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Looking in the Wrong Direction Correlates With More Accurate Word Learning

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Abstract

Previous research on lexical development has aimed to identify the factors that enable accurate initial word-referent mappings based on the assumption that the accuracy of initial word-referent associations is critical for word learning. The present study challenges this assumption. Adult English speakers learned an artificial language within a cross-situational learning paradigm. Visual fixation data were used to assess the direction of visual attention. Participants whose longest fixations in the initial trials fell more often on distracter images performed significantly better at test than participants whose longest fixations fell more often on referent images. Thus, inaccurate initial word-referent mappings may actually benefit learning.

Keywords: Word learning; Fast mapping; Initial accuracy; Statistical learning

1. Introduction

The speed and efficiency of word learning present a puzzle. Learning a word involves at the very least encoding the relevant form-meaning mapping, representing the word's syntactic properties, and learning the conditions of its use. It may also entail profound conceptual reorganization (Carey, 1978). Yet by age 6, children have vocabularies of about 14,000 words and mastery of most syntactic and pragmatic rules of their language (Bloom, 2000; Carey, 1978). Given the demands of the task, how do children become proficient language users so fast?

A key to this puzzle is the human ability for fast mapping. Fast mapping involves encoding a new word in long-term memory and representing some of its syntactic and

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semantic properties from a single exposure (Carey, 1978). Accordingly, language acquisition and development research has targeted the identification of attentional (Regier, 2005; Samuelson & Smith, 1998), pragmatic (Baldwin, 1993), conceptual (Gentner, 1982; Markman, 1990), phonological (Cassidy & Kelly, 2001; Fitneva, Christiansen, & Monaghan, 2009), and other biases, assumptions, or predispositions that may assist learners in accurately mapping words to referents. The assumption behind much of this research is that it is not only the swiftness of fast mappings that accounts for the speed and efficiency of word learning but also its accuracy (e.g., Markman, 1989).

In Carey's original study of fast mapping a teacher introduced the word *chromium* (meaning olive color) by a request: ''bring me the chromium tray, not the blue one, the chromium one'' (Carey, 1978). The request provided syntactic and lexical cues that the novel word referred to color, as well as contextual cues (the presence of only one other tray in a common color) that could suffice for accurately and completely learning the new word. Nevertheless, some children appeared to have only learned the word form itself and not associated any stable semantic features with it, some adopted a wrong hypothesis about its meaning, for example, green, and some did not show any evidence of learning. The incidence of incorrect initial mappings may be substantial under conditions of greater uncertainty. Such conditions may exist, for example, when a new word is used alone, when it is used amid other unfamiliar words, or when it is encountered in the context of listening on others' conversations.

A capacity to track the co-occurrences of words and potential referents across situations could help rectify inaccuracies in fast mapping and explain the quick induction of word-referent mappings in the absence of constraints or biases helping the learner hone in on them (e.g., Siskind, 1996). For example, if in situation *i*, a learner sees items *a* and *b* and hears words *A* and *B* and in situation $i + n$ she sees items *a* and *c* and hears words *A* and *C*, she may be able to infer the correct word-referent mappings, that is, *A-a, B-b,* and *C-c*, even if there are no spatial or temporal cues to these mappings. Indeed, in a series of recent experimental studies, Yu and Smith demonstrated that both infants and adults are able to use such cross-situational statistics to learn the meaning of several new words over a short period of time (Smith & Yu, 2008; Yu & Smith, 2007). Thus, even if learners make inaccurate initial word-referent mappings, they can still rapidly acquire robust representations of the accurate mappings.

Nevertheless, Yu and Smith (2006) suggested that the probability of making accurate initial word-referent mappings is a critical determinant of the outcome of cross-situational learning, for two reasons. First, an incorrect mapping would require correction on a subsequent trial (or lead to an incorrect response at test if uncorrected). Second, an accurate initial mapping may facilitate learning by allowing the learner to focus on identifying other mappings. These two points resonate with the traditional view that accurate initial mappings are key to set the learner on the fast track of vocabulary development.

Despite the key role initial accuracy has played in language learning theory and research, thus far there is no direct empirical evidence for its importance. Although much research attempts to evaluate the relative strength of initial biases in guiding word-referent mapping (e.g., Brandone, Golinkoff, Pence, & Hirsh-Pasek, 2007; Fitneva et al., 2009; Hollich et al., 2000; Houston-Price, Plunkett, & Duffy, 2006) or how many exposures to a word-referent mapping are sufficient for learning (Houston-Price, Plunkett, & Harris, 2005), we still do not know whether and to what extent word learning is facilitated by accurate mappings and impeded by error.

