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The Development of Word Retrieval Abilities in the Second Year and its Relation to Early Vocabulary Growth

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The present research investigated the development of word retrieval abilities late in the second year when most children display a marked increase in word production. When asked what was hidden in a given box, children with still quite limited productive vocabularies were reliably less likely to produce the labels of the hidden objects than were children with larger productive vocabularies even though (1) all children could name those objects and (2) all children did well when asked to find those same hidden objects. Additionally, the provision of pictorial cues facilitated word retrieval, especially in the early stage of lexical development. Naming errors during a naturalistic book-reading session peaked in children whose productive vocabularies had recently begun to expand, further suggesting that word retrieval processes undergo significant changes at this time.

INTRODUCTION

Children's first words usually emerge late in the first year, although some children may begin to speak at 8 months whereas others do not until 18 months or older. Following the onset of expressive language, the rate of word acquisition is initially rather slow, with children learning only a few new words per month. Toward the end of the second year, children typically display a sudden spurt in vocabulary growth, roughly after their productive lexicons have reached 50–100 words (e.g., Bates, Bretherton, & Snyder, 1988; Benedict, 1979; Bloom, 1973; Corrigan, 1978; Dore, 1978; Dromi, 1987; Fenson et al., 1990; Gentner, 1983; Goldfield & Reznick, 1990; Goldin-Meadow, Seligman, & Gelman, 1976; Gopnik & Meltzoff, 1987; Halliday, 1975; Ingram, 1978; Khami, 1986; Lifter & Bloom, 1989; McShane, 1980; Nelson, 1973, 1985). The advent of this linguistic milestone indexes the beginning of a period of significant developments in the language domain. For instance, the first word combinations usually emerge soon after the onset of the vocabulary spurt (e.g., Bates et al., 1988). The use of language to refer to things that are not physically present is also reported to increase at this time (e.g., Sachs, 1983). Furthermore, overextended, onomatopoeic, and idiosyncratic words—commonly found among children's early words—tend to disappear after the onset of the vocabulary spurt (e.g., Goldin-Meadow et al., 1976).

This steep increase in the number of words used by children in their speech has intrigued researchers of early language development for over two decades. Its typically abrupt onset, coupled with the seemingly qualitative changes observed in children's language use at this time, had researchers pointing to sudden insights, or new levels of conceptual understanding, as possible causal mechanisms underlying this phenomenon. Over the years, the vocabulary spurt has been linked to the development of representational skills (e.g., Bloom, 1973; Corrigan, 1978; Ingram, 1978; McCune-Nicolich, 1981), the metalinguistic insight that words refer to things (e.g., Dore, 1978; Khami, 1986; McShane, 1980; Nelson, 1985) or that everything has a name (Reznick & Goldfield, 1992), an emergent appreciation of a linguistic constraint (e.g., Markman, 1991), a rise in children's fast mapping of object words (e.g., Mervis & Bertrand, 1994), and a new interest in categorization (e.g., Gopnik & Meltzoff, 1987, 1992). Each of these hypotheses to explain the vocabulary spurt sparked research that has significantly advanced our understanding of the complex relation between language and cognition in the second year. None, however, can be considered to provide a complete account of the vocabulary spurt because they typically failed to consider the fact that comprehension far exceeds production in the early stages of language acquisition (e.g., Bates et al., 1988; Benedict, 1979; Clark & Hecht, 1983; Goldin-Meadow et al., 1976; Huttenlocher, 1974). From a logical point of view, the advances posited to account for the onset of the vocabulary spurt in many of these proposals appear to be equally necessary for both language comprehension and production. Thus, if failure yet to have any of the proposed sudden realizations is what constrains the size of children's early productive vocabularies before the vocabulary spurt, these same limitations should

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also be found in children's receptive vocabularies. This is clearly not the case. Although evidence suggests that children's receptive abilities may improve after the vocabulary spurt (Reznick & Goldfield, 1992), experimental data indicate that well before the onset of the spurt in production children can learn new words quickly, even with limited exposure (Woodward, Markman, & Fitzsimmons, 1994).

This asymmetry between early receptive and productive abilities highlights the need to consider carefully the distinct processes by which word meanings can be comprehended and produced. As Huttenlocher (1974) pointed out, language comprehension requires *recognition* of word sounds and recall of what a word stands for (e.g., objects, events, actions, or relations). In contrast, language production requires *retrieval* of the pattern of sounds associated with a given meaning. Consider the case of object names. To understand or produce an object label, a child must have stored in memory nonverbal information about that object kind (e.g., its shape, color, function, etc.), as well as a phonological representation of the pattern of sounds that make up its label. The discrepancy between comprehension and production of that object label, then, must depend on the processes of retrieving these two types of information. In comprehension, the child's task is to retrieve the mental representation of a particular object upon hearing its label; in production, the child's task is to retrieve the phonological representation associated with that object label, whether the object is perceptually present or mentally represented. At the simplest level of analysis, retrieving a word meaning should generally be easier than retrieving a word sound for two reasons. First, young children can mentally represent people, objects, and events well before the emergence of expressive language (e.g., Ainsworth, 1973; Mandler, 1988). Second, words assume significance only if mapped onto nonlinguistic information, whereas objects, people, and events are meaningful in and of themselves. The phonological representation of a word may also have to be "retrieved" for comprehension to occur, in the sense that a match has to be found between the word just heard and its phonological representation stored in memory for the meaning of that word to be accessed. This retrieval process, however, differs substantially from the self-initiated word retrieval required for language production, which involves accessing the phonological representation of a word in the absence of external cues, as well as holding this representation active during the planning and execution of a motor plan. This distinction, or dissociation, between the type of retrieval required for word comprehension versus production can be fully appreciated, for example, in the tip-of-the-tongue phenomenon in which one temporarily experiences an inability to retrieve a word for production, although that same word could be accessed immediately, and without effort, in comprehension (see Reznick, Corley, & Robinson, 1997, for additional discussion of the processes supporting language comprehension and production).

