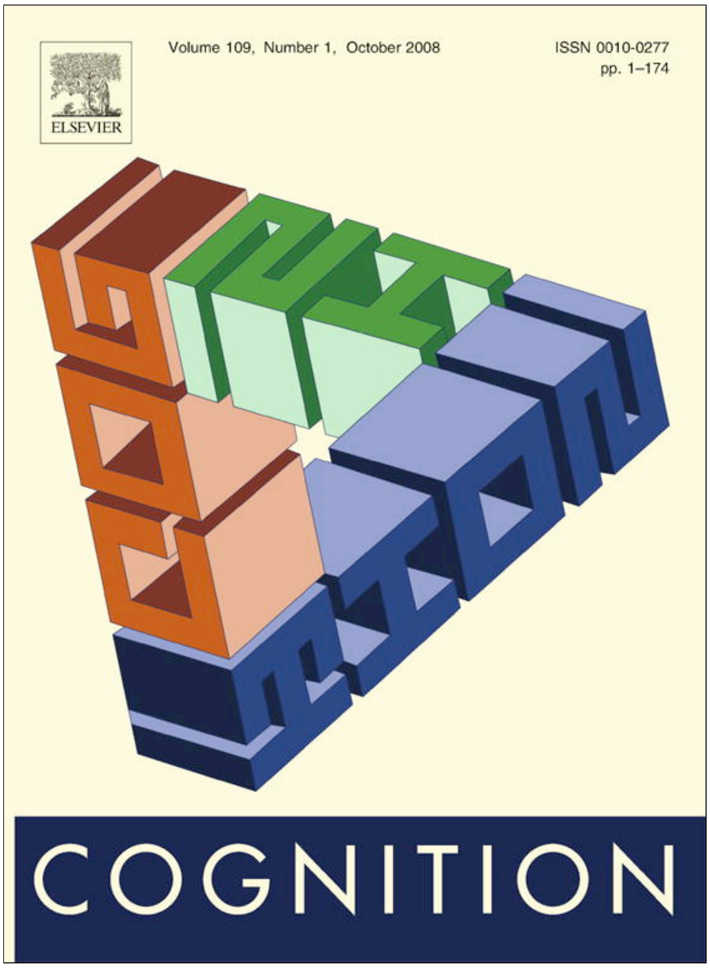
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Brief article

The spacing effect in children's memory and category induction

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ABSTRACT

The spacing effect describes the robust phenomenon whereby memory is enhanced when learning events are distributed, instead of being presented in succession. We investigated the effect of spacing on children's memory and category induction. Three-year-old children were presented with two tasks, a memory task and a category induction task. In the memory task, identical instances of an object were presented and then tested in a multiple choice test. In the category induction task, different instances of a category were presented and tested in a multiple choice test. In both tasks, presenting the instances in a spaced sequence resulted in more learning than presenting the instances in a massed sequence, despite the difficulty created by the spaced sequence. The spaced sequence increased the difficulty of the task by allowing children time to forget the previous instance during the spaced interval.

1. Introduction

Young children have dynamic memories; they forget quickly (Fagen & Rovee-Collier, 1983), but they also learn quickly (Carey, 1978). Children spend a considerable amount of time constructing categorical representations of their world, because so much that surrounds children is new and unfamiliar – from learning the key features of a boat, to generalizing about how objects behave when they collide, to determining which facial expressions signify the emotion of happiness. In order to learn these categories, young children must aggregate experiences in order to generalize across events or abstract concepts; that is, children must use processes of induction to organize their world.

What factors enhance learning in young children? Since the late 1800's (Ebbinghaus, 1964), research on memory and learning has demonstrated that distributing learning events across time, rather than massing them together, enhances memory. This robust effect is commonly called the *spacing effect* (Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006). Hundreds of articles in the memory literature, including a number of reviews (e.g., Dempster, 1996; Glenberg, 1979) and meta-analyses (e.g., Cepeda et al., 2006; Donovan & Radosevich, 1999), have found a spacing effect in a wide variety of tasks and contexts. However, despite a large body of research, studies almost always presented learners with tasks in which the identical information was presented multiple times on either a massed or a spaced schedule. For example, in a typical study participants are asked to remember words that are presented multiple times with a variable degree of spacing between instances and, at the end of the session, participants are asked to free recall the words that were presented (e.g., Bahrick, Barhick, Bahrick, & Bahrick, 1993; Childers & Tomasello, 2002; Rea & Modigliani, 1987; Toppino, 1993). Whether spacing instances apart in time aids learning of categories and concepts, when stimuli are not identical, is not known (see Kornell & Bjork, 2008, for a recent exception). In fact, the spacing of learning sessions over time has been given little consideration outside of the memory literature.

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In real-world situations, learning new categories and concepts involves aggregating variable experiences through the process of induction. In category induction studies, children are typically given massed presentations of novel instances of a category. For example, in a typical experiment, children are shown a different instance of a category in each presentation and are later asked to select a novel instance of the category at test (e.g., Ross, Gelman, Rosengren, 2005; Eimas & Quinn, 1994; Sloutsky, Kloos, & Fisher, 2007). As an example, children might be shown a red fuzzy triangle labeled "wug," a blue bumpy triangle labeled "wug," a green scratchy triangle labeled "wug," and then at the test be asked to pick out a "wug" (a yellow squishy triangle) among two or three other objects. Thus, to succeed in categorization tasks children have to abstract relevant features across instances.

Many studies have described how children are adept at learning categories, however no studies have addressed how the timing of instance presentation affects category learning. The literature suggests that in the context of a pure memory experiment, spacing the instances may be advantageous. Spacing causes forgetting between learning events – whereas massing prevents such forgetting – and forgetting an initial presentation increases the potency of encoding on subsequent presentations (Bjork & Allen, 1970; Cuddy & Jacoby, 1982). In category learning, however, forgetting may be disadvantageous (Gagné, 1950); it may be difficult to abstract the relevant features of a category if one forgets the previous instances during the spaced interval – especially for children. For example, in cued-memory tasks, making items perceptually different from each other reduces and sometimes eliminates the spacing effect (Mammarella, Russo, & Avons, 2002). Thus, spacing the instances apart in time may lead children to forget the relevant features and consequently fail to induce the category.

The current investigation examined how distributing instances across time affects three-year-old children's performance in memory and category induction tasks. In the memory condition, children were presented with an identical instance in every presentation, followed by a multiple choice test. In the category induction condition, children were presented with a new instance of a category in each presentation and a new instance at the multiple choice test. Children in both conditions received massed and spaced presentations. To our knowledge, this is first study to systematically investigate the effect of spacing on young children's learning in both memory and category induction tasks.

2. Method

2.1. Participants

The participants were 36 three-year-old children ($M = 42.8$ months, range: 36–48 months). Half of the children were assigned to participate in the memory condition ($M = 43.3$ months, 9 girls and 9 boys) and the other half were assigned to the category induction condition ($M = 42.2$ months, 9 girls and 9 boys). The children were recruited from preschools in the Los Angeles area.

2.2. Stimuli

Novel objects were constructed using arts and craft supplies and objects from hardware stores (see Fig. 1 for examples). Each novel object was randomly assigned a novel label (e.g., "wug", "blicket", "dax"). The object presentation order and object-label pairing was randomly assigned for each participant.

2.3. Design

The study used a 2×2 design; presentation style (massed or spaced) was a within-subjects factor and learning style (memory or category) was a between-subjects factor. In total, children completed 16 trials. Because we were concerned with the amount of time it would take to complete all of the trials, the experiment was broken up into four sessions. Each session took place on a separate day. Two of the days consisted of massed presentations and two consisted of spaced presentations. At each session children were presented with four objects or categories, thus, across the entire study children participated in eight massed object presentations and eight spaced object presentations. The order of the four sessions was counterbalanced.