Language researchers have always been aware that corrections provide a powerful constraint on learning (Markman, 1992; Pinker, 1984). The idea that initial word-referent associations have to be accurate has been primarily driven by arguments that corrections interrupt the course of communication and the processes that subserve it. Corrections may also trigger broader revisions of the linguistic and conceptual systems of which the word and referent categories are part. Even holding the old, inaccurate meaning in memory together with the new, accurate one may require cognitive effort to resolve the conflict. Thus, corrections may slow learning down, which is seen as incompatible with the speed of word learning. However, recent research suggests that this argument may not always be right. In particular, work on the role of fluency in cognitive processes—the incidental experience of ease or difficulty associated with undertaking a cognitive task—reveals that experiencing disfluency leads to more elaborate subsequent processing (Alter, Oppenheimer, Epley, & Eyre, 2007; Oppenheimer, 2008; Oppenheimer & Frank, 2007). For example, Alter et al. (2007) found that when participants initially experienced difficulty with a task, they subsequently made more systematic judgments and showed improved syllogistic reasoning. Similarly, participants in a categorization task gave higher typicality ratings when they first had experienced mild cognitive disfluency (Oppenheimer & Frank, 2007; M. F. Frank, personal communication, June 9, 2009). More generally, Bjork (1994) argued for ''desirable difficulty'' in learning and reviewed evidence suggesting that difficulty experienced during learning leads to better long-term retention. Thus, the experience of disfluency or difficulty that the correction of incorrect initial word-referent mappings may create in learners could promote more elaborate and systematic processing and thus facilitate rather than impede word learning.

The present experiment was designed to test these conflicting predictions about the role of accuracy of initial referent mappings with adult learners in a cross-situational word learning paradigm. We were interested in whether learners who show more accurate initial word-referent mappings would perform better or worse than those with fewer accurate initial mappings.

To identify the initial word-referent mappings without interfering with the learning process, we relied on eye-movement measures. The learning trials were classified as correct or incorrect depending on whether the location of the longest fixation was on the target image or distracter. It is important to note that we will use the term ''initial mappings'' without committing to whether these mappings are consciously made (e.g., as in a deliberate guess about the meaning of a word) or whether they arise as a byproduct of independent auditory attention and visual exploration processes. In either case, ''correct mapping'' refers to a situation where visual attention is directed to the correct referent. (We return to this issue in the Discussion.) Depending on the proportion of correct mappings in the first learning block, participants were classified as having high or low initial accuracy. There were four learning blocks in the study and the target word-referent mappings in principle could be identified as soon as Block 2. To assess learning, participants were given a forced-choice recognition test.

2. Method

2.1. Participants

Forty undergraduate students participated in the study in exchange for course credit (mean age 21.75 years, range 20–28). All were monolingual, native speakers of English and all reported no history of speech, hearing, or reading disability.

2.2. Materials

Twenty-four monosyllabic pseudowords were used in the study, all phonologically valid in English. The words were recorded by a trained female native English speaker. Twelve pictures of common objects and twelve pictures of actions served as referents (a key, a feather, running, dancing, etc.). By including actions, we aimed to extend prior work on cross-situational word learning, which has been constrained to object label learning (Gillette, Gleitman, Gleitman, & Lederer, 1999). As we note below, referent category had no effect in the analyses, thus showing that cross-situational statistics contribute to the learning of both object and action labels.

2.3. Design

The pseudowords were divided into two sets. One was paired with the object pictures and the other with the action pictures. The exact picture-pseudoword pairing was randomized across participants.

There were 48 learning trials split into four blocks of twelve. Each learning trial combined an action-pseudoword and an object-pseudoword pair. The counterbalancing of picture location and pseudoword order resulted in four types of trials: object picture on the left—object label first, object picture on the left—object label second, object picture on the right—object label first, and object picture on the right—object label second. Every block contained three trials of each type. Each picture-pseudoword pair appeared four times in the course of the study (once in each block) and the location of a picture (on the left or on the right) and the order of the corresponding pseudoword (first or second) were counterbalanced across the four occurrences. Two picture-pseudoword pairs appeared together only once. Consequently, although no explicit feedback was provided, participants could begin to assess the accuracy of their word-referent associations based on cross-situational statistics in Block 2.

Two test lists, 12 items each, were generated by evenly dividing the two sets of pseudowords. In each test trial, participants heard a single pseudoword and saw two pictures of the same category (e.g., two objects). Seeing two pictures of the same category ensured that participants could not use potential intuitions about the lexical category of a word to guess the correct referent. The number of test trials was limited to 12 to avoid presenting images as both targets and distracters and ensure the independence of each test trial. The target and distracter locations were counterbalanced across trials and trial order was randomized. The presentation of the two test lists was counterbalanced with the two pairings of pseudoword lists and referent category.

2.4. Procedure

Participants were randomly assigned to pseudoword list—referent category pairing and test list. They were seated approximately 60 cm from the monitor of a Tobii 1750 remote eye tracker in a dimmed, sound-attenuated room. Eye movement data were recorded at a 50 Hz sampling rate and sound stimuli were delivered over headphones.

For the learning phase of the study, participants were instructed that their task was to figure out which word corresponded to which image. There were two practice trials with English words and images not used in the study. Each trial began with a fixation point in the middle of the screen for 250 ms, after which the two images were presented simultaneously on the screen. One second later, the two pseudowords were played one after the other with a 750 ms silence after each.

For the test trials, the participants were instructed to place their dominant hand on the computer keyboard and to use the 1 and 2 keys to select the left and right image, respectively. After a fixation point that appeared for 250 ms, the two images were presented for 1 s before the pseudoword was played. Participants were asked to identify the pseudoword's referent as quickly and accurately as possible.

2.5. Data analysis

We relied on the location of the longest fixation as an index of the direction of visual attention. Word learning studies have found that the longest fixation on an image is a sensitive and robust measure of target preference with relatively little influence of extraneous variables such as trial duration (Schafer & Plunkett, 1998).[1] We validated the location of the longest fixation as an index of the language learner's most likely choice of a referent by examining its relation with participants' choice of referent at test. The location of the longest fixation was indeed strongly correlated with participants' choice of a referent.[2]

We used generalized estimating equations (GEEs) to analyze repeated measures binary data (Carey, Zeger, & Diggle, 1993) and report Wald chi-square statistics as measures of statistical significance. Mixed models analyses of variance were used to model continuous repeated measures data, and we report the F-statistics associated with the fixed effect variables. Preliminary analyses showed that the order in which words were presented during a learning trial did not affect our dependent measures, so we considered performance with one word as independent from performance with the other. Hereafter, we use the term ''learning trial'' to refer to the time period from the onset of a pseudoword to the end of the pause after it. Preliminary analyses also revealed no effects of test list, pseudoword list, and referent category. Therefore, these variables are not discussed further.

3. Results

Consistent with previous studies of adult cross-situational word learning (Yu & Smith, 2007), performance at test was robust: Mean accuracy was 83%. The main question of the study, however, was whether and how learning was affected by the accuracy of participants' initial word-referent mappings. We used the location of the longest fixation in a trial to categorize the mappings of pseudowords and referents as correct or incorrect. We only considered fixations in the target and distracter regions from 200 ms after the onset of a pseudoword to the end of the subsequent pause on learning trials and to the participant's response on test trials. It takes approximately 200 ms to plan and launch an eye movement in response to an auditory cue (Viviani, 1990). Not surprisingly, the average accuracy of word-referent mappings in Block 1 was 50%. Nonetheless, the initial accuracy of these mappings was negatively correlated with test performance, $r = -.36$, $p = .025$. To further explore this relationship, we performed a median split on the basis of the proportion of correct trials in Block 1 and divided the participants into High and Low initial accuracy groups. Fig. 1 reports the study's principal result. Contrary to the expectation that accurate initial mappings would result in better learning, the accuracy of initial mappings was inversely related to participants' accuracy at test. The Low initial accuracy group performed significantly better at test than the High initial accuracy group: 90% versus 76%, Wald χ^2 (1) = 14.483, $p < .001$.

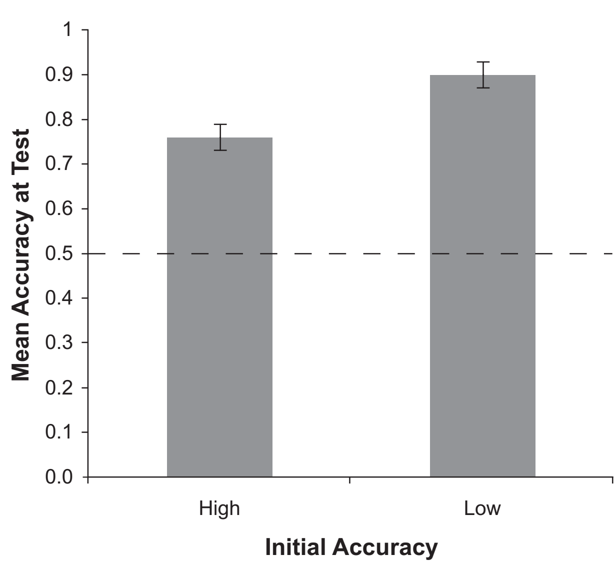

Fig. 1. Mean accuracy at test as a function of participants' accuracy in Block 1. Error bars indicate ±1 *SE*.

We carried out three supplemental analyses to determine the robustness of the inverse relation between the accuracy of initial word-referent mappings and word learning. First, to ensure that the inverse effect of initial accuracy reflects the strength of word-referent representations and not a speed-accuracy trade-off, we examined whether there were reaction time differences between the groups at test. Incorrect trials and trials with response times more than two standard deviations away from the mean were excluded. A mixed model analysis of variance revealed no significant difference between the High and Low groups, $F(1, 37.8) = 1.219$, $p = .27$, suggesting that the inverse relation between the accuracy of initial mappings and accuracy at test is unlikely to be due to speed-accuracy tradeoffs. Indeed, the Low group's responses were somewhat faster than the High group's: 908 ms versus 1070 ms.

Second, we examined the relation between the accuracy of initial mappings and the latency of moving the eyes away from the initially fixated image on test trials, which has been extensively used in the last 10 years as an implicit measure of word-referent knowledge (e.g., Fernald, Pinto, Swingley, Weinberg, & McRoberts, 1998; Swingley & Fernald, 2002). Prior research has shown learning-related decreases in the time it takes to move the eyes away from initially fixated distracter images (for a method overview, see Fernald, Zangl, Portillo, & Marchman, 2008). Here, we also considered trials where participants initially fixated on the target. We reasoned that effects of learning would be reflected in these trials as well, with better learning resulting in participants taking longer to look away from the image. We did not include trials where (a) one of the images was not fixated at the onset of the pseudoword, (b) the shift occurred earlier than 200 ms after pseudoword onset (because such eye movements may not be stimulus driven), or (c) the eye movement did not result in a fixation on the other image before the end of the trial. Trials where no shift occurred by the end of the trial were included. Fig. 2 shows the summary data for the two groups. A linear mixed model showed that participants moved their eyes more slowly when

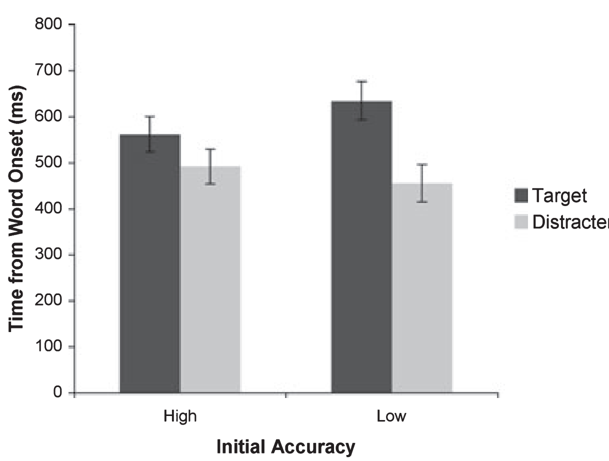

Fig. 2. Mean latency to initiate a shift from the initially fixated image on test trials. The data are shown as a function of participant initial accuracy and whether the target or distracter image was initially fixated. Error bars indicate ±1 *SE*.

they fixated on the target rather than the distracter at pseudoword onset, $F(1, 222.3) = 8.963$, $p = .003$. This trend was present in both groups and the interaction term was not significant, $F(1, 222.3) = 1.725$, $p = .19$. However, as Fig. 2 shows, participants in the Low initial accuracy group were 36 ms faster than participants in the High initial accuracy group in shifting their eyes from the distracter, and 73 ms slower in shifting their eyes away from the target. Consistent with the behavioral data, this finding indicates that the greater the number of longest fixations on distracters in Block 1 is, the better subsequent learning is. The latency of looking away from the initially fixated image in test trials depended on whether that image was the target or distracter only in the Low initial accuracy group, $F(1, 117.5) = 9.907$, $p = .002$. There was no effect of category of fixated image in the High initial accuracy group, $F(1, 103.7) = 1.371$, $p = .24$.

In the third supplemental analysis, we examined whether participants who performed at above-chance level at test differed in their accuracy of initial mappings from those whose performance was below or at chance level at test. For this analysis, we separated participants into those who had 10 or more correct answers at test (i.e., performed significantly above chance according to a binomial test) and those who had 9 or fewer correct answers. There were 24 participants in the former group and 16 in the latter. On average, the longest fixation was on the correct referent in 49% of the trials in Block 1 for learners who performed above chance at test and in 54% of the trials in Block 1 for learners who did not perform above chance, Wald χ^2 (1) = 5.401, $p = .02$. Thus, this analysis also revealed an inverse relationship between the accuracy of initial mappings and learning outcome.

In addition to the above analysis, we explored the changes in visual attention over the learning phase. Fig. 3 depicts the proportion of trials where the longest fixation was on the target for each block. An analysis of fixation location (i.e., whether the longest fixation was on the correct or incorrect referent) as a function of group (high vs. low accuracy of initial mappings) and block (2, 3, and 4) revealed a significant overall increase of the proportion of longest fixations on target over block, Wald χ^2 (1) = 4.813, $p = .028$. The block x group interaction was not significant, Wald χ^2 (1) = 1.325, $p = .250$. However, as Fig. 3 suggests, the linear increase in the proportion of longest fixations on target was significant in the Low initial accuracy group, Wald χ^2 (1) = 6.232, $p = .013$, but not in the High initial accuracy group, Wald χ^2 (1) = .48, $p = .48$. Thus, the learning outcomes for the two groups were correlated with visual attention differences in the learning phase. (Given the fluctuations of the means apparent in the High initial accuracy group, there could be a question as to whether this group may surpass the Low initial accuracy group in a later block. The fluctuation function cannot be estimated on the basis of three blocks of data, but based on the linear functions, the groups can be expected to continue to diverge. Fig. 3 shows the predicted performance of the two groups in a hypothetical Block 5.)

Finally, we asked whether the inverse effect of word-referent mapping on learning is specific to the initial word-referent mappings.[3] Given that the uncertainty about the mappings could be resolved as early as Block 2, the accuracy of word-referent mappings in later blocks should be positively correlated with learning. The question is, when does this happen? To explore this question, we examined how word-referent mapping accuracy in Blocks 2, 3, and 4 is related to test performance. As for Block 1, we split participants according to

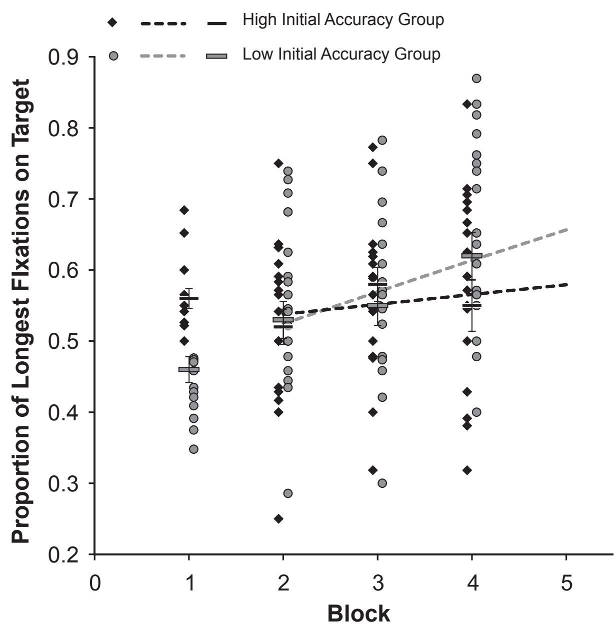

Fig. 3. Proportion of trials in which the longest fixation was on the target image, by participant initial accuracy and block. Group means are indicated with bars; error bars indicate ±1SE. The dotted lines show the linear models fitted to the data from Blocks 2, 3, and 4 and their interpolation to a hypothetical Block 5.

the proportion of trials in which the longest fixation was on the target. In contrast to the previous findings based on Block 1, the accuracy of word-referent mappings in Blocks 2 and 3 was not related to performance at test, Wald χ^2 (1) = .1, p = .75 for both Block 2 and Block 3 accuracy as predictors. The accuracy in Block 4 was marginally but positively related to performance at test, Wald χ^2 (1) = 2.764, p = .09. Participants who showed lower accuracy in Block 4 tended to perform worse than participants who showed higher accuracy: 80% versus 85%, respectively. As indicated by Fig. 3, this reversal reflects that the Low initial accuracy participants as a group surpass the High initial accuracy participants.

4. Discussion

Much previous research has focused on identifying factors that enable accurate mapping of words and referents, but little attention has been paid to the underlying assumption that accurate initial mappings are critical for the speed and efficiency of word learning. The present research provides converging evidence from behavioral and looking measures that initially incorrect mappings may be relatively advantageous compared to initially correct ones, at least in the very early stages of word learning and in conditions of substantial initial uncertainty. The inverse relation between the accuracy of initial word-referent mappings and learning was clear whether we used participants' explicit identification of referents or the latency of moving their eyes away from the initially fixated image as a measure of learning. The inverse relation was not a product of a speed-accuracy trade-off. In addition, it held in reverse: Participants who performed above chance at test were more likely to have fixated the wrong images.

Our findings are consistent with recent work on the role of fluency in cognition, which suggests that when people experience a disfluency with a cognitive task, as our participants may have after an incorrect initial word-referent mapping, they tend to engage in more systematic and elaborate processing (Alter et al., 2007; Oppenheimer & Frank, 2007; see Bjork, 1994; Oppenheimer, 2008, for reviews). The greater number of errors may have led the initially less accurate learners to implicitly adopt a more analytical approach, eventually resulting in better learning. In contrast, the smaller number of errors may have led the initially more accurate learners to adhere to the intuitions that supported their mappings at the beginning. Thus, our findings point toward a prediction-based learning mechanism, in which implicit feedback on the incorrect initial mappings promotes more systematic learning.

As we indicated in the Introduction, the location of the longest fixation may reflect a guess about the meaning of a word or visual exploration. Previous studies show that the location and duration of the longest fixation reliably reveal learners' referent decisions (Schafer & Plunkett, 1998). This was confirmed by our analyses of our test data, although clearly the location of the longest fixation was an imperfect predictor of learners' behavioral responses. In addition, our instructions explicitly directed participants to find the matches between words and referents and during debriefing, when asked about any specific strategy used in learning, a number of participants reported that they tried to guess the word's referent (e.g., on the basis of the sound of the word). Thus, it is likely that the location of the longest fixation in our study reflects learners' guesses. However, a few participants reported that they tried to remember both pairings for any given word. Thus, we cannot rule out that autonomous visual processes rather than a guess about the meaning of the spoken word determined the location of the longest fixation for part of our participants. (There was no association between these reports and whether participants were in the High or Low initial accuracy group.) No matter how learners' initial mappings arose, however, inaccuracy leads to wrong predictions about subsequent word-referent occurrences and thereby offers an opportunity for learning from violations of expectations (e.g., Wills, 2009). Learners will eventually do well even if it is visual exploration that leads them to initially focus on material that is highly informative when cross-situational learning begins (such as the wrong image), and they will do less well otherwise. Thus, the nature of initial word-referent mappings likely does not constrain our finding that initial accuracy correlates inversely with learning.

We would like to point out that natural visual exploration tendencies may in part explain the patterns seen in Fig. 3. In particular, the inhibition of return literature suggests that the visual detection of an object leads to temporary inhibition of the object's subsequent detection (Posner & Cohen, 1984). A mechanism like this would naturally lead to the small fluctuations in accuracy apparent in the data of the High initial accuracy group. But if inhibition of return explains these data, then visual attention may not have been fully engaged in the service of learning. In contrast, what we see in the Low initial accuracy group—a linear increase in the number of fixations on target from Block 2 to 4—may be the harnessing of visual exploration tendencies in the service of learning.

Our analyses also showed that only the accuracy of word-referent mappings in Block 1 was inversely related to learning outcomes at test. By Block 4, there was a positive relationship between mapping accuracy and performance at test. This result is not surprising given that, theoretically, participants could resolve all word-referent mappings in Block 2. If participants could not resolve the word-referent mappings until a later block, then the inverse relation between word-referent mappings and test performance could have extended to that point. No matter when the resolution point occurs, our results indicate that it may take learners several exposures to establish reliable connections between words and referents. Indeed, a number of participants reported being confused about the words' referents in Block 2 and recovering their confidence by the end of the study.

Further research is needed to determine whether our findings generalize to more complex learning environments that demand greater cognitive and attentional resources. Yu and Smith (2007) found that learners performed worse when the learning setting comprised four words and four referents than when it comprised two words and two referents. Given that in their studies distracters were sampled with replacement, it is difficult to tell whether this difference resulted from the greater degree of within-trial uncertainty, the later point in time at which the target association could be identified, or other cognitive and memory demand differences between the conditions. Thus, it remains a distinct possibility that an inverse relation between the initial accuracy and learning may also be observed in more complex environments. The accuracy of initial mappings may be negatively related to learning outcomes even if overall learners perform worse when within-trial uncertainty is greater.

Future research should also examine whether the accuracy of initial mappings has similar effects on learning among infants and children. Despite the progress made in understanding word learning, surprisingly little has been done since Carey's (1978) original studies to understand the process through which the first and each subsequent exposure to a word affect its representation. Artificial language studies have been extensively used to gain an insight into language acquisition processes (Magnuson, Tanenhaus, Aslin, & Dahan, 2003; Saffran & Wilson, 2003). Yet they have focused on bigger chunks of experience, and this is the first study to examine learning as a function of the first exposure to a word. The importance of understanding the earliest stages of learning should not be overlooked because usually a few exposures are sufficient to learn a word (e.g., Xu & Tenenbaum, 2007). Children clearly make errors in mapping the lexical and conceptual domains (e.g., Markman, 1992) and they are sensitive to both direct and indirect corrections by adults (e.g., Chouinard & Clark, 2003). There are also remarkable continuities in children's and adults' capacity to use statistical information available in the environment in the process of word learning (Saffran, Aslin, & Newport, 1996; Saffran, Newport, Aslin, Tunick, et al., 1997; Smith & Yu, 2008; Yu & Smith, 2007). Nevertheless, research has also revealed differences in children's and adults' word learning (e.g., Mirman, Magnuson, Graf Estes, & Dixon, 2008; Ramscar & Gitcho, 2007), thus underscoring the necessity of directly examining whether findings with adults generalize to children. At the very least, however, our findings draw attention to the value and need of investigating the role of initial mapping accuracy in word learning.

In conclusion, we return to the puzzle with which we began: the remarkable speed of language development. A possible answer to this puzzle—fast mapping—introduces yet another: Given the rich but ambiguous perceptual and linguistic input that language learners receive and the complexity of the tasks of analyzing and coordinating these data streams, fast mapping errors are inevitable. So how could fast mapping lead to fast word learning? The present findings suggest a possible resolution of this conundrum: Some amount of initial errors could actually be beneficial for learning. It may be useful to liken word learning to a game in which the word learner is a player, as long suggested by philosophers (Wittgenstein, 1963) as well as psychologists (Brown, 1958). Proficiency in most games comes not from adopting strategies that minimize the risk of errors but from the ability to learn from error. Perhaps it is the same in the acquisition of language.

Notes

1. Schafer and Plunkett (1998) relied on the difference in duration between the longest fixation on target and the longest fixation on distracter in their analyses. As we examined fixations in a time window much shorter than theirs (about 1.5 s vs. 10 s), and had fewer fixations per trial, we deemed it preferable to work with the categorical measure of location of the longest fixation.
2. For this analysis, we excluded (a) test trials where participants took more than 1500 ms to respond because they may not represent the decision processes in learning trials, which were on average about 1500 ms long, (b) trials where there were less than two fixations, and (c) trials where the longest fixations the two images attracted were equally long. The location of the longest location (target vs. distracter) on a trial was a significant predictor of accuracy, Wald χ^2 (1) = 11.451, p = .001. Participants were more likely to make a correct response when the longest fixation was on the target referent than when it was on the distracter (94% vs. 81%).
3. We thank an anonymous reviewer for suggesting this analysis.

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