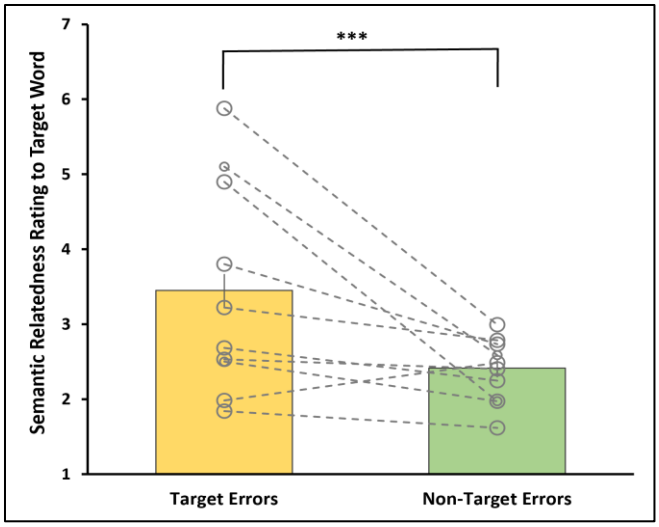

Figure 4. Mean semantic relatedness ratings between target nouns and the errors produced in the Word Identity Test for that target noun, and between target nouns and the errors produced for the other set of target words. Dotted lines represent the mean ratings for the ten target nouns. Error bars reflect standard errors of the means (SEM). *Note*: *** $p <$ .001.

Performance on Category Learning Task

A second analysis that speaks to the partial knowledge about NBLOC nouns participants acquired is the performance on the Category Learning Task, especially the performance of those who did not identify the precise target noun in the Word Identity Test. Following the protocol of other category learning studies (e.g., Kalra et al., 2019), performance was split into the first and second halves (first 16 trials and next 16 trials) of the study. For each half, we calculated the proportion of trials in which participants correctly identified whether the vignette did or did not contain the mystery word. Overall, the participants performed above chance (.50) in both the first (M = .57, SD = .14), $t(119) = 5.18$, $p < .001$, d = .47, and second half (M = .58, SD = .16), $t(119) = 5.65$, $p <$ .001, d = .52. Not surprisingly, by the second half of the study, participants who identified the correct target noun in the Word Identity Test (M = .76, SD = .15) outperformed those who did not (M = .54, SD =.14), $t(118)$, $p < .001$, d = 1.58. Most importantly for the current study, however, as depicted in Figure 5, is the fact that even those participants who did not guess the correct target noun nonetheless performed significantly better than chance rates (M = .50) by the second half of the Category Learning Task, $t(97) = 3.17$, $p < .005$, d = .32. This suggests that even when the observational context did not yield correct NBLOC word-to-referent mappings, it nonetheless allowed learners to identify the likely observational contexts in which you might and might not observe the word being uttered.

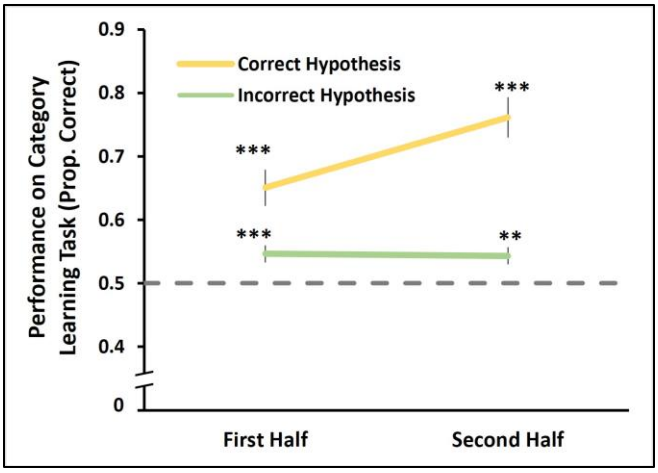

Figure 5. Performance on the Category Learning Task over the course of the study as a function of guess accuracy on the Word Identity Test. Error bars represent SEM. *Note*: ** $p < .01$, *** $p < .001$.