2.4. Procedure

At the beginning of each session, children were told that they were going to play a game in which they would learn about some new toys. Two experimenters conducted each session; one experimenter coordinated the objects under a cover and table, so that they were not visible until a presentation, and the second experimenter kept the object in the gaze of the child at all times. If children began to look away during a presentation, the second experimenter would keep the child's attention by moving the object with the child's gaze, ensuring equivalent looking times across all trials. During each session, children were introduced to four sets of stimuli and each set was presented in three phases: learning phase (massed or spaced), distractor phase, and test phase.

The learning phase consisted of three presentations (Fig. 1a). In the memory condition, children viewed the same object in each of the three presentations. In contrast, children in the category induction condition viewed a different instance of the category in each presentation; each instance varied in color, texture, and perceptual features, but all instances had the same functional parts and shape. In the massed presentations, objects were presented in immediate succession, with less than one second between presentations. After a presentation, the object was briefly taken away (<1 s) and then presented again. In the spaced presentations, 30 s elapsed between each instance presentation, in which children played with play-doh, read story books, and/or completed puzzles. In all conditions, the object was presented for 10 s in each presentation. During this time, the object was labeled 2–3 times (for example; "Look at this wug! See the wug? You hold the wug.")

The distractor phase began immediately following the learning phase (Fig. 1b). A distractor object was presented

