Brief Report

Developmental differences in children's context-dependent word learning

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ABSTRACT

In this study, 2.5-, 3-, and 4-year-olds ($N = 108$) participated in a novel noun generalization task in which background context was manipulated. During the learning phase of each trial, children were presented with exemplars in one or multiple background contexts. At the test, children were asked to generalize to a novel exemplar in either the same or a different context. The 2.5-year-olds' performance was supported by matching contexts; otherwise, children in this age group demonstrated context dependent generalization. The 3-year-olds' performance was also supported by matching contexts; however, children in this age group were aided by training in multiple contexts as well. Finally, the 4-year-olds demonstrated high performance in all conditions. The results are discussed in terms of the relationship between word learning and memory processes; both general memory development and memory developments specific to word learning (e.g., retention of linguistic labels) are likely to support word learning and generalization.

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Introduction

Research on children's word learning and generalization has focused primarily on how children determine and use information that is relevant to the category or task at hand. For example, research has demonstrated that children generalize new words based on perceptual properties of an object category such as shape (e.g., Landau, Jones, & Smith, 1988). However, less is known about how children use information that is less relevant to the task, such as the background context, to generalize words. In this study, we examined how changes in contextual information across learning and testing events affect children's developing word learning and generalization.

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Context effects in memory

The context that frames a stimulus or an event has been shown to produce pervasive effects on human behavior across multiple domains (e.g., Yeh & Barsalou, 2006). Context has been shown to affect learning in memory retrieval (e.g., Godden & Baddeley, 1975), problem solving and reasoning tasks (e.g., Cheng & Holyoak, 1985), and artificial intelligence tasks (e.g., Brooks, 1991). The robust finding is that performance is enhanced when the learning and testing contexts are the same and performance is hindered when the learning and testing contexts are different.

For example, in studies of memory retrieval, recollection is consistently affected by the interaction between the properties of the encoded context and the properties of the retrieval context (e.g., Tulving, 1983). The more commonalities that exist between the encoded context and the retrieval context, the more likely it is that the memory trace will be retrieved. These types of contextual effects can be so strong that learners fail to retrieve information outside the context in which it was learned. If learners fail to retrieve memories in the new context, these memories are considered to be context dependent (e.g., Godden & Baddeley, 1975; Smith, 1982).

Although a mismatch between context at learning and context at recollection is detrimental to performance, context dependency can be reduced by distributing learning events across multiple contexts (e.g., Rothkopf, Fisher, & Billington, 1982; Smith, 1982). For example, one study (Smith, 1982) had participants memorize word lists in either one classroom or a series of three different classrooms. When later asked to recollect the words in the new classroom, the participants who had studied the word lists in multiple classrooms (i.e., multiple contexts) had higher performance than those who had studied the material in one classroom (i.e., single context). In sum, distributing learning across multiple contexts results in a greater diversity of cues during learning and, thus, increases the likelihood that a memory will be recalled (e.g., Smith, 1982).

Context-dependent learning also appears to vary across development (e.g., Hartshorn et al., 1998). For example, Hartshorn et al., (1998) documented changes in how context affects memory throughout infancy. The results of these studies demonstrated age-related differences in the effects of context changes on performance. When infants were tested after a 3-day delay, 3-month-olds showed impaired retention from context changes, but 12-month-olds did not. However, when 12-month-olds were tested after a 56-day delay, their retention was also affected by the changes in context. The results suggest that the impairing nature of contextual change tracks the end of the expanding forgetting function. That is, infants' level of memory development influenced whether or not context changes affected performance.

Context effects in word learning and generalization

Word learning tasks differ from memory tasks in that, instead of learners recalling a particular memory trace (e.g., did they see that dog yesterday?), learners are required to abstract across learning events (e.g., the dogs they have seen at a friend's house and the dogs they have seen at school), map a linguistic label to a category (e.g., "dog"), and generalize a word and category to novel learning situations (e.g., the novel creature they see at the park is also a dog). In addition to these differences in task demands, performance on memory and generalization tasks is often quite different (e.g., Fisher & Sloutsky, 2005; Sloutsky & Fisher, 2004). Consequently, it may be that contextual information affects generalization in a different manner from how it affects memory.

