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Title: Two-year-olds learn novel nouns, verbs, and conventional actions from massed or distributed exposures.

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Abstract: Two-year-old children were taught either 6 novel nouns, 6 novel verbs, or 6 novel actions over 1 month. In each condition, children were exposed to some items in massed presentations (on a single day) and some in distributed presentations (over the 2 weeks). Children's comprehension and production was tested at 3 intervals after training. In comprehension, children learned all types of items in all training conditions at all retention intervals. For production, the main findings were that (a) production was better for nonverbal actions than for either word type, (b) children produced more new nouns than verbs, (c) production of words was better following distributed than massed exposure, and (d) time to testing (immediate, 1 day, 1 week) did not affect retention. A follow-up study showed that the most important timing variable was the number of different days of exposure, with more days facilitating production. Results are discussed in terms of 2 key issues: (a) the domain-generality versus domain-specificity of processes of word learning and (b) the relative ease with which children learn nouns versus verbs. (PsycINFO Database Record (c) 2012 APA, all rights reserved) (journal abstract)

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Two-Year-Olds Learn Novel Nouns, Verbs, and Conventional Actions From Massed or Distributed Exposures

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Two-year-old children learn new words on a daily basis. A variety of things are known about this process, including the contribution of cognitive skills in this learning (e.g., Gopnik & Meltzoff, 1997), the kinds of social-pragmatic cues children use when learning new words (e.g., Tomasello, 2000), and word-learning principles that may assist them in early word learning (e.g., Golinkoff, Mervis, & Hirsh-Pasek, 1994). Although many studies have examined early word learning, many basic questions remain, including How many exposures does it take for a child to learn a word? Is this different for different kinds of words, such as nouns and verbs? Is this different for comprehension and production? How long can children retain a word after they have learned it (i.e., without further models)? How does the spacing of models across time affect learning and retention? Do the quantitative factors that affect word learning affect the learning of conventional nonverbal activities in the same way?

The most comprehensive quantitative assessments of children's word learning derive from the McArthur Communicative Development Inventories (MCDI; Fenson et al., 1994). On the basis of norms generated from very large samples of Western, middle-class children, we know that 1-year-old children learn about one new word per day and 2-year-old children learn about two new words per day, with comprehension leading production by several months during this period. We also know that the average Western middle-class child hears several thousand utterances per day, most of them multiword utterances (Wells, 1981), and that the more language they hear, the larger their vocabularies (Hart & Risley, 1995; Hoff & Naigles, 2002; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). But in these naturalistic studies there is no information about precisely how often and in what ways children hear particular words, or about how this affects their learning of those words.

A few studies have examined some of the quantitative dimensions relevant to understanding the acquisition of words in comprehension. The most robust finding is that comprehension precedes production. When Goldin-Meadow, Seligman, and Gelman (1976)simply asked 2-year-old children to comprehend or produce common words in an experimental setting, children comprehended about two to three times as many words as they produced. Exploring comprehension further, Carey and Bartlett (1978)found that 3- and 4-year-old children could comprehend a novel word used for a novel object after only a few exposures, and many children retained this comprehension up to 6 weeks later. Markson and Bloom (1997)found that 3- and 4-year-olds comprehended a novel object label 1 week after having heard just a few exposures to it (see also Heibeck & Markman, 1987; Rice, 1990). Woodward, Markman, and Fitzsimmons (1994)found that even 13-month-old infants comprehended a new word at above-chance levels after a 24-hr delay, given only a single training session with nine exposures to the novel word.

Fewer studies have examined the quantitative conditions that facilitate the production of a new word. Nelson and Bonvillian (1978)found that after only a few exposures to a novel label for a novel object, 2½-year-olds could produce that label appropriately more than half the time in that same session (depending on several other factors). In the only study to systematically investigate how many exposures are needed to learn a novel word productively, Schwartz and Terrell (1983)found that children between 12 and 18 months took, on average, about 10–12 exposures to a novel word to be able to produce it appropriately. These children eventually acquired about 35% of a group of 16 novel words presented to them over a 10-week period.

Three other variables of special interest are present in some form in one or another of these studies. First, Schwartz and Terrell (1983)reported a very surprising finding. They presented children with novel words on one of two schedules during their 10 weekly sessions. On one schedule they exposed children to a novel word only once per session. On the other schedule they exposed children to a novel word twice per session. What they found was that children took approximately the same number of sessions to learn to produce the new word (6–8), meaning that the less frequently presented words were actually learned after almost half as many exposures as the more frequently presented words (approximately 7–12). This finding was interpreted in the context of the well-known finding in studies of animal and human learning that, given an equal number of exposures, distributed (or spaced) practice at a skill is almost always superior to massed practice with a skill. This finding holds for many different skills for many different species and has been replicated literally hundreds of times (see Underwood, 1961, and Dempster, 1996, for reviews). To our knowledge, there are no other studies that explore this phenomenon systematically for children's word learning.

Second, in a series of two studies, Markson and Bloom (1997; see also Markson, 1999) compared the learning of words to the learning of verbal and nonverbal facts. Thus, they taught some 3- and 4-year-olds the name of a single novel object (or a set of identical objects) saying “Let's measure the koba” (or “Let's use the kobas to measure which is longer”); they taught others that “My uncle gave this to me” (or “My uncle gave these to me”); and they taught still others that “This goes here. That's where this goes” (a sticker on a particular object). They found that in all of the conditions with verbally presented information (the first two), learning was equally good both immediately and after week-long and month-long delays. In the sticker condition, children were equally good on the test of immediate recall, but their memory for the sticker diminished significantly over the week-long and month-long retention intervals. Markson and Bloom interpreted these results as demonstrating that children can learn verbally presented facts about objects as easily as they can learn their names, implying that at least some learning principles are general across linguistic and nonlinguistic domains. At the same time, the nonlinguistically presented fact (the sticker) might involve somewhat different learning principles because children did not seem to retain it as long as the verbally presented fact or name. It should be noted, however, that Markson and Bloom did not test what is arguably the most natural nonverbal learning in which young children engage, namely, the social learning of conventional actions on objects (e.g., combing with a comb; Tomasello, 1999).

Third, one of the most contentious issues in the modern study of word learning is whether children find it easier to learn nouns or verbs. Following Gentner's (1982)review and theoretical proposals, many researchers have begun to examine whether young children's early vocabularies show a “noun advantage” and how patterns in vocabulary growth may be tied to the input. Several studies have shown that children learning English tend to have larger noun than verb vocabularies early in development (e.g., Tardif, Shatz, & Naigles, 1997). There are some indications that this finding may not hold for children learning other languages (Gopnik & Choi, 1995; Tardif, 1996; but see Au, Dapretto, & Song, 1994, and Tardif, Gelman, & Xu, 1999). The problem for the question of ease of acquisition is that in every language that has been studied, children hear nouns and verbs in different ways. For example, the input to English-hearing infants appears to favor nouns (Fernald & Morikawa, 1993; Goldfield, 1993), whereas there seems to be less of an advantage for nouns in the input in Korean and Mandarin (Gopnik &

Choi, 1995; Tardif, 1996; Tardif et al., 1997). The fact is that there are almost no experimental studies that address directly the issue of whether, when the frequency of nouns and verbs is experimentally controlled, nouns are easier to learn than verbs.

One exception is a study by Schwartz and Leonard (1984). They found that toddlers taught 16 new nouns and verbs were able to learn more nouns than verbs, and required between 20 and 40 exposures to learn the words they eventually produced. However, the children in their study were learning 16 words at a time with 64 objects and actions presented and named in each session. Tomasello and Akhtar (1995)found that 2-year-olds could learn both novel nouns and verbs with enough exposures, but there was no direct comparison of how many or what kinds of exposures are needed in the two cases. Oviatt (1980)found no indications of noun-verb differences in the comprehension of 1-year-olds. Overall, the fact is, the relative ease of acquisition of nouns and verbs must be systematically tested experimentally.

In the current studies, we sought to investigate these three issues experimentally. In the main study, we taught three different groups of 21/2-year-old children six different words or actions over a month-long period. Some of the children learned nouns, some of the children learned verbs, and some of the children learned nonverbal actions associated with particular objects. In all three of these groups, each of the six items was learned on a different schedule. Some were learned on a massed schedule (all exposures on a single day), and the others were learned on various kinds of distributed schedules, ranging from 2 to 4 days of exposure (with different spacing between those exposure days, and one manipulation of number of exposures). Children were subsequently tested at three different retention intervals (immediately, 1 day later, 1 week later) in both comprehension and production.

With this design, the main question we attempted to answer was what kinds of temporal distribution in exposures (perhaps in interaction with number of exposures) are most facilitative of word learning? By including different kinds of words, our results also contribute to understanding differences between verbal and nonverbal information and, perhaps, to the noun-verb question. However, our study was primarily designed to address a basic quantitative question in word learning: How many times (and on how many days) does a 2-year-old need to hear a word to be able to learn it? In one follow-up study, we investigated some additional parameters of the timing and distribution of exposures for the acquisition of novel nouns.

Study 1: Main Study

In this study, we taught 2-year-old children novel nouns and verbs, varying the number of models and the spacing of the models across days. We then tested children's comprehension and production of these words at various intervals of delay. In addition, we followed the exact same procedures in teaching children novel actions on objects in an attempt to see if the same learning principles applied in a nonverbal task.

Method

Participants

Thirty-six 21/2-year-old children participated in the study (mean age = 2 years 7 months; range = 2 years 4 months to 2 years 10 months). There were 19 girls and 17 boys in the final sample. Six additional children were dropped from the study because they either were not cooperative or they were not able to attend or complete all of the sessions in the 4 weeks of the study. All children were recruited from day-care centers in a large metropolitan area in the southern United States, and informed consent was obtained through letters sent home to the parents. In the three between-subjects groups, the noun group had 5 girls and 7 boys, with an average age of 2 years 7 months; the verb group had 8 girls and 4 boys, with an average age of 2 years 7 months; and the action group had 6 girls and 6 boys, with an average age of 2 years 6 months.

Materials and Design

Children were assigned to one of three experimental groups: the noun group, the verb group, or the action group. Each child in each of these groups was exposed to six sets of objects, one for each timing-of-exposures condition (see below). Each object set contained three familiar objects (which served as a warm-up set for each task) and three novel objects. One novel object from each of the object sets was randomly selected as the target, and the other two novel objects served as distractors (target objects were thus the same across children and conditions). Novel objects were obtained from hardware, kitchen utensil, and toy stores. In an informal survey with adults, we determined that none of the objects was easily named. A full list of objects and nonce names for targets is given in and B. In the verb group, there were six generic actions that could potentially be performed with any of the novel objects (e.g., spinning); lists those six actions and their nonce names. In the action group, there were six other generic actions that could potentially be performed with any of the novel objects (e.g., balancing it on one's head); lists those six actions.

Before the study began, for the noun group, a novel word was randomly assigned to each target. The object sets were then assigned to timing-of-exposures conditions in a counterbalanced manner across children. For the verb and action groups, a target action was randomly assigned to each target object (and in the case of the verb group, a novel verb was randomly assigned to it as well). As in the noun condition, the object sets were then assigned to timing-of-exposures conditions in a counterbalanced manner.

There were three within-subject variables. The first, timing of exposures, included the six different schedules we used to expose children to target nouns, verbs, and actions. Two schedules grouped exposures on a single day (Massed 4: four exposures in a single day; and Massed 8: eight exposures in a single day). Two schedules spaced exposures across 4 different days (Daily 4: one exposure per day for 4 consecutive days; and Widely Spaced 4: one exposure per day on 4 days, but with 3 days intervening between each exposure day). Two schedules represented a compromise between a massed and distributed schedule (Clumped 4: two exposures on 1 day and two exposures on another day, 3 days later; and Clumped 8: two exposures on 1 day, four exposures 3 days later, two exposures 3 days after that).

The practical constraints of children's and researchers' schedules precluded perfect counterbalancing of order. Instead, two different orders were created, each of which intermixed the six conditions during a 4-week period. In one schedule, the initial exposures were ordered in the following way: Daily 4, Widely Spaced 4, Clumped 8, Massed 4, Clumped 4, Massed 8. The other schedule was constructed so that the initial exposures were ordered in the following way: Widely Spaced 4, Massed 4, Massed 8, Clumped 4, Clumped 8, Daily 4. Half of the children in each of the three item-learned groups were seen in each of these orders. Both orders were constructed so that no child in any of the groups was exposed to more than two novel items (words or actions in training or testing) on a single day.

The other two within-subjects variables concerned the ways that children were tested for retention. One variable was response type: comprehension versus production. The other variable was retention interval: testing immediately following completion of training, testing 24 hr after completion of training, or testing 1 week after completion of training. Each child in each of the three item-learned groups (noun, verb, action) was tested for retention in each of the six timing-of-exposures conditions in both comprehension and production at all three retention intervals.

Training Procedure

Each exposure session for children within a given group was identical, regardless of the timing of exposures. The exposure sessions within each of the three groups involved interaction with a female experimenter (E) for 5 to 10 min. An observer (O) was also present and videotaped the session.

Noun group

The experimental session began with E producing a plastic bag containing the appropriate object set. E then chose one of the objects at random, with the restriction that the three familiar (warm-up) objects be chosen before the three novel ones. After choosing an object, E made sure the child was attending, said something about it (different for different objects), gave it to the child for a brief period of play, and then asked the child to put the object away into a colorful bucket. The same procedure was followed for each of the six objects in the set. The order in which the objects were presented was randomized by having E choose objects randomly from the plastic bag. The language E used was different for different objects; that is, she commented on the five nontarget objects, but she named the target object. (The comments on the nontarget objects concerned some property of those objects and were kept fairly constant across children, conditions, and objects.) Thus, when a nontarget object was introduced, E showed interest in it and commented by saying things like “Look at this! It's really neat. See? What color is it? Can you put it in the bucket?” When the target object was introduced, E showed the same interest in the object but labeled it with one or more pairs of labeling sentences (depending on the timing conditions)—for example, “Look at this! This is a wuggy. See? It's a wuggy. Can you put it in the bucket?”

Verb group

The procedure for this group of children was identical to that used for the noun group, except that actions and novel verbs were incorporated into the game. For the three familiar objects (always presented first), as E chose an object, she also demonstrated a simple action while using a familiar verb (e.g., “Look at this. It swims/it rolls/I'm biting it.”). For the three novel objects, as E picked up the target object, she demonstrated a novel action while producing one (or more) pairs of utterances containing the novel verb (depending on the timing condition assigned to that object set). For example, E demonstrated a target action two times while saying “Look at this! It's dacking. See? It dacks. Can you put it in the bucket?”. [1] For the two other novel objects serving as distractors, to keep the procedure as simple as possible, E did not produce novel actions but instead simply showed interest in these objects by saying things like “Look at this! It's really neat. See? What color is it? Can you put it in the bucket?” (as for the noun group).

Action group

The procedure for this group of children was the same as for the verb group, except that as E picked up the target object, she demonstrated a target action two times and said (with no verb label) “Look at this! Look what we can do with this. See? Look what we can do with it. Can you put it in the bucket?”

Testing Procedure

The production and comprehension testing procedures for children within a given group were identical, regardless of timing of exposures or retention interval. Production testing preceded comprehension testing at all three retention intervals. The three retention intervals were as follows: immediate (testing took place within 1 min after the last training), one day (testing took place approximately 24 hr after the last training), and one week (testing took place approximately 7 days after the last training).

Noun group

E began the production task by asking the child to name the three familiar objects (in random order), one by one, as a way of introducing them to what was expected of them. Then, in continuous sequence, she asked for names of the three novel objects (in random order). In each case, E simply held up the object and said to the child, “Look at this! What is this called? Can you tell me? What is it?” In the comprehension task, E showed the child the set of familiar objects and asked the child to choose one of the familiar objects. E then showed the child the set of novel objects (arrayed randomly) and asked her to choose the target by saying “Show me the wuggy. Which one's the wuggy? Can you put it in the bucket?”

Verb group

In the production task, E held up each object (familiar before novel, as for nouns) and asked the child, first, to show her what it does and, second, to tell her what the action was called. Thus, during an initial enactment of the action E asked, “Look at this! What does it do? What does this do?” Then the child was invited to perform the action with the object (if the child did not perform the action himself or herself, E performed it for the child). While the action was being performed (by the child or by E), E asked the child to say the novel verb by saying, “Look! What is it doing?” Thus, children were asked to both enact the action and say the verb in the production task, and their ability to enact the action or say the verb was analyzed separately in the following analyses.

In the comprehension task, following the test trial with the familiar objects and actions, E showed the child the three novel objects (arrayed randomly) and asked the child to choose the target, saying “Show me the one that dacks. Which one was dacking? Can you put it in the bucket?” Although choosing an object does not conclusively demonstrate that children comprehend the meaning of a new verb, to be consistent across the three conditions, children were simply asked to choose the target object. If children in the verb condition remembered the target object but not the associated action, their performance in this comprehension task would overestimate their knowledge of the verb and action.

Action group

In the production task, E held up each object (familiar before novel) and asked the child to show her the action, saying “Look at this. What do we do with this? What does this do?” In the comprehension task, E enacted the action using her hand (e.g., patting her head) and asked the child to choose the target object (from the novel objects, arrayed randomly), saying “Show me the one that goes like this. Show me the one that goes like this. Can you put it in the bucket?” As noted in the verb condition, to be consistent across all three conditions, children were asked to choose an object in the comprehension task. Thus, our comprehension task may reveal more about whether children remembered the target object associated with an action than whether they remembered the nonverbal action itself.