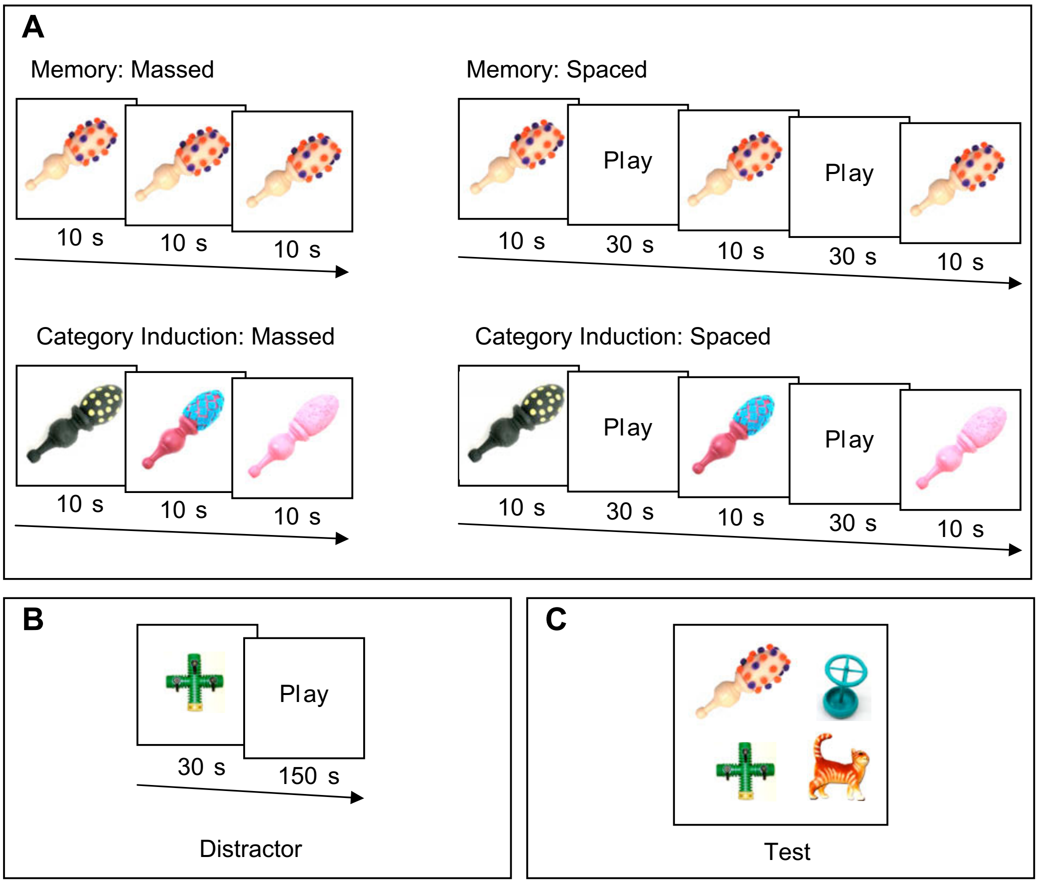

Fig. 1. Experimental procedure. (A) Study phase. Three novel objects, either all the same instance or all different instances, were presented and given a label (e.g., "wug") in massed or spaced presentations. (B) Distractor phase. A novel object was presented without a label (e.g., "it") followed by a play period. (C) Test phase. Four objects were presented and the child was asked to identify the target (e.g., "Can you hand me the wug?").

for 30 s; this object was different in shape and functional parts from the objects presented in the learning phase. This object was not given a label (for example; "Look at this!") and was viewed for 30 s. The distractor object was then taken away and for the remainder of the 3 min retention interval, children played with play-doh, read story books, and/or completed puzzles. The purpose of introducing a distractor object was to have a familiar object in the multiple choice test that was presented during the experiment, but that was not the target object ("wug"), ensuring that children were not simply responding based on the familiarity of the objects during the test.

During the test phase, children were given a multiple choice test (Fig. 1c). Children were simultaneously presented with four items, in random placement order, and were asked to pick out the target object ("Can you hand me the wug?"). The first object was the target object (e.g., "wug"); in the memory condition, the target object was the same object that had been presented in the learning phase, whereas in the category induction condition the target object was a new instance of the category. The second object was the distractor item presented during the distractor phase. The third object was an unfamiliar novel object and the fourth object was a known object (for example, a toy dog). Children had not viewed the third and fourth objects previously in the study. Children were not given feedback after making their selection.

3. Results

As Fig. 2 shows, spaced presentations resulted in more learning than massed presentations, $F(1,34) = 74.833$, $p < .001$, $\eta_p^2 = .69$. There was also a main effect of condition, $F(1,34) = 4.059$, $p = .052$, $\eta_p^2 = .11$, confirming that performance in the memory condition was significantly higher than performance in the category induction

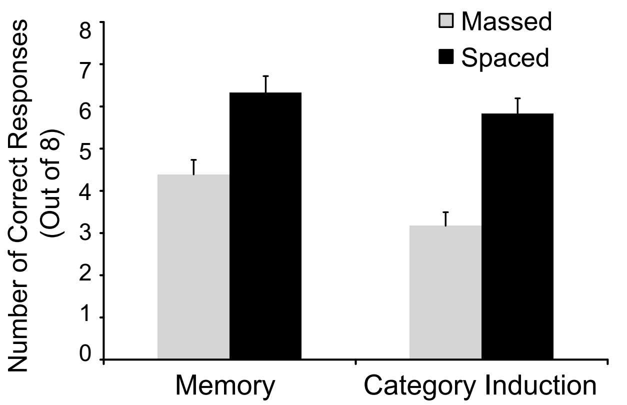

Fig. 2. Mean number of correct responses (out of a possible eight) by presentation style (massed or spaced) and learning style (memory or category). Error bars represent standard errors.

condition. The interaction between presentation style and learning style was not significant, $F(1,34) = 1.836$, $p = .184$, suggesting that the benefit of spacing was equivalent in the memory and categorization tasks.

4. Discussion

We found that spacing learning events apart in time enhanced children's learning, regardless of whether the instances were identical (in the memory condition), or varied (in the category induction condition). Paradoxically, allowing children time to forget the instances of the categories that they were learning about enhanced their ability to remember the categories later.

The current findings are not consistent with some deficient processing explanations of the spacing effect. For example, inattention theory (Hintzman, 1974) suggests that massing impairs learning by reducing the amount of attention people pay to repeated presentations, because the massed items become highly familiar. In the massed conditions of the current experiment, the same item was presented repeatedly in the memory condition, which, according to deficient processing theory, should lead to inattention. However, different items were presented in the category induction condition, which should result in less inattention, yet the magnitude of the spacing effect was the same in the two conditions. This finding suggests inattention was not the primary cause of the spacing effect in this study.

The current findings are, however, consistent with encoding variability theories (Melton, 1970; Glenberg; 1979). This class of models proposes that memory traces stored during learning represent both an item and the context in which the item is learned. With the passage of time, the existing context is assumed to undergo random drift. Thus, the distance between the prior context and the present context will increase over time. When learning occurs in varying contexts, retrieval cues associated with an item increase and therefore the probability of recall increases. In the current experiment, spaced presentations should result in more encoding variability than massed presentations. Consequently, encoding variability theory predicts that recall should be better in the spaced condition than the massed condition – and indeed it was. Although encoding variability explanations have been primarily invoked as explanations for the spacing effect in memory tasks, encoding specificity can also explain the spacing effect in induction tasks. In the latter, it is the central concept (e.g., triangle) – not any particular item – that is learned in multiple contexts.

The current findings are also consistent with another explanation of the effect of spacing on inductive learning, namely that spacing allows time for forgetting, and forgetting promotes abstraction. In the spaced condition, the interval between successive presentations allowed time for participants to forget surface characteristics (e.g., texture, color) so that when the item was presented again it contributed to an abstract representation of the central features (e.g., shape). By contrast, in the massed condition, because there was no time interval between presentations, participants were more likely to remember specific characteristics of each of the previous presentations of a given item as they were presented. Whether the presented items were repeated (in the memory condition) or not (in the induction condition), the more abstract representation engendered by spacing would be beneficial at testing because abstract memories tend to be more durable than concrete memories (Brainerd & Reyna, 2002). Moreover, more abstract memories may aid in the induction condition where participants were required to identify items that had not been previously presented. Alternatively, while spacing allows time for forgetting, spacing also provides time for consolidation. Because the spaced schedule provided more time for consolidation than the massed schedule, consolidation may have been a factor in the higher performance of children in the spaced condition (but see Bjork & Allen, 1970).

The present findings highlight the intimate relationship between category learning and memory. Memory is a critical factor in categorization in two ways: First, the formation of categories depends on one's ability to remember previous category instances. Second, there is little value in forming concepts and categories if one cannot remember them. Because category learning depends on remembering past instances, the same factors that affect memory are likely to affect category induction, both during category formation and at recall. Thus, the present results contribute to an expanding body of literature (e.g., Markson & Bloom, 1997; Smith, 2002) suggesting that many aspects of categorization rely on domain-general processes of learning and memory.

Interestingly, many studies of "fast mapping", a term which describes children's ability to learn words rapidly (e.g., Carey & Bartlett, 1978; Markson & Bloom, 1997), that have demonstrated exceptional retention have utilized spaced learning schedules. For example; in Carey and Bartlett's (1978) seminal paper on "fast mapping", children learned new words in multiple learning sessions that were separated anywhere from 2 days to 10 weeks. The spaced learning schedules may have been a contributing factor in children's retention of the words in the experiment.

The findings also have broad pedagogical implications. Spacing is one of a class of findings which, taken together, suggest that creating challenges for learners enhances long-term learning (Bjork, 1994). Spacing allows time for learners to forget, which would seem disadvantageous for learning (and is often perceived as so by learners; see Kornell & Bjork, 2008); however, many studies indicate a large benefit of forgetting for retention (e.g., Bjork, 1988). Even in difficult tasks, such as category learning, additional time between presentations can be advantageous for learning.

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