For example, because learning words occurs across time and in multiple contexts, context-dependent learning would intuitively seem to be even more detrimental in generalization tasks than in recollection tasks. In memory tasks, the object itself can serve as a cue to prior instances of that memory regardless of the current and/or previous context(s). However, in generalization tasks, category members might not be sufficient cues to prior instances because of the variation between category members. Moreover, if category members are bound to contexts, the current context might not serve as a sufficient cue to previous category instances and/or contexts. If children are not able to recall previous instances, this could prevent children from generalizing to novel situations. As a result, children would be able to recall words only in the context in which they were learned.

Alternatively, context-bound categories may be particularly important in generalization; shared context may aid in aggregating instances experienced over time. For example, studies have demonstrated

that providing redundant correlated cues results in greater learning than does providing a single cue. In these studies, learners were presented with correlated cues (e.g., linguistic, perceptual) that mutually reinforce each other, leading to stronger performance than when learners were presented with a single cue (e.g., Thiessen & Saffran, 2003; Yoshida & Smith, 2005). Thus, when category instances appear across similar contexts, the shared contextual support provides redundant and correlated cues between events.

The current study

The current investigation examined how changes in background context support and deter word learning and generalization. We presented a novel noun generalization task in varying contexts to three groups of children: 2.5- to 3-year-olds, 3- to 4-year-olds, and 4- to 5-year-olds. We predicted a possible developmental progression in children's ability to generalize words in novel contexts. Therefore, we examined word learning across early childhood.

Method

Participants

A total of 108 children participated in this study. There were 36 children in each of three age groups: 2.5- to 3-year-olds ($M = 32.0$ months, range = 30–35, 17 girls and 19 boys), 3- to 4-year-olds ($M = 42.0$ months, range = 36–47, 17 girls and 19 boys), and 4- to 5-year-olds ($M = 52.9$ months, range = 48–58, 17 girls and 19 boys). Children in each age group were randomly assigned to one of the three between-participant conditions, totaling 12 children in each condition, for each age group. All children were monolingual English speakers and were recruited from local preschools in the Los Angeles area.

Design

This study used a 3 (Age Group) $\times$ 3 (Context Condition) design. Both factors were between-participant factors. The three context conditions varied the learning and testing contexts but were identical in every other way. The context in each of these conditions was defined by a large patterned cloth on which stimuli were presented and played with. Fig. 1 depicts an example of the three conditions. In the match condition, children learned about objects in the same context in which they were tested (e.g., they learned and were tested on a blue piece of cloth). In the mismatch condition, children learned about objects in one context and were tested in a second context (e.g., they learned on a blue piece of cloth but were tested on a purple piece of cloth). In the multiple condition, children learned about objects in a new context for every learning event and were tested in a new context (e.g., they learned on one blue, one green, one yellow, and one gray piece of cloth but were tested on a purple piece of cloth).

Each child participated in eight trials in which they learned and were tested on novel words and categories. All trials had three phases: a learning phase, a distractor phase, and a testing phase. During the learning phase, children were presented with three instances of a novel category, each paired with a novel name (e.g., "dax"). During the distractor phase, children were presented with a distractor object but no label. During the testing phase, children were given a forced-choice test in which they identified a novel category exemplar from a group of objects.

Stimuli

Novel objects were constructed using arts and crafts supplies and objects from hardware stores (see Fig. 1 for examples). Each instance of a category varied from the other instances in color, texture, and perceptual features, but all instances had the same shape. Each novel object was randomly assigned a novel label (e.g., dax). The cloth pieces were purchased from fabric stores and were quite large (1×1.33 m in size). It is important to note that the objects, object–label pairings, and contexts
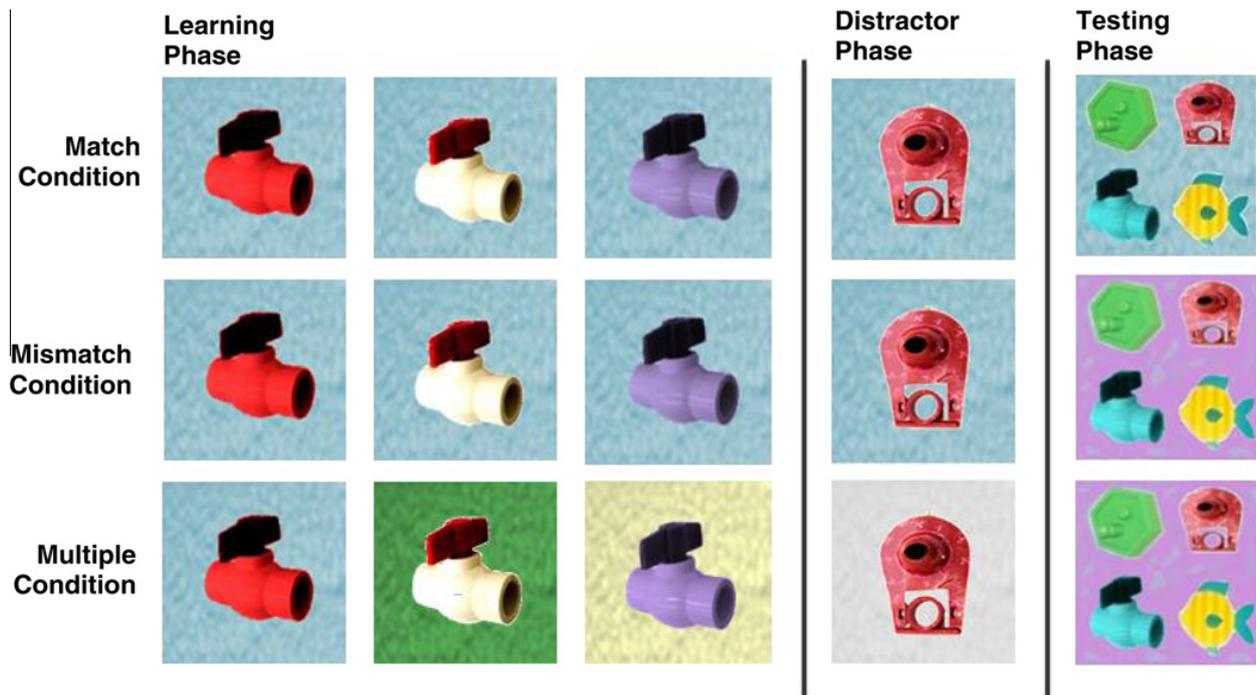
Fig. 1. Example stimuli and contexts for each condition. One row represents one trial of the experiment. Actual backgrounds were patterned cloths but have been simplified in this figure. The objects, object–label pairings, and contexts were randomly assigned for each participant. Thus, this figure depicts one possible combination for each of the conditions.

(i.e., cloths) were randomly assigned for each participant. Random assignment was used to ensure that differences in performance would not be attributable to a particular pattern of cloth or object.

Procedure

At the beginning of each session, children were told that they were going to play a game in which they would be learning about some new toys. During each presentation, a patterned cloth was underneath the object and, hence, was the visual background for each object. During the session, children participated in eight trials. Each trial had three phases: a learning phase, a distractor phase, and a testing phase.

During the learning phase of each trial, children were shown three instances of an object category, one right after the other. During each presentation, the object was presented and labeled two or three times (e.g., "Look at the dax!"). Each object was presented for 10 s.

During the distractor phase of each trial, children were shown a novel object immediately following the last category instance presentation. This object was presented for 30 s so that there was equivalent exposure time to the target category (dax) and distractor objects. This object was also presented on a patterned cloth according to condition. In the match and mismatch conditions, the fabric was the same as during the learning phase. In the multiple condition, the fabric differed from that used during both the learning and testing phases. The distractor object was not labeled (e.g., "Look at this!"). The purpose of introducing a distractor object was to have a familiar object that was not the target object in the forced-choice test that children viewed during the experiment. This ensured that children were not simply responding based on the familiarity of the objects during the test.

During the testing phase of each trial, children were shown four objects simultaneously and asked to hand the target object (dax) to the experimenter. The four objects were (a) the target object (which was a novel instance of the dax category), (b) the distractor object, (c) a novel object, and (d) a known object that had not been presented previously in the experiment (e.g., a toy cat or dog). Once children handed the experimenter an object, the next trial began, and this would continue until all of the trials had been completed.

Each object (or set of objects at test) was wrapped in a tablecloth according to the condition to which the child was assigned (i.e., match, mismatch, or multiple). The patterns of the cloth were randomly assigned for each trial and each participant. The cloth was turned inside out and kept shut using a clip, creating the appearance of a bag. When the bag was opened during each learning, distractor, or testing presentation, the patterned cloth was underneath the object(s) and, hence, was the visual background for each presentation. This procedure was used to minimize and equate the amount of time between presentations and phases of each trial. Moreover, this procedure ensured that context changes appeared to be incidental rather than deliberately made by the experimenter between presentations.

Results

To determine whether there were context effects and a developmental progression of these effects, we conducted an overall analysis using a 3 (Age Group) $\times$ 3 (Context Condition) analysis of variance (ANOVA) with the number of correct responses as the dependent measure. This analysis revealed a significant main effect of context condition, $F(2, 99) = 22.755$, $p < .001$, $\eta_p^2 = .336$, a main effect of age group, $F(2, 99) = 50.185$, $p < .001$, $\eta_p^2 = .527$, and an interaction between age group and context condition, $F(4, 99) = 11.083$, $p < .001$, $\eta_p^2 = .330$ (see Fig. 2).

Post hoc analyses were used to examine the interaction between age group and context condition. First, three univariate ANOVAs were conducted within each age group. We then computed three planned comparisons using t tests with Bonferroni corrections ($\alpha = .05$) to determine the nature of the difference between context conditions within that age group. We expected there to be differences in context effects across the age groups. This analysis addressed whether there were differences in the way in which context affected children's performance at different ages.

These tests revealed that there were significant differences in the way in which context affected children's performance at different ages. First, for the youngest age group, 2.5- to 3-year-olds, there was a significant main effect of context condition, $F(2, 33) = 59.513$, $p < .001$, $\eta_p^2 = .783$. The planned comparisons revealed that children's performance in the match condition was higher than children's performance in both the multiple condition ($p < .001$) and mismatch condition ($p < .001$). As we expected, younger children were affected by context changes.
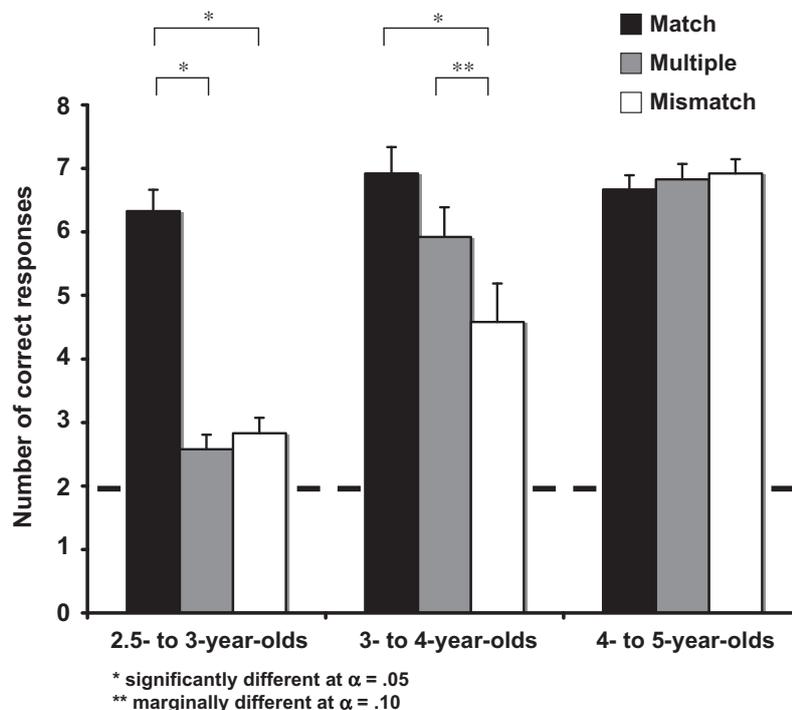

Fig. 2. Mean number of correct responses (maximum = 8) by age group (2.5- to 3-year-olds, 3- to 4-year-olds, and 4- to 5-year-olds) and experimental condition (match, multiple, and mismatch). Error bars represent standard errors, and the dashed line indicates chance performance. All means were significantly above chance.

Second, for the middle age group, the 3- to 4-year-olds, there was a significant main effect of context condition, $F(2, 33) = 5.386$, $p = .009$, $\eta_p^2 = .246$. The planned comparisons revealed that children in the match condition outperformed children in the mismatch condition ($p = .04$). Children's performance in the multiple condition was not significantly different from children's performance in the match condition ($p > .05$), suggesting that children in the match and multiple conditions had equivalent levels of performance. Children in the multiple condition had marginally higher performance than children in the mismatch condition ($p = .093$). Thus, children in this middle age group were affected by context changes; however, learning about exemplars across multiple contexts helped to alleviate context-dependent learning.

Finally, for the oldest children, 4- to 5-year-olds, there was no effect of context condition, $F(2, 33) = 0.302$, $p > .05$. Children in the match, multiple, and mismatch conditions all had similar levels of performance ($ps > .05$).

Discussion

Changes in context resulted in clear differences in performance on the generalization task. These effects differed depending on the developmental level of the children. The 2.5-year-olds had higher performance when the contexts matched but lower performance when the contexts varied (both mismatch and multiple conditions). The 3-year-olds also had higher performance when the contexts matched; however, when category members were presented across multiple contexts, performance was also high. Finally, the 4-year-olds had uniformly high performance in all three context conditions.

The current results present context effects that are similar to context effects found in memory tasks (e.g., Hartshorn et al., 1998; Smith, 1982), problem solving and reasoning tasks (e.g., Cheng & Holyoak, 1985), and artificial intelligence tasks (e.g., Brooks, 1991). The current study contributes to this literature by demonstrating (a) that changes in context can affect performance in inductive learning tasks such as word learning and (b) that although distributing learning across multiple contexts alleviates context-dependent learning, this effect is mediated by developmental level. In this experiment, only 3-year-olds demonstrated a benefit of having learning distributed across contexts.

Why were there differences in performance across development? Because the current results closely parallel findings from memory research, differences in memory development may have contributed to differences in performance across the age groups. Indeed, children go through rapid memory development during early childhood (see Schneider & Pressley, 1997, for a review). For example, early in development, memories are more contextually bound (e.g., Hartshorn et al., 1998). If category instances are bound to contexts, this could prevent children from generalizing to novel situations because the novel object itself might not be a sufficient cue to recall previous instances and/or contexts. As memory abilities develop, children are able to retain more information for longer periods of time, and their memories are less contextually bound. This development could support word learning by enabling children to track a greater number of cues across word learning events.

In addition to general memory development, changes in the ability to retain linguistic labels may also have contributed to differences in performance across the age groups. Children in this study were of ages at which they have a significant number of words in their productive vocabularies (e.g., 300+ [Fenson et al., 1994]). However, children often fail to retain words that they have previously mapped to objects. For example, in one study (Horst & Samuelson, 2008), 2-year-olds were presented with a novel noun mapping task. Although children readily mapped novel words to objects at an immediate test, when tested 5 min later, children demonstrated low retention of these words. In sum, children's ability to retain and recall words over time may lag behind the ability to map words to objects.

This study brings to light the intimate relationship among word learning, generalization, and memory. Memory is a critical factor in Author learning; memory supports word mapping, category learning, retention, and recall. Because word learning relies on memory processes, the same factors that affect memory are likely to affect word learning and generalization. The relationship between word learning and memory in this study contributes to an expanding body of literature (e.g., Samuelson & Smith, 1998; Sandhofer & Doumas, 2008; Sloutsky & Fisher, 2004; Vlach, Sandhofer, & Kornell, 2008), suggesting that many aspects of word learning rely on domain-general processes of learning.

Context effects here, but no context effects there?

It might seem surprising to many word learning researchers that subtle changes in background context, such as changes in the pattern of a tablecloth, could dramatically affect children's performance. A significant body of research has demonstrated that children's performance on word learning tasks appears to be equivalent across contexts (e.g., Akhtar, 2005; Scofield, Williams, & Behrend, 2007). On the other hand, a separate body of research has demonstrated that varying contextual information during learning may lead to differences in performance on word learning tasks (e.g., Samuelson & Smith, 1998; Smith, Colunga, & Yoshida, 2010). What could be contributing to such differing results in the literature?

Research on context effects in memory has also resulted in differing results across studies (see Smith & Vela, 2001, for a review and discussion). There have been several hypotheses proposed to explain why context can appear to affect learning in one situation but not affect performance in another similar situation. For example, context effects depend on the salience of background contexts (e.g., Smith & Vela, 2001) and on whether or not previous contexts are mentally reinstated (e.g., Krafka & Penrod, 1985). Moreover, although background context is irrelevant to the task, the degree to which context outshines relevant cues is likely to affect the presence of context effects (e.g., Smith, 1988).

The current study highlights an additional account that is often overlooked by reviews and meta-analyses of context effects (e.g., Smith & Vela, 2001), namely that development and experience are likely to influence the degree to which context changes affect learning (e.g., Hartshorn et al., 1998). Although most investigations of context effects have not focused on development, we predict that similar patterns of results would be found during adulthood. In this case, experience with a particular task, rather than general developmental changes, may affect the degree to which context changes affect learning.

Acknowledgments

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