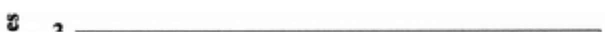
Scoring

An observer coded the children's responses live during the experimental sessions. In the production tasks, children in the noun and verb groups were considered correct if they produced the target noun or verb when asked about the target object or action, respectively; otherwise they were incorrect. In the action group, they were considered correct if they produced (acted out) the target action upon request.

In the comprehension tasks, children in the noun group were correct if they chose the target object when asked for it by name (via target noun). Children in the verb group and the action group were considered correct if they responded to E's query, “Show me the one that dacks. Which one dacks. Which one was dacking?” for the verb condition, or “Show me the one that goes like this” (with manual enactment) for the action condition, by choosing the object that had been used in the demonstration during training. For each group of children, a second blind coder then coded the videotapes for three children from each group (25%). Interrater reliabilities, as estimated by Cohen's kappa, were 1.00 for noun comprehension,.96 for noun production,.94 for verb comprehension,.82 for verb production, 1.00 for action comprehension, and.92 for action production.

Results

As preliminary analyses revealed no significant differences between the two counterbalanced orders, order was ignored in further analyses. There were also no differences among the retention intervals for any of the three groups, so children's scores were combined across these intervals (p>.05 in all three cases). Combining across retention interval, a given child had a comprehension score in each timing-of-exposures condition that ranged from 0 to 3. The main analysis was thus a 3 (item learned) × 6 (timing of exposures) mixed analysis of variance (ANOVA), with number of items comprehended as the dependent measure. There were no main effects and no interactions among variables in this analysis. Thus, in comprehension testing, children were very good at recalling the target objects in all conditions. Summed across the three retention intervals, children in the noun group comprehended 2.67 out of 3 items, children in the verb group comprehended 2.37 out of 3 items, and children in the action group comprehended 2.58 out of 3 items (see Figure 1).



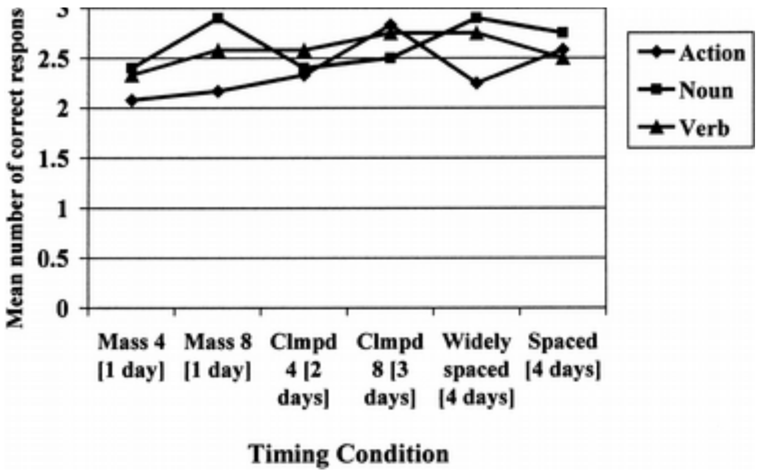


Figure 1. Mean number of correct target choices in comprehension (out of three) as a function of item learned and timing of exposures in Study 1. Clmpd = clumped

As expected, production was much more difficult for the children. Additionally, their recall as measured by production showed effects of both item learned and timing of exposures. Again, there was no difference in the two counterbalanced orderings of conditions, and there were no differences among the retention intervals, so these variables were ignored in the main analysis (see for productions at different retention intervals). The main analysis was thus again a 3 (item learned) × 6 (timing of exposures) mixed ANOVA, with number of items produced (out of three) serving as the dependent measure. This analysis revealed a main effect for training group, $F(2, 35) = 12.53$, $p<.01$; a main effect of timing of exposures, $F(5, 35) = 5.89$, $p<.01$; and a significant interaction between these two variables, $F(10, 35) = 4.98$, $p<.01$ (see Figure 3).

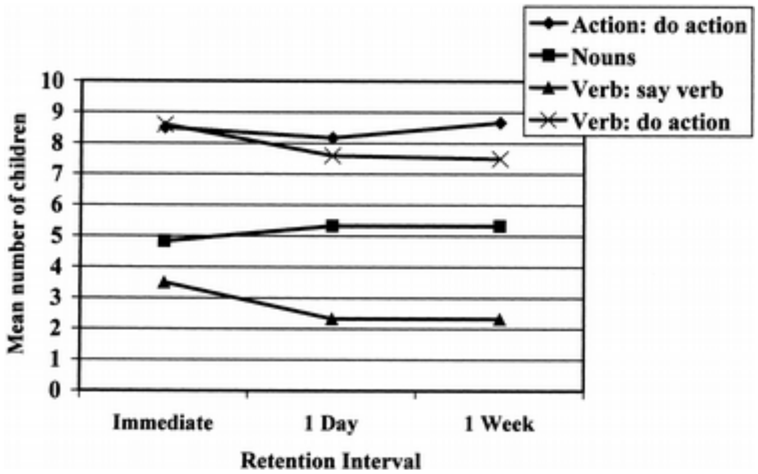
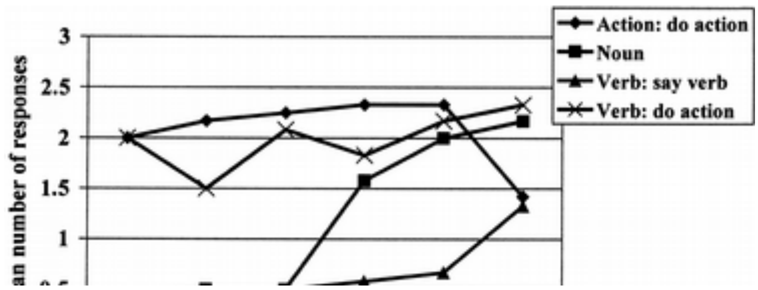


Figure 2. Average number of children recalling word in production as a function of retention interval in Study 1



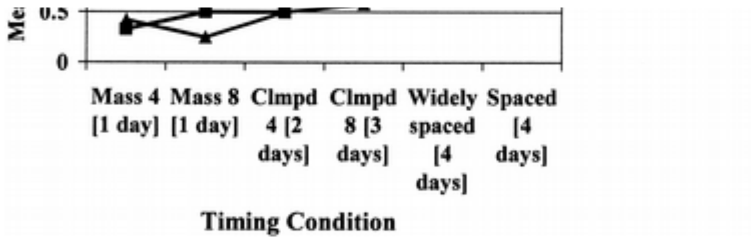


Figure 3. Mean number of times word produced (out of three) as a function of item learned and timing of exposures in Study 1. Clmpd = clumped. Spaced = Daily 4

Post hoc analyses were used to examine the nature of this interaction in more detail. First, six univariate ANOVAs were computed to compare the three items-learned groups within each of the six timing-of-exposures conditions. If the univariate ANOVA was significant, we then computed three pairwise comparisons using *t* tests with Bonferroni corrections to determine the nature of the difference between the different word types for that timing condition. This analysis thus addressed the question of whether, within a particular timing-of-exposures condition, some of the items learned were produced more often than were others.

These pairwise comparisons revealed, first, that in three timing conditions (Massed 4, Massed 8, and Clumped 4), children's production of nonverbal actions was significantly different from their production of nouns and verbs ($p<.05$ in all six comparisons), whereas production of nouns and verbs did not differ from each other. In a fourth condition (Clumped 8), children's production of nonverbal actions was significantly different from their production of new verbs ($p<.05$) but was not different from their production of nouns. Of the two remaining timing conditions, in one condition (Widely Spaced 4), children produced more nonverbal actions and nouns than verbs ($p<.05$ for both comparisons), whereas in the last timing condition, Daily 4, there were no differences in the production of nouns, verbs, or nonverbal actions.

One conclusion is thus that the nonverbal actions are easiest to produce ($M= 2.08$); children produced significantly more nonverbal actions than nouns in three conditions and more actions than verbs in five conditions. Further, children produced almost twice as many nouns as verbs overall ($M= 1.18$ for nouns, 0.63 for verbs), with the difference between noun and verb production most clearly demonstrated in the Widely Spaced 4 condition. It should be noted that there were two ways to score children's responses to the production test in the verb condition. One response children made was to demonstrate the correct action on the target object and the other was to actually produce the target verb. shows that children's acting out of the target action was similar to the nonverbal action condition, as might be expected, so they clearly recalled the action involved. However, actually learning to produce the verb was much more difficult.

A second set of post hoc analyses focused on the three items-learned groups and how each group was individually affected by the timing-of-exposures manipulation. In this case, three univariate ANOVAs were computed, one for each items-learned group. If the univariate ANOVA was significant, then the six timing-of-exposures conditions were compared using pairwise comparisons (*t* tests with Bonferroni corrections). When significant differences were found for these comparisons, all significant differences were found to meet or exceed $p<.01$.

In the noun group, the Daily 4 timing condition was significantly different from three other conditions, Clumped 4, Massed 8, and Massed 4, which were all not different from each other.

The Widely Spaced 4 condition was also significantly different from the Massed 8 and Massed 4 conditions, which again did not differ from each other. In the verb group, the Daily 4 condition differed from the Massed 8 and Massed 4 conditions. In the action group, no significant difference was revealed by the univariate ANOVA.

A clear conclusion here is that our timing-of-exposures manipulation affected the two types of words more than it affected the nonverbal actions. In particular, the two massed conditions were inferior to the distributed condition (Daily 4) for both nouns and verbs. It is particularly noteworthy that for both nouns and verbs, there was at least one condition with four distributed exposures that was statistically higher than another condition with eight massed exposures.

Discussion

Perhaps surprisingly, children's word learning in this study was not affected by retention interval in either comprehension or production. If they recalled a word immediately after training, then they also recalled it one day and one week later; this was true in all experimental groups and conditions. This finding is consistent with the findings of Markson and Bloom (1997), Carey and Bartlett (1978), and others. It should be noted, however, that in the current study, spacing condition was a within-subjects variable, so children were getting repeated trials over the three testing sessions. Thus, in a sense, after the immediate test, children were getting reminders at each testing session because in the comprehension test, the word or action was performed by the experimenter. Under these conditions, children's comprehension was very good (near ceiling) across the board and showed no strong differences among experimental conditions—confirming the well-known advantage for comprehension over production (e.g., Fenson et al., 1994; Goldin-Meadow, Seligman, & Gelman, 1976).

The novel findings of the study all concern production. First, in general, children found it easier to recall the associated action an adult had performed with an object than the word they had used for that object (noun) or the word they had used for an associated action (verb), although this was not true in the most distributed exposure conditions, where learning of all the different types of items was equally good. This finding would seem to conflict with those of Markson and Bloom (1997), who found no difference between word learning and the learning of verbally expressed facts (e.g., “My uncle gave this to me”) or the immediate learning of a visually experienced fact (i.e., seeing a sticker placed on a particular object). The explanation of this discrepancy presumably rests in the specific nature of the nonverbal item learned in the two studies. In the current study, we demonstrated actions on objects and told the children, “Look what we can do with this.” They were thus learning a social-conventional behavior: what we do with this object or how we play with it. Even though Markson and Bloom also told their children about the sticker, “Watch where this goes,” this is more of an arbitrary fact and clearly not the same as learning what an object affords for one's own actions in a social (play) setting. Some possible explanations for why learning nonverbal actions should be easier than learning nonverbal facts—and in many cases words—will be explored in the general discussion.

Second, the current findings may begin to provide some experimental support for the proposals of Gentner (1982; Gentner & Boroditsky, 2001) that nouns are easier to learn than verbs—although the way we taught and tested our nouns and verbs should be carefully considered (and our findings are confined to English-speaking children). In general, children found it easier to recall new nouns than verbs, producing three times as many nouns as verbs. One serious problem is that whereas the way we taught our nouns would be considered by most researchers to be a natural and effective way to teach them, verbs present some difficult decisions. We decided to teach and test children's knowledge of verbs such that comparisons between the noun and verb groups could be made. In our study, children in the noun group were asked to map a new word onto a new object (as, again, is natural and common in noun learning). Children in the verb group had to map a new word onto an action that was related to a specific object. By asking about actions related to specific objects, we were able to teach and test the verbs in a way that was similar to the nouns. However, in everyday contexts, verbs are mostly used for a range of objects (with the range being fairly large, e.g., for a verb like *move,*or small, e.g., *hammer,*depending on the verb). Thus, children's difficulty in the verb condition may have been exacerbated by our insistence that they attach the verb to target objects. On the other hand, children in the nonverbal action condition appeared to readily attach new actions to specific objects.

More important, perhaps, is that the way we tested verb comprehension may have been biased in favor of nouns: Children were asked to choose the target object that was associated with the new action. In future studies it will be important to design verb comprehension tasks that clearly test whether children recognize a particular action, not whether they choose a target object. We also designed our production test such that the same test could be applied to all three item types. However, again, this test may favor noun productions. In our production test, we asked children in the verb condition to reproduce the action and the verb label. Thus, children in this condition were asked to make two responses, whereas children in the noun condition only needed to make one response. On the other hand, testing verb production in this way allowed us to demonstrate that what children in the verb condition were having difficulty accomplishing was not mapping actions to specific objects (as they readily accomplished in their verb reproductions and in the nonverbal action condition), but learning verbs to refer to these actions (which is the task faced in everyday verb learning situations).

Two other difficult decisions were (a) whether to teach the verb in a transitive or intransitive sentence frame (“The ball is meeking” vs. “I'm meeking the ball”) and (b) whether to use the verb to describe the child's action or that of an object (or other person). We chose to teach the child an intransitive verb for the action of an object because we thought that that would make this condition most comparable to the noun and action conditions. When done in this way, the training could in all cases be object focused and could use similar language, and the testing could be comparable in the sense that there could again be a focus on objects and their names, associated actions, or the names of their associated actions. But there is some indirect evidence that children learn some kinds of verbs better when they are used for their own actions (Smiley & Huttenlocher, 1995), and so we cannot be sure that we did not put the verbs in the current study at a disadvantage by teaching them in something other than their most conducive learning contexts.

Third and most importantly, although the timing of exposures did not have an effect on the learning of the action, it had a strong effect on the learning of the two types of words (at least in terms of production). For both nouns and verbs, the worst learning conditions were the two massed conditions, in which children received all of their exposures on the same day—and it did not matter whether they got four or eight exposures on that day. Also, for both nouns and verbs, the best learning conditions were the two conditions that took place over 4 days—and for nouns it did not matter how many days intervened between the individual sessions (either 1 or 3 days). The key variable in these timing-of-exposures conditions thus seemed to be the number of different days on which children received language models. Many issues are left open by this initial exploration into issues of the influence of the timing of models on production, and indeed why distributed practice is better than massed practice in skill learning in general is not totally clear. In any case, in Study 2 we investigated the spacing of models in terms of days between exposures to determine whether number of days is indeed an effective variable by itself and to examine whether many days between exposures might begin to produce recall deficits.

Study 2: Variations of Timing of Exposures

The main finding of Study 1 was that the timing of exposures seemed to be a more powerful aid to word learning than did number of exposures—at least within the number of exposures and timing conditions utilized. Additionally, what seemed to be the most important single aspect of timing was the number of days on which children were exposed to a new word (regardless of how many times they heard the word on that day). Moreover, there were some indications that the spacing between days of exposure was important, with large gaps between exposures having a negative influence on word learning (i.e., production). In the current study, we held the number of models constant at four (i.e., at four pairs), as in the majority of conditions in Study 1, and varied the number of days on which the child heard those four models and the number of days that elapsed between modeling days. We trained and tested with nouns only, and we did not vary retention interval, as this variable had no effect in Study 1.

Method

Participants

Participants were twenty 21/2-year-old children (mean age = 2 years 6 months; range = 2 years 3 months to 2 years 10 months); 14 girls and 6 boys participated. Two additional children failed to complete the study. Children were recruited and informed consent was obtained in the same way as in Study 1.

Materials and Design

In a totally within-subjects design, each child was exposed to seven sets of objects, one in each experimental condition. The object sets were assigned to conditions in a counterbalanced manner. As in Study 1, each object set contained three familiar objects and three novel objects, one of which was the target and the other two of which were used as foils in the comprehension testing. There were two within-subjects variables. The first was the number of days on which children received their four models. In different conditions, they received them either all in one day (1-day), two per day in two consecutive days (2-day), one-then-two-then-one in 3 consecutive days (3-day), or one per day for 4 consecutive days (4-day). There were three additional conditions (gaps between days) in which children always received their four models in 2 days, but with different lags between those days: with a 2-day gap between modeling days (2-gap), with a 5-day gap between modeling days (5-gap), and with a 10-day gap between modeling days (10-gap).

As in Study 1, perfect counterbalancing of order of conditions was not logistically possible.

Instead, two different schedules were created, each of which intermixed the seven conditions in a different ordering during a 2-week period. One schedule was constructed so that the initial exposures were ordered as follows: 2-day, 1-day, 10-gap, 3-day, 5-gap, 4-day, 2-gap. The other schedule was constructed so that the initial exposures were ordered as follows: 3-day, 10-gap, 2-day, 5-gap, 1-day, 2-gap, 4-day. Half of the children in each of the three training groups were seen in each of these orders. Both orders were constructed so that no child in any of the groups ever was exposed to more than two novel items on a single day.

Training Procedure

Each exposure session was identical to the sessions in the noun group of Study 1. Each involved interaction with E for 5–10 min with a single object set, with O also present and videotaping the session. For each exposure session, E picked up each object in the set, labeled it (if the target) or commented on it (if a distractor), and gave the object to the child. The child was then asked to put the object into a bucket. The process was repeated until all of the objects in a set were either labeled or commented on. For the distractor objects, E showed interest in the object and commented on it (e.g., saying, “Look at this. What color is it? See? It's fun. Can you put it in the bucket?”). When the target object was introduced, E labeled the object in a pair of utterances (e.g., “Look. It's a wuggy. See? It's a wuggy. Can you put it in the bucket?”).

Testing Procedure

Following all of the training sessions for a given condition (i.e., on the last day of training for a given condition), children received both a production and comprehension test for that word. As in the previous study, in each test children were first asked about the familiar objects and then were asked about the novel objects. In the production task, E simply held up each object and asked the child to name it (e.g., “Look at this. What's this called? What is it?”). In the comprehension task, E showed the child the set of novel objects and asked him or her to choose the target (e.g., “Show me the wuggy. Can you put it in the bucket?”).

In an effort to introduce a short delay, 10 children experienced a 5-min delay before testing in all conditions, with book reading occurring in the interval. This turned out to depress performance in production much more than expected, so an additional 10 children were given their production tasks immediately after training (with the comprehension test for these children coming 5 min later).

Scoring

Children's productions in the production test and choices in the comprehension test were scored as correct or incorrect live by O. When a child produced the novel word in the production test, it was counted as correct. When the child chose the correct object corresponding to the novel noun in the comprehension test, that response was scored as correct. Following the initial coding, a second blind coder also coded six (25%) of the children's responses. Interrater reliability, as estimated by Cohen's kappa, was equal to 1.00 in both comprehension and production.

Results

The number of children learning the target word in production and comprehension is presented in and 2. Clearly, children were not as good at producing the novel nouns as they were in Study 1, presumably because the delay with a distractor task interfered with their retention. Nevertheless, a very similar pattern of results was observed.

Table 1
Number of Children Producing and Comprehending Words in the Different Experimental Conditions of Study 2: Gaps Between Days

	Task	
Gaps between days	Comprehension	Production
1-gap	12	2
2-gap	15	3
5-gap	15	0
10-gap	14	1

Note. $N = 20$. The 1-gap condition is the same as the 2-day condition in the number-of-days analysis.

Number of Children Producing and Comprehending Words in the Different Experimental Conditions of Study 2: Gaps Between Days

Table 2
Number of Children Producing and Comprehending Words in the Different Experimental Conditions of Study 2: Number of Days

	Task	
Number of days	Comprehension	Production
1-day	11	1
2-day	12	2
3-day	14	4
4-day	13	6

Note. $N = 20$. The 1-gap condition is the same as the 2-day condition in the number-of-days analysis.

Number of Children Producing and Comprehending Words in the Different Experimental Conditions of Study 2: Number of Days

In the comprehension task, children were asked to choose the target object from a set of three objects. The probability of choosing the target object by chance was.33. If children were choosing the target by chance, we would expect approximately 7 children to succeed in any condition (.33 × 20 children = 6.6). Instead, at least 11 children were successful in each condition (range = 11–15). One-tailed binomial tests comparing the number of children who were successful to the number that would be expected by chance were significant ($p<.05$) in all cases. Thus, as in Study 1, children were able to comprehend new nouns relatively quickly and there were no differences in the timing conditions.

Children's productions were examined using the Cochran's *Q*test. For gaps between days (see Table 1), there were no significant differences in children's productions (due to a floor effect across all conditions). But it is worth noting that very few children (1) learned to produce a novel word when models were distributed either 5 or 10 days apart. In the number-of-days analysis (see Table 2), the Cochran's *Q*test was significant, $Q(3) = 10.11$, $p<.02$, such that, in agreement with Study 1, distributing models over days helped children to learn new words. In sum, there was a general linear increase such that distributing four models over 4 days was many times better than having those same models on 1 or 2 days.

Discussion

Roughly two thirds of the children comprehended the word in all of the conditions in this study, with this figure being above chance in all conditions. The production data show a floor effect in the gaps-between-days conditions, and so it is unclear whether under different conditions this variable would have an effect. But even though the numbers are small, the pattern of results suggests that spacing out models over a few days—even keeping number of models constant—helps children to learn new words in production, whereas spacing out models over a few days with very large gaps between those days is not helpful. How these spacing effects might interact with number of models is a question for future research. A second question for future research is how and why our small delay in testing—with a verbal distractor task—produced such a negative effect on children's productions.

General Discussion

Two-year-old children hear many hundreds of words that they do not know every day. They learn about two of them. There are many factors that conspire to determine which ones these are: children's cognitive readiness for the concept involved, the transparency of the pragmatic contexts in which they hear the word being used, the perceived usefulness of the word for their daily activities, and others. However, in addition, there are purely quantitative factors, including the frequency with which they hear a new word and the timing of the occasions in which they hear it. The current study has established that the well-known learning principle that distributed exposure is better for learning than massed exposure—a phenomenon that applies to many kinds of learning in many animal species—also applies to children's word learning (at least in production). The 2-year-olds in our study learned to produce a word more readily—by several orders of magnitude—if they heard it once per day for 4 days rather than eight times in a single day. Findings from both Study 1 and Study 2 suggested that the major timing factor in the current experiments was the number of different days on which the child heard the new word, with more days being better. The gaps between days did not seem to be a major factor in the current studies—children learned just as well when their four models came on 4 consecutive days and on 4 days spread further apart—but Study 2 provides suggestive evidence that there are gaps wide enough apart to affect learning adversely (as in some types of infant learning; Rovee-Collier, 1995). Although future research is needed to clarify the precise trade-off between the number and timing of exposures in word learning, our study suggests that 2-year-old children can learn to produce a new noun or verb from hearing it repeated a small number of times, provided that those models are distributed over about a week.

Bloom (2000)proposed that many of the principles that govern word learning are general principles that are shared with other types of learning, and the findings of Saffran et al. (Saffran, Johnson, Aslin, & Newport, 1999; Saffran, Loman, & Robertson, 2000), Ramus, Hauser, Miller, Morris, and Mehler (2000), and Hauser, Newport, and Aslin (2001)suggest something similar for the early learning and memory of some auditory aspects of language as well. Our findings suggesting that word learning is facilitated by distributed as opposed to massed exposures are in accordance with this hypothesis, as the massed-distributed learning effect has extremely broad application across tasks, ages, and even animal species (see Underwood, 1961, and Dempster, 1996, for reviews). On the basis of his findings that showed some advantage for words as compared to other visually presented information (Markson & Bloom, 1997; see also Markson, 1999), Bloom proposed further that perhaps “socially transmitted information” that leaves no trace in the environment is the sort of information that the child needs to learn and can “fast map,” whereas other information (including visually based information) that is, in a sense, stored in the environment, does not need to be fast mapped because it can be accessed perceptually as needed. Given this view, our nonverbal action condition is the kind of information that the child would need to attend to, and perhaps fast map, because the transient action is not “stored in the world.” On this view, fast mapping is not a process specific to language but is a process reserved for any information that will not be perceptually available at a later time.

A different explanation could also be offered to explain our children's performance in the nonverbal action condition. That is that, in contrast to the visual fact that Markson and Bloom (1997)used (i.e., placing a sticker on a particular object arbitrarily), in our study, children saw what we do with this object or its function in this play interaction. In a sense, this learning is very much like learning the meaning of a word in that children are perhaps learning the social-conventional meaning of this odd object—its significance for human action. So perhaps Bloom's hypothesis may be revised to say that what children learn most readily and retain the longest are social-conventional behaviors that they learn from other persons (including social-conventional facts). These behaviors are learned by imitation of other persons, whereas learning where to place a sticker is not learned via imitation—at least not in the sense of learning specific verbal or nonverbal behaviors. Perhaps the superior performance of our children with the imitated actions simply reflects the fact that once we humans have seen an object used in a certain way, when we see that object again, its function is, in a sense, directly perceived as one of its features and we understand how we might (re)produce it (Tomasello, 1999). It is not clear why our nonverbal actions did not show effects of mass versus distributed exposure, but it is possible that this resulted from the high amount of recall overall (a ceiling effect), and that fewer exposures or greater delays would evidence such effects.

We should also note that Waxman and Booth (2000)reported that when 4-year-old children learned a novel count noun for a novel object, they generalized it to similar objects, but when they learned a novel fact (“My uncle gave this to me”), they did not generalize this fact to other similar objects. Waxman and Booth thus argued that the learning of count nouns differs from the learning of this kind of fact (though not all facts) in the use of categorization processes. (Obviously, gifts from uncles are single objects and the fact that he gave you a particular umbrella for Christmas does not mean that he gave you other umbrellas as well.) In contrast, however, it is likely that the nonverbal actions that children learned in our study would be extended to other similar objects because, in this case, actions that can be used with one object are quite often used with other objects of the same type (if twisting is what one does with this bottle cap, then very likely it is what one does with other types of caps). So our modeling of actions on objects is a further test of Waxman and Booth's hypothesis that word learning invokes categorization processes, whereas other kinds of learning mostly do not. In fact, a recent study suggests that their hypothesis should be expanded to include the kind of nonverbal modeling and learning of actions on objects used in the current study (Childers & Tomasello, in press).

Finally, our findings begin to provide some experimental support for the proposal that nouns are learned more easily than verbs (Gentner, 1982; Gentner & Boroditsky, 2001). In the current study, the trend for both nouns and verbs was for children to be more likely to be able to produce the new word the more days they heard it, but they still produced three times as many nouns as verbs. On the other hand, we gave children in all three conditions the same type of comprehension and production tests, and these tests probably favored nouns. Thus, in future studies it may be useful to compare noun and verb learning (production) using tests that are differently tailored for the noun and verb items. As this was one of the first studies to experimentally compare nouns with verbs, we felt it was important to begin by administering the same kind of test for both word types. It is also possible that this finding holds only for English-speaking children, either because of the structure of the English language or because English-speaking 2-year-olds have more practice at noun than at verb learning. Learning may even work differently for different types of nouns or verbs; for example, relational or complex nouns like *father*or *pedestrian*may behave more like verbs, and change-of-state verbs like *give*or *clean*might be easier to learn than the characteristic actions we used in the current studies. Once again, these are all questions for further research, and each would contribute significantly to evaluating in more detail Gentner's (1982; Gentner & Boroditsky, 2001) specific hypothesis that nouns are easier to learn than verbs because their intended referents are more easily individuated cognitively—a finding that should hold across languages for basic level nouns and verbs, but which might show some differences within languages for different types of these words.

Learning words is part of a larger process of language acquisition. It relies on some general principles of primate, perhaps even mammalian, perception, learning, and cognition (e.g., auditory and visual discrimination, massed vs. distributed practice, categorization), and also on some processes of cultural learning unique to the human species, involving the reading of communicative intentions and the imitative learning of these and other intentional actions (Tomasello, 1999). It is possible, in addition, that some aspects of language acquisition or word learning rely on domain-specific principles as well, but there are many domain-specific principles to consider and each must be investigated individually. The current study contributes to a growing body of literature (e.g., Hauser et al., 2001; Markson & Bloom, 1997; Ramus et al., 2000; Saffran et al., 1999, 2000) suggesting that many aspects of language acquisition —although perhaps not all—rely crucially on domain-general processes of human perception, learning, and cognition.

Footnotes

[1] Note that there was somewhat more variety in the verb constructions as compared with the noun frames. However, Leonard and Schwartz (1985)found a noun advantage even when noun and verb constructions were held constant.

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APPENDICES

APPENDIX A: Materials for Studies 1 and 2

Figure A1. The target object is shown as the left object in each set

APPENDIX B: Nouns, Verbs, and Actions

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