Performance on Semantic Relatedness Test

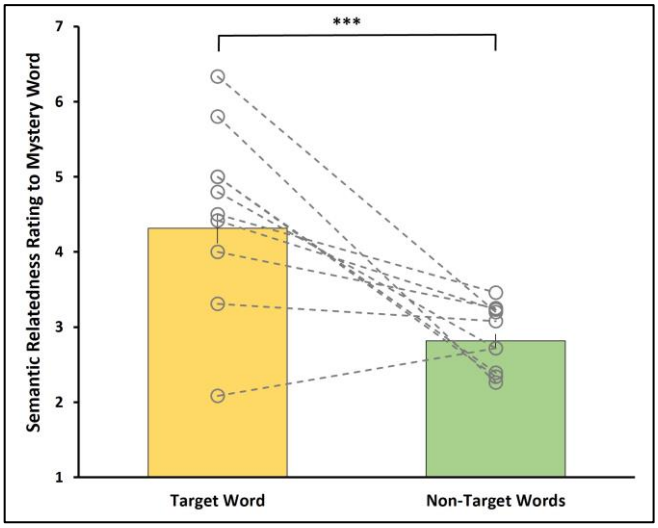

Figure 6. The average rating on the Semantic Relatedness Test of the mystery word to the target word and to the other set of target words. Error bars represent SEM. *Note*: *** $p < .001$.

Across participants, we computed the average semantic relatedness judgment between the mystery word and the target noun. Additionally, we computed the average semantic relatedness judgments between the mystery word and the other nine nouns. Unsurprisingly, the participants who correctly guessed the target word in the Word Identity Test rated the mystery word as more semantically related to the target noun (M = 6.86, SD = .35) than participants who posited an incorrect guess in the Word Identity Test (M = 4.32, SD = 2.01), $t(118) = 11.72$, $p < .001$, $d = 1.39$. Of greater interest to the current study, however, is the finding that even participants who did not guess the correct target noun in the Word Identity Test nonetheless rated the mystery word as more similar to the target noun (M = 4.32, SD = 2.01) than to the other nine nouns (M = 2.82, SD = .88), $t(97) = 6.74$, $p < .001$, $d = .68$. This suggests that the observational context led these participants to the target word's correct semantic neighborhood.

General Discussion

There is a long history in the lexical acquisition literature of studies highlighting the limits of observational information for acquiring the *complete* meaning of "hard words" (see Gleitman et al., 2005). There is a much shorter history however that explores whether there are *some* aspects of meaning of these hard words, and if so which, that can be learned via observation (West et al., 2022; Zhang et al., 2020). The current work represents one step towards better understanding this issue by studying one type of hard word (non-basic level nouns). We created a novel experiment featuring several tests of learning that builds off prior work which employed the Human Simulation Paradigm, a paradigm generally associated with having revealed the shortcomings of observational contexts in learning hard words (see Gillette et al., 1999; Gleitman & Trueswell, 2020). Consistent with previous HSP research, the current data suggest that it is indeed difficult, even for adults, to identify the precise meanings of non-basic level nouns from their observational contexts alone (see Gleitman et al., 2005; Kako, 2005; Snedeker & Gleitman, 2004). However, although participants struggled in acquiring the precise meanings of these nouns, analyses of their error patterns, scene categorization behavior, and semantic relatedness judgments suggest that participants were successful in acquiring systematic partial knowledge that brought them close to the meanings of these nouns.

The current findings extend our understanding of the informativity of observational contexts for word learning in at least two ways. First, a bulk of the research on this topic has focused on the inputs to nouns that denote basic level object categories (Clerkin & Smith, 2022, Suanda et al., 2019, Suarez-Rivera et al., 2022). Although nouns that do not denote basic level object categories occupy a smaller portion of infants' and toddlers' early vocabularies, their acquisition nevertheless demands an explanation (see Bergelson & Swingley, 2013). The current data represent a proof-in-concept that there are aspects of the meanings of these nouns that may be learnable simply from their word-to-world co-occurrence patterns. Second, this work underscores the importance of considering what counts as learning in assessing the informativity of the input. These results suggest that if the threshold for learning is the capacity to identify the exact word meaning intended by a speaker (the classic dependent variable in the HSP), then the current findings are in line with prior work showing the limits in the informativity of observational contexts (see, Kako, 2005). However, a wealth of data over the years has revealed that the learning of all kinds of words is a long and protracted process (Tillman

& Barner, 2015; Ogren & Sandhofer, 2022; Wagner et al., 2013). Thus, whether a source of the input does not get learners all the way there does not preclude the possibility that that source of input might play an important role in getting learners partially there or in laying the foundation upon which other sources of input can build.

In line with this goal of furthering our understanding of the role the observational context plays in the learning of hard words, we suggest multiple future directions that address the limitations of the current work. First, it remains to be seen whether the learning patterns exhibited by adult participants in our study generalize to children's word learning. Although the current findings offer an important step in revealing the potential value of the observational context in learning hard words, extending a simplified version of this task to child participants is a crucial next step. Furthermore, we also recognize that picture books are just one of the many valuable sources of input for language-learning children (Horst & Houston-Price, 2015; Montag et al., 2015) and extending the current work to video vignettes of child-directed speech is also an important next phase of the current work.

Multiple interesting future directions also emerge from notable patterns in the current data. First, across all the analyses we conducted, we observed a great deal of inter-word variability (see Figure 7), suggesting that while observational contexts may even be sufficient for acquiring the complete word meaning of some NBLOC nouns, they may play a much more limited role in acquiring even partial word meanings for others. It is important to note here the critical role that the linguistic context has been found to play in word learning more generally (Gleitman et al., 2005; Snedeker & Gleitman, 2004), and for learning NBLOC nouns more specifically (Kako, 2005). Future work that extends the current design to better understand the nature and the sources of this inter-word variability may help us understand the precise ways that observational and linguistic contexts jointly shape word meaning acquisition. Second, the current data suggests that the contexts in which the hard nouns (e.g., "wind") occur in are sufficiently informative to allow learners to distinguish scenes that do and do not contain those words. However, whether those contexts allow learners to distinguish between scenes containing words that overlap a great deal in meaning (e.g., "breeze") is an open question. Finally, the current data say little about the quantity or quality of these scenes responsible for the partial knowledge we observe, a topic that is of great interest in the word learning literature (see K. Smith et al., 2011; Gleitman & Trueswell, 2020; Yu & Smith, 2012). A cursory interpretation of the categorization patterns of participants who acquired partial knowledge in the Category Learning Task suggests that they acquired that knowledge very rapidly and then exhibited very little improvement over time (see Figure 5). Although such an interpretation would be consistent with Susan Carey's classic two-phase model of learning word meaning (Carey & Bartlett, 1978; Carey, 2010), whether that interpretation is correct for these data awaits more careful analyses and future work.

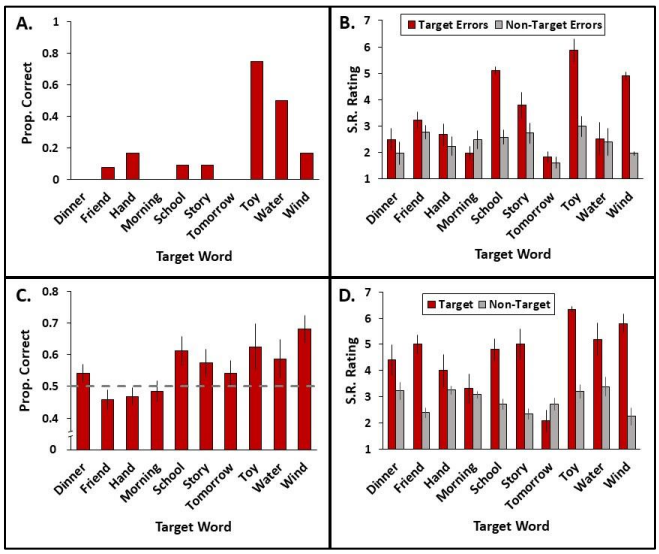

Figure 7. *Inter-word variability across all four key analyses: (A) Proportion of correct guesses on the Word Identity Test; (B) Mean semantic relatedness ratings of errors produced in the Word Identity Test; (C) Mean proportion correct in the second half of the Category Learning Task (only including participants who guessed incorrectly in the Word Identity Test); (D) Mean semantic relatedness judgments between the mystery word to the target noun and to the other set of nouns in the Semantic Relatedness Test.*

Conclusion

The composition of children's early vocabularies has long piqued the interest of cognitive and developmental scientists alike. The fact that some word types dominate early vocabularies and other word types appear much less common has historically served as a window into the key differences in the underlying acquisition processes of different word types. A different fact about vocabulary development, however, is that the trajectory in meaning acquisition of even a single word is often a protracted one (e.g., Ameel et al., 2008). A consequence of this protracted trajectory is that what can be concluded about underlying processes will depend on the assessments and thresholds used to determine which words are and are not part of a child's early vocabulary – or, in other words, how word learning is defined. Although further work is needed, the current data suggest the possibility that exploring a range of assessments of word knowledge may turn out to reveal more similarities in the acquisition processes of different word types than has commonly been assumed.

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