Focusing on precisely this latter kind of word retrieval, the present research set out to investigate how changes in children's word retrieval abilities may be related to the dramatic developments seen in children's productive vocabularies toward the end of the second year. To be sure, other investigators here entertained the notion that word retrieval processes undergo significant changes at this time. For instance, Huttenlocher (1974) speculated that word retrieval difficulties in the beginning stage of lexical development may account for the large gap between early comprehension and production. Deficient word retrieval abilities have also been invoked to help explain children's early overextension of words in production but not in comprehension (Fremgen & Fay, 1980; Huttenlocher, 1974; Naigles & Gelman, 1995; Rescorla, 1980; Thompson & Chapman, 1977). More recently, Bloom (1993, p. 99) has further suggested that "the relevant developments in the single-word period, leading to the vocabulary spurt, are in the cues a child can use for recalling the words they have stored in memory." Empirical evidence of systematic changes in word retrieval abilities late in the second year, however, has proven extremely hard to come by; to date, only a single published study has indirectly supported this notion by reporting a transient rise in the frequency of naming errors at the time when children begin to produce many more words (Gershkoff-Stowe & Smith, 1997).

The primary goal of the present research, then, was to fill this void by seeking empirical support for the hypothesis that word retrieval processes undergo significant changes at the time when most children show a steep increase in their productive lexicons. To this end, building on data from a previous pilot study (Dapretto, Bjork, & Gelman, 1991), an experimental procedure was devised to assess word retrieval abilities in children at different stages of lexical development. Briefly, familiar objects that a child was able to name were first hidden inside boxes; the child was then asked what was inside each box and, later, to find those same hidden objects. The logic of this design was as follows. Both tasks required that a child be able to recall where a given object was hidden. Only the first task, however, required that the child also be able to retrieve the object label (when asked, "What's in this box?"); in contrast, the child needed only to comprehend the object label in the second task (when asked, "Where is the______?"). Thus, a direct comparison of children's performance on these two tasks allowed for the assessment of their word retrieval abilities independently from their ability to recall what was hidden in a given box. Children's ability to retrieve an object label when asked what was hidden in a given box was expected to increase as a function of their level of lexical development (overall indexed by the size of their productive vocabularies); in contrast, children's ability to recall an object location when asked to find a hidden object was not expected to differ substantially as a function of their level of lexical development, given previous research findings indicating good location memory in very young children (e.g., DeLoache, 1980, 1984).

A second goal of the present study was to investigate whether the presence of visual cues would differentially facilitate word retrieval in children at different stages of lexical acquisition. There is some suggestive evidence for this possibility. Some researchers have noted that children begin to refer to things that are not physically present—a process that clearly requires the ability to retrieve words in the absence of perceptual cues—at about the same time that they show a vocabulary spurt (Ingram, 1978; Sachs, 1983). Before the vocabulary spurt, children typically use very few of the words they know when their referents are out of sight; instead, they tend to name objects when they first catch their attention or when they are inspecting and handling them (e.g., Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Lempert & Kinsbourne, 1985)—that is, when a host of perceptual cues are available to facilitate retrieval of the object names. If deficient word retrieval abilities limit the productive output of children in the early stage of lexical acquisition, the presence of visual cues for an object that is no longer perceptually available should enhance the likelihood that its label will be produced. Thus, the provision of pictorial cues was expected to facilitate retrieval of an object label possibly across all stages of lexical development but particularly so in the early stage when word retrieval processes are deemed to be less efficient.

The third and final goal of this study was to replicate Gershkoff-Stowe and Smith's intriguing finding (1997) of a sharp increase in naming errors (i.e., mislabeling pictures of objects whose labels have been correctly used earlier) in the period surrounding the vocabulary spurt. Children's word retrieval processes, then, were also examined by observing their spontaneous naming behavior during a naturalistic "book-reading" session. Gershkoff-Stowe and Smith's findings may initially appear to run counter to the hypothesis that word retrieval abilities improve at the time when children's productive lexicons begin to expand rapidly. However, these naming errors—taken to reflect interference during the retrieval process from recently retrieved words—manifested themselves in the context of an activity (i.e., book reading) likely to elicit a great deal of naming. Accordingly, this surge in naming errors following the onset of the vocabulary spurt rests, in a sense, on children's newly found ability to produce (i.e., to retrieve) more and more words in close temporal contiguity. Given the considerably greater opportunity for children to engage in object-naming activities during the spontaneous book-reading session versus the structured task outlined previously, it was expected that children who had recently begun to produce many new words might make more naming errors during book reading, while nevertheless showing improved retrieval abilities in the experimental task.

METHODS

Participants. Thirty children (16 girls and 14 boys), ranging in age from 14 to 24 months, were recruited from the wait-list of the UCLA Child Care Services, through ads placed in the UCLA Family Housing, and through birth announcements in a local newspaper. The children came from various ethnic backgrounds, although the great majority were White and middle class.

Group assignment. The vocabulary spurt is indexed by a change in the rate at which new words are added to a child's productive vocabulary. Researchers, then, have often defined the onset of the spurt as the time when some 10 or 12 new words are acquired over a specified period of time, typically 2 or 3 weeks (e.g., Gopnik & Meltzoff, 1987; Lifter & Bloom, 1989; Reznick & Goldfield, 1992).[1] Clearly, this definition cannot be used in a cross-sectional investigation where no information is available on the rate of growth of a child's productive vocabulary. This increase in rate,

[1] Note that in addition to the differences in the number of words required to define a spurt and in the length of the period allowed between assessments, previous studies have also differed with respect to the way the vocabulary data were gathered (by using diary records or word checklist), as well as to whether all words, or just object names, were included in the count. Even if used consistently across investigations, such a definition of the vocabulary spurt, as all other possible definitions ultimately resting on a critical cutoff value, may still lead to an imperfect classification (e.g., a child barely falling short of meeting the criteria while consistently adding many new words would be treated the same way as a child who fails to meet the criteria by failing to produce any new words or by adding just one or two words at each assessment point).

however, is logically associated with an increase in productive vocabulary size. Thus, in the absence of longitudinal data, the size of a child's productive vocabulary may be used as an overall estimate of where a child is in the course of early language development, or it may be used to estimate the likelihood that a child has reached this important milestone. Indeed, some authors have used the attainment of 50 words in production as a marker of the onset of the vocabulary spurt (e.g., Gershkoff-Stowe & Smith, 1997; Waxman & Hall, 1993) on the basis of research suggesting that the spurt typically occurs after a child's productive vocabulary has reached 50–100 words (e.g., Bates et al., 1988).

In the present study, children's level of language development was assessed by using a different—although closely related—measure relating the size of children's productive vocabularies to the size of their receptive vocabularies. Empirical support for the validity of such a measure comes from research (Dapretto & Bjork, 1993; Dapretto, Bjork, & Gelman, 1997; Goldin-Meadow et al., 1976) indicating that different comprehension-to-production ratios can reliably identify children at different stages of lexical acquisition that closely correspond to the developmental periods before, during, and well after the onset of the vocabulary spurt. Parental reports on the word checklist from the Infant Scale of the MacArthur Communicative Development Inventories (Fenson et al., 1990) were used to assess the children's comprehension and production vocabularies. Portions of the Toddler Scale were used to assess the presence and length of word combinations, the use of grammatical morphemes (regular plural -s, possessives -'s, progressive -ing, and past tense -ed), and children's referential word use (i.e., reference to past and future events and about absent objects and people).

For each child, a comprehension to production ratio was calculated on the basis of the combined number of common nouns and verbs reported as comprehended and produced on the word checklist. This ratio was then used to assign the child to one of three groups.

Five girls and four boys (mean age = 19,2, *range* = 15,5–22,1) with comprehension to production ratios of 3:1 or higher were assigned to the prevocabulary spurt group on the basis of Goldin-Meadow et al.'s (1976) data indicating that comprehension-to-production ratios of 3:1 or higher characterize children with very limited productive vocabularies who have not yet shown a vocabulary spurt. English was the primary language for all children, but two girls were also exposed to Spanish and one girl to Japanese. All but one boy were firstborns.

Six girls and six boys (mean age = 20,2, *range* = 13,9–24,4) with comprehension-to-production ratios higher than 1.5:1 but lower than 3:1, were assigned to the vocabulary spurt group because Goldin-Meadow et al.'s longitudinal data suggested that comprehension-to-production ratios of about 2:1 characterize children who have recently begun to display a marked increase in production. Two boys in this group had older siblings.

Finally, six girls and three boys (mean age = 21,9, *range* = 18,5–24,1) with comprehension-to-production ratios of 1.5:1 or lower were assigned to the postvocabulary spurt group, again on the basis of Goldin-Meadow et al.'s data showing that comprehension-to-production ratios of 1.5:1 or lower characterize children with quite large productive vocabularies. Although English was their primary language, one girl and one boy were also exposed to Yiddish and Spanish, respectively. All but one girl were firstborns.

Children in the vocabulary spurt group did not differ in age from children in either the prevocabulary spurt group, $F(1, 19) = .70$, $p > .05$, or the postvocabulary spurt group, $F(1, 19) = 2.89$, $p > .05$, but children in the prevocabulary spurt group were reliably younger than children in the postvocabulary spurt group, $F(1, 16) = 7.76$, $p < .05$.

Validation of Group Assignment. Following group assignment, a number of statistical analyses were conducted to corroborate the validity of this classification procedure in the current sample of children. First, children assigned to the three groups differed reliably in the number of words produced, $F(2, 27) = 136.2$, $p < .001$, as well as in the number of words they comprehended, $F(2, 27) = 11.4$, $p < .001$. Pairwise comparisons revealed that children in the prevocabulary spurt group comprehended and produced fewer words than children in the vocabulary spurt group, who, in turn, comprehended and produced fewer words than children in the postvocabulary spurt group, all *p*s < .05 by Fisher Protected least significant difference (LSD). The mean number of words comprehended and produced by children in the three groups is shown in Table 1.

It is important to point out that although group assignment was not based on a pure production measure, no between-group overlap was obtained in the number of words produced by children in the three groups. Indeed, the child producing the most words in the prevocabulary spurt group produced 29 fewer words than the child producing the least words in the vocabulary spurt group; in turn, the child producing the most words in the vocabulary spurt group produced 10 fewer words then the child producing the least words in the postvocabulary group. This is not surprising in light of the high correlation, $r(28) =$

Table 1 Mean Number of Words Produced and Comprehended By Children in the Three Groups

	Mean	Range
Words Produced		
Prevocabulary Spurt Group	42	24–58
Vocabulary Spurt Group	127	87–163
Postvocabulary Spurt Group	269	173–306
Words Comprehended		
Prevocabulary Spurt Group	189	101–247
Vocabulary Spurt Group	246	136–336
Postvocabulary Spurt Group	304	238–357

$-.75$ $p < .001$, found between the total number of words produced and the comprehension-to-production measure used during group assignment.

Second, children in the three groups differed reliably in their use of word combinations (as revealed by a multinomial analysis of variance, *p*s $< .05$). Specifically, whereas several children in the vocabulary spurt group and all children in the postvocabulary spurt group had started to combine words, children in the prevocabulary spurt group had not (although two of these children were reported to do so, the single examples provided by their parents, such as "all done" or "bye-bye," are not considered true two-word combinations). Furthermore, an analysis of the three longest sentences produced by children in the vocabulary and postvocabulary spurt groups (as listed by their parents on the questionnaire) showed that children in the latter group were able to produce reliably longer sentences than children in the vocabulary spurt group, who typically produced only two-word combinations, $F(1, 19) = 20.5$, $p < .001$.

Third, the number of children reported to use morphological markers in their speech differed reliably across groups (as revealed by a multinomial analysis of variance, *p*s $< .05$). As could be expected, no child in the prevocabulary spurt group was reported to use any grammatical morpheme yet; only a few children in the vocabulary spurt group were reported to have begun to do so sometimes; whereas all children in the postvocabulary spurt group were reported to use several grammatical morphemes and to do so often.

A composite index of a child's use of displaced reference was derived from parental reports on five questions of the MacArthur Toddler Scale asking parents to report whether their child understood when asked for something in another room, whether their child ever named an absent person while pointing to an object belonging to that person, whether their child ever talked about absent people or objects, about past events, and about future events. The parents' responses to each of the five questions were scored as follows: A score of 0 was assigned when a child had not yet displayed the behavior in question, a score of 1 was assigned when a child had displayed that behavior sometimes, and a score of 2 was assigned when a child had displayed that behavior often. A composite score was then obtained for each child by adding these scores for all five questions. Reliable group differences were observed in children's referential use of language, $F(2, 27) = 46.79$, $p < .001$. Further pairwise comparisons indicated that children in the prevocabulary spurt group were less likely to show displaced reference in their language use than were children in both the vocabulary spurt and the postvocabulary spurt groups, *p*s $< .05$ by Fisher Protected LSD, whereas the difference between the last two groups was not reliable.

Taken together, these results indicate that the group assignment procedure used in the present study based on children's comprehension-to-production ratios was successful in sorting the children into three distinct groups, such that children's linguistic abilities differed maximally between groups and minimally within each group.

The slightly different priorities used to schedule the testing sessions for children at different points of lexical development may also have contributed to maximizing variance between groups, as well as to minimizing variability within each group. The experimental task used in this study required that all children be able to produce the names of at least six test items. Pilot work indicated that this condition was usually met by the time a child had reached a cumulative productive vocabulary of about 30 words. Accordingly, parents were asked to fill out the language questionnaire once their child was able to produce at least two dozen words. Because of this requirement, children assigned to the prevocabulary spurt group were probably very close to the time when they could be expected to show a vocabulary spurt in production. Thus, testing was scheduled as soon as possible (usually within a few days) for these children for fear they might soon begin to show a spurt in production. The second highest priority was given to those children, assigned to the vocabulary spurt group, who had a comprehension-to-production ratio less than 2:1, or more than 125 words in production; testing was scheduled as soon as possible for these children for fear they might have to be reassigned to the postvocabulary spurt based on the parents' update of the language inventory at the time of testing. The lowest priorities were given to those children, assigned to the vocabulary spurt group, who had comprehension-to-production ratios greater than 2:1, or less than 100 words in production, and to the children assigned to the postvocabulary group; for these children, the initial group assignment was least likely to be affected by linguistic developments that might have occurred over a 1- to 2-week period.

Design. A 3 × 2 mixed factorial design was used in the experimental task, with stage of lexical development (prevocabulary spurt versus vocabulary spurt versus postvocabulary spurt) as a between-subjects variable and cueing (cued versus uncued object labels) as a within-subjects variable. Two dependent variables were measured: (1) the number of correct object labels produced by children when asked what was hidden in a given box (hereafter referred to as "label retrieval"), and (2) the number of objects that were correctly located when children were asked to find the hidden objects (hereafter referred to as "object retrieval"). The first measure involved both retrieval of an object label and knowledge of an object location. The second measure reflected knowledge of an object location without requiring retrieval of the object label. A comparison between these two measures allowed an assessment of word retrieval abilities independently from the ability to recall what was hidden in a given box.

Children's spontaneous naming activities were observed during a short book-reading session with their mothers. These data were then coded for the frequency of naming attempts (i.e., the number of pictures labeled by a child) and of naming errors, defined as the use of an incorrect label to name a known object—that is, an object that had previously been named correctly by the child. The errors were also classified as (a) categorical errors, if the objects belonged to the same conceptual category (e.g., calling a bear "dog"); (b) perceptual errors, if the objects shared some perceptual attribute such as shape or color (e.g., calling a red cup "apple" after labeling correctly a red apple); and (c) phonological errors, if the two words in question shared the initial phoneme (e.g., "cat" and "cow").

Materials. A transparent plastic box (5 × 4 × 4 inches) and a small ball (1.5 inches in diameter) were used during a warm-up trial. Two identical white gift boxes (6 × 4 × 4 inches) were used for hiding the test items. Small color photographs (1.5 × 1.5 inches) of the test items were used in the cued label recall condition. The pool of test items consisted of 12 brightly colored, large puzzle pieces (3 mm thick)[2] depicting animals (bunny, cat, cow, dog, duck, fish, horse, and lamb) and fruit (apple, banana, orange, and pear) whose names tend to be acquired very early by most children (e.g., Clark, 1979; Nelson, 1973; Rescorla, 1981). To test children with quite limited productive vocabularies, each child was shown only two pairs of objects belonging to different categories (e.g., apple–cat, dog–banana). One pair of objects was hidden in a box with four small pictures on one side. Two of these pictures depicted the two objects hidden in that box (targets); the other two pictures depicted two objects that were not in that box (distracters). The pictures were arranged on the box in a 2 × 2 matrix. For half of the children in each group, the targets appeared on the left-upper and right-lower quadrants. For the other half, the targets appeared on the right-upper and left-lower quadrants. The remaining two objects were hidden in another box with no pictures on it. The order of presentation of the cued and uncued boxes was counterbalanced within each group. Importantly, each child only saw objects (targets and distracters) that he or she was already able to name, as determined from the parents' reports on the word checklist. The proportion of children tested with each particular test item was kept constant across the three groups. Furthermore, each test item was used equally often as a target and as a distracter in the three groups.

A booklet consisting of 44 color photographs, 4 inches × 6 inches in size, was used during the book-reading session following the experimental task. The photographs depicted brightly colored, three-dimensional objects whose labels are extremely likely to be found in the vocabularies of very young children (e.g., Benedict, 1979; Goldin-Meadow et al., 1976; Huttenlocher & Smiley, 1987; Nelson, 1973; Reznick & Goldfield, 1989). A list of the objects pictured in the booklet is presented in the Appendix. The pictures were placed on the front of each page only so that a single picture appeared at every turn of a page.

Procedure. The testing session was usually scheduled within a week from the date on which the parents filled out the language questionnaire. Whenever testing could not be accomplished within that time frame, the experimenter asked the parents to update the word checklist during the visit to provide an accurate measure of the child's vocabulary at the time of testing. Most children were tested individually in their own homes. Five children (one in the prevocabulary spurt group, one in the vocabulary spurt group, and three in the postvocabulary spurt group) were tested at their daycare center, although they were tested individually and with their mothers present as were all the other children. All testing sessions were videotaped for later scoring.

[2] Pilot data indicated that carrying out the testing procedure when using three-dimensional objects was sometimes difficult because some children were so eager to play with them that they reached for the boxes and took out the objects before the experimenter had a chance to go over the protocol.

The experimental session was as follows. Upon arrival, the experimenter usually interacted with both parent and child until the child was clearly at ease. During the testing session, the child, the parent, and the experimenter usually sat across from each other at a table, with the child usually sitting on the parent's lap. The experimenter began by placing a small ball in a transparent box in front of the child and asking the child what was inside the box. The child usually named the object and was then praised by the experimenter. If a child failed to name the object, the experimenter labeled it for the child saying "It's a ball! There's a ball inside the box!" This warm-up trial was introduced to ensure that all children understood the nature of the task, as well as to assess possible group differences in children's willingness to provide a label on demand.

After removing the transparent box, the two boxes for the actual experimental trials were positioned in front of the child (approximately 12 inches apart). The experimenter first showed, labeled, and placed two objects in one of the two boxes and then asked the child what was inside that box. A few alternatives were used to elicit a response (e.g., "What's inside this box?" or "What's in here?" or "What did we put in here?"), and the parent was also invited to repeat the probe. When the child correctly recalled an item, the experimenter said "Very good!" or "That's right!" and then prompted the child to remember more (e.g., "Is there anything else?" or "What else is in here?"). This entire procedure was then repeated with the second box. After the child was asked to recall the contents of the second box, the experimenter asked the child to actually find the objects hidden in both boxes (e.g., "Where's the ____?" or "Can you find the ____?" or "Where did the ____ go?").

The two boxes were presented in identical fashion, except that the experimenter had to turn the box with the cueing pictures around after hiding the objects in it so that the side with the pictures faced the child when he or she was asked what was inside that box. This box was then turned around again, so that the pictures were no longer visible to the child when the experimenter proceeded to ask the child to find the objects hidden in the boxes.

Following the experimental task, children's naming activities were videotaped during a short book-reading session with their mothers. The picture book was given to the parent who was simply asked to go over it with the child as if they were reading a children's book.

RESULTS

Preliminary analyses. Children's responses to the warm-up trial were analyzed. No group differences were found in the number of children who correctly named the ball when asked what was inside the transparent box, $p > .36$, as revealed by a multinomial analysis of variance.

Although the children were not asked to do so by the experimenter, children often labeled the test items as these were first shown to them. The number of labels spontaneously produced by children in the three groups ($M = 2$, 2.17, and 2.78, for children in the prevocabulary, vocabulary, and postvocabulary spurt groups, respectively) was not found to be different, suggesting that children in all three groups were equally likely to extend known labels to the objects used as test items.

Label versus object retrieval. As predicted, the differences between the three groups varied as a function of the type of retrieval task. As shown in Figure 1, children in the three groups differed reliably in the number of object labels they produced when asked what was hidden in a box, $F(2, 25) = 5.20$, $p < .01$, but they did not differ in the number of objects they could locate when asked to find the objects hidden in the boxes. (A boy in the vocabulary spurt group and a girl in the postvocabulary spurt group were not included in the analyses because they failed to complete the task as a result of fussiness).

Specifically, children in the prevocabulary spurt group produced fewer object labels ($M = 25\%$) than children in the vocabulary spurt group ($M = 48\%$), who, in turn, produced fewer object labels than children in the postvocabulary spurt group ($M = 72\%$). The difference between the number of labels produced by children in the prevocabulary spurt group versus the number of labels produced by children in the vocabulary and postvocabulary spurt groups combined was reliable, $F(1, 25) = 7.52$, $p < .01$. Pairwise comparisons (by Fisher's Protected LSD) indicated that although the difference between the prevocabulary and postvocabulary spurt groups was reliable, $F(1, 25) = 10.4$, $p < .01$, the differences between the prevocabulary spurt and vocabulary spurt groups, and between the vocabulary and the postvocabulary spurt groups did not reach significance, $F(1, 25) = 2.86$, $p = .10$, and $F(1, 25) = 3.02$, $p = .09$, respectively. However, these group differences were reliable by less conservative one-tail *t*-tests, $t(18) = 1.69$, $p < .05$, and $t(17) = 1.74$, $p < .05$, which seemed warranted given the a priori hypothesis about the direction of these effects.

The previous main analyses were also repeated excluding those children who failed to recall any of the object labels (two in the prevocabulary spurt group, three in the vocabulary spurt group, and one in the postvocabulary spurt group) because their failure to

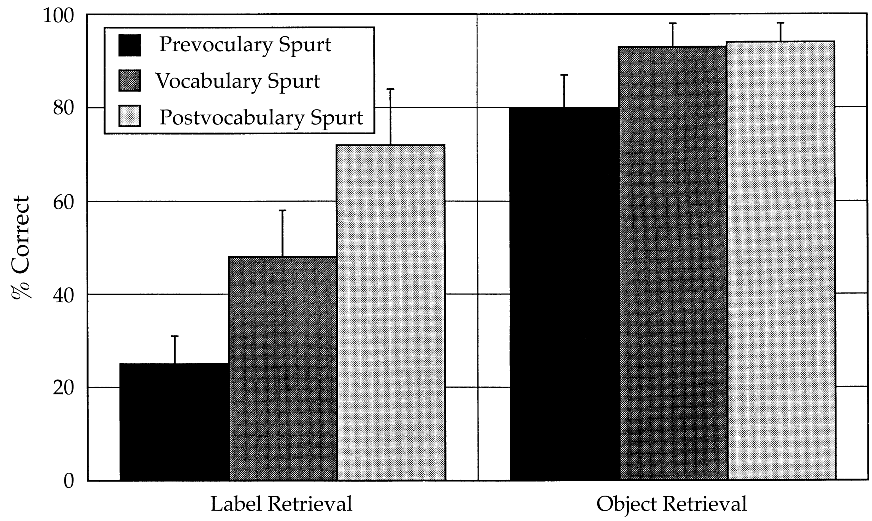

Figure 1 Percent correct label and object retrieval in the prevocabulary spurt, vocabulary spurt, and postvocabulary spurt groups.

perform this task could be taken to reflect unwillingness to comply with the experimenter's request rather than word retrieval difficulties. The same pattern of results emerged from these analyses. Again, children in the three groups did not differ reliably in the number of objects they could retrieve when asked to find the objects hidden in the boxes (M = 79%, 97%, and 93%, for children in the prevocabulary, vocabulary, and postvocabulary spurt groups, respectively). In contrast, children in the three groups differed reliably in the number of object labels they produced when asked what was hidden in a box, $F(2, 19) = 15.87$, $p < .001$. Pairwise comparisons (by Fisher's Protected LSD) indicated that children in the prevocabulary spurt group produced reliably fewer object labels (M = 32%) than children in the vocabulary spurt group (M = 66%), $F(1, 25) = 6.70$, $p < .001$, and in the postvocabulary spurt group (M = 82%), $F(1, 25) = 28.91$, $p < .001$, whereas the difference between the vocabulary spurt and the postvocabulary spurt groups was only marginally reliable, $F(1, 25) = 3.55$, $p = .07$.

Retrieval of cued and uncued object labels. Children's ability to retrieve an object label was enhanced by the presence of visual cues. Overall, children produced reliably more object labels when visual cues were provided (M = 59%) than when they were not (M = 37%), $F(1, 25) = 8.72$, $p < .01$. This effect was reliable in the prevocabulary spurt group, $F(1, 25) = 4.47$, $p < .05$, but it did not reach significance in the vocabulary and postvocabulary spurt groups, $F(1, 25) = 2.48$, $p = .13$, and $F(1, 25) = 1.92$, $p = .18$, respectively. The group $\times$ cueing interaction was not reliable. The percentages of cued and uncued object labels correctly produced by children in the three groups are shown in Figure 2.

The number of distracters labeled by children in the three groups was also examined. First, no group differences were found in the number of children who labeled any of the distracters in the cued label retrieval condition: 33%, 45%, and 25% of the children in the prevocabulary, vocabulary, and postvocabulary spurt groups did so, respectively ($p > .5$, by a multinomial analysis of variance). Second, children in all three groups were reliably more likely to produce the labels of the targets (M = 64%)—that is, the labels of the objects actually hidden in a given box—than the labels of the distracters (M = 23%), $F(2, 25) = 20.79$, $p < .001$.

Furthermore, children tended to label a distracter only after they had produced the labels of the target objects. This was not surprising because parents often praised their children when they produced the labels of the target objects and the task often turned into a naming game where the children proceeded to label all the pictures on the box. Thus, the number of distracters labeled by the children appeared to reflect their interest in naming activities more than their failure to remember what objects were hidden in a given box.

Task performance and vocabulary measures. As shown in Table 2, the size of the children's productive vocabularies was reliably correlated with their performance on the label-retrieval task, $r(26) = .44$, $p < .05$, but not with their performance on the object-retrieval task, $r(26) = .24$, $p > .10$. The children's comprehension-to-production ratios were negatively correlated with

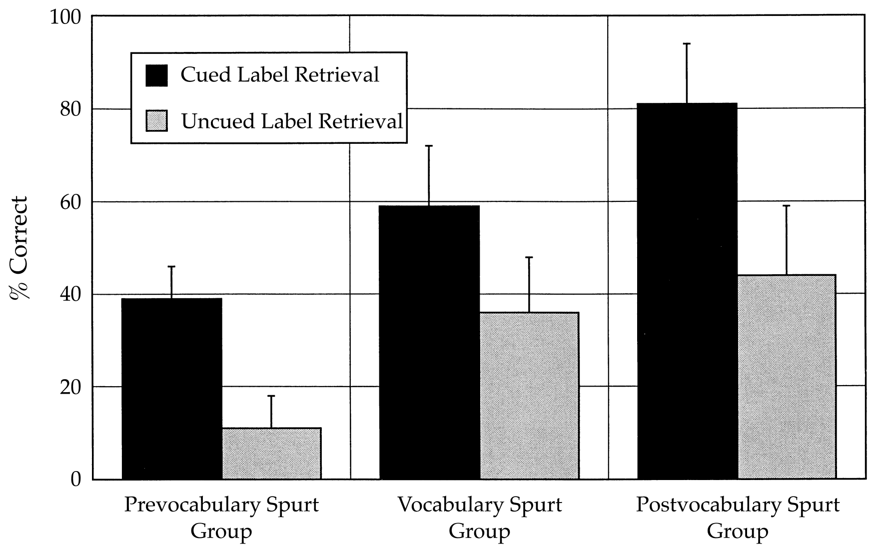

Figure 2 Percent correct cued and uncued label retrieval in the prevocabulary spurt, vocabulary spurt, and postvocabulary spurt groups.

their performance on both the label-retrieval, $r(26) = -.40$, $p < .05$, and object-retrieval tasks, $r(26) = -.48$, $p < .05$. The size of the children's receptive vocabularies was not reliably correlated with their performance on either the label-retrieval or the object-retrieval task; however, this could reflect a possible ceiling effect in the size of children's receptive vocabularies in the postvocabulary spurt group.

Naming errors. Not surprisingly, the number of pictures labeled by children during the book-reading session increased as a function of the children's stage of lexical development, $F(2, 27) = 10.9$, $p < .001$. The pattern of naming attempts across the three groups is illustrated in the top panel of Figure 3. Children in the prevocabulary spurt group labeled fewer pictures ($M = 11.33$) than children in both the vocabulary and postvocabulary spurt groups ($M = 24.67$ and $M = 32.11$, respectively), *p*s < .05 by Fisher Protected LSD, whereas the difference in the number of pictures labeled by children in the latter two groups was not reliable. When children's naming errors were examined, the frequency of naming errors (i.e., the number of pictures incorrectly labeled) was also found to differ reliably in the three groups, $F(2, 27) = 5.67$, $p < .001$. As seen in the bottom panel of Figure 3, however, a different pattern of group differences emerged.

Specifically, children in the vocabulary spurt group made reliably more naming errors ($M = 3.75$) than children in both the prevocabulary and postvocabulary spurt groups ($M = .9$ and $M = 1.8$, respectively), *p*s < .05 by Fisher Protected LSD, whereas the difference between the prevocabulary and postvocabulary spurt groups was not significant. Furthermore, a multinomial analysis of variance revealed that reliably more children made naming errors in the vocabulary spurt group (92%) than in the prevocabulary and postvocabulary spurt groups (56% and 67%, respectively), *p*s < .05. The difference in the number of children who made any naming errors in the prevocabulary and postvocabulary spurt groups was not reliable.

The majority of these naming errors (72%) involved a label that had been previously used by the child, or by the parent, to name its correct referent in the course of the book-reading session. Most errors consisted of categorical errors (75%), with fewer errors based exclusively on perceptual features (34%) and phonetic similarity (9%).

Table 2 Pearson Correlation Coefficients between Vocabulary Measures and Performance on the Experimental Tasks

	Label Retrieval	Object Retrieval
Number of words comprehended	.34	.21
Number of words produced	.44*	.24
Comprehension/production ratios	−.40*	−.48*

* $p < .05$.

DISCUSSION

Replicating and extending the preliminary findings of a previous pilot study (Dapretto et al., 1991), the results of the present research provide solid empirical

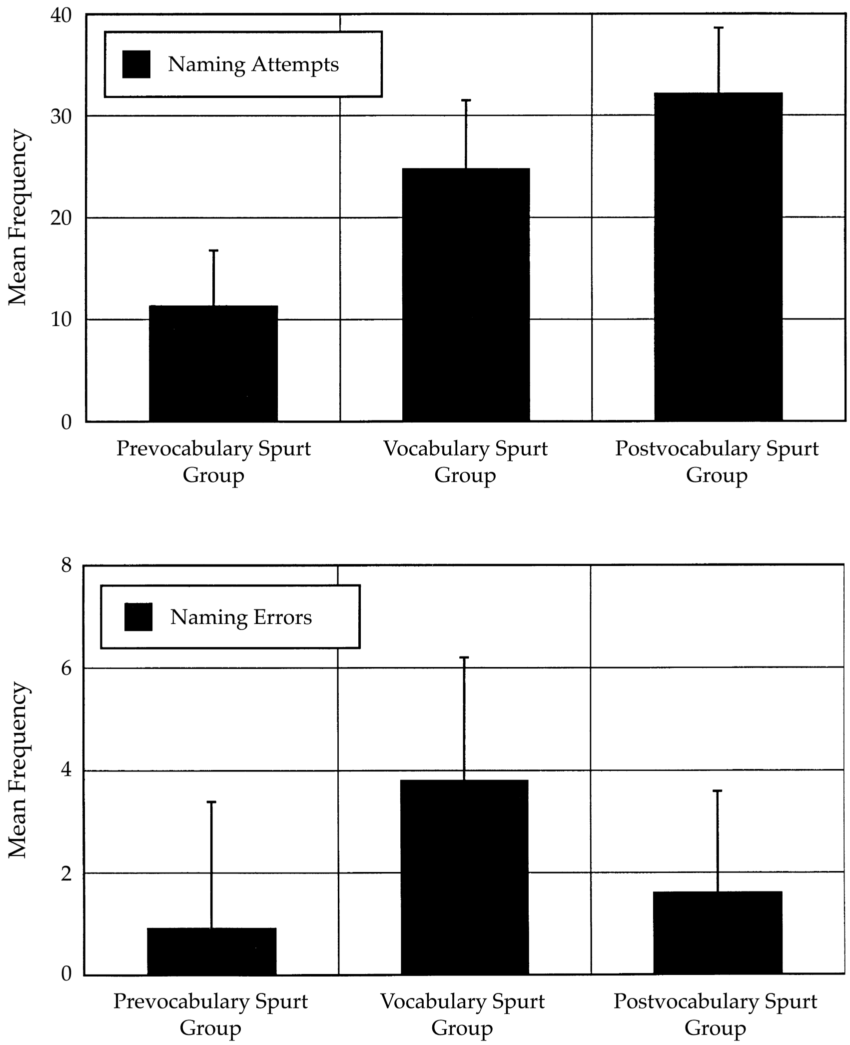

Figure 3 Mean number of naming attempts (i.e., pictures named) and naming errors made by children in the prevocabulary spurt, vocabulary spurt, and postvocabulary spurt groups.

evidence of significant changes in children's word retrieval processes late in the second year, a time when dramatic developments are observed in children's productive vocabularies. In the experimental task used in the present study, when asked what was hidden in a given box, children with still very limited productive vocabularies were reliably less likely to produce the familiar object labels than were children with larger productive vocabularies. In contrast, when asked to identify the box in which those same objects had been hidden, all children did well, regardless of their level of lexical development. Because all children could name the objects hidden in the boxes and were apparently equally successful at encoding where the objects were hidden, this pattern of results—where the performance of children at different stages of lexical development differed in the task requiring retrieval of an object label but not in the task requiring only comprehension of that object label—offers strong support for the hypothesis of improving word retrieval processes in the period just following the onset of the vocabulary spurt.

In interpreting these findings, it is important to remember that the different number of object labels produced by children at different levels of lexical development cannot be attributed to children in the early stage not having those object names in their productive repertoires: Only objects for which each child had a label in his or her productive vocabulary were used as test items. Although reliance on the information provided by the parents on the word checklist to select the test items could be seen as problematic, high accuracy in parental reporting was expected because parents had been informed that their child needed to understand and *use*, during the experimental task, some of the words reported as comprehended and produced on the word checklist. Moreover, children in all three groups were equally likely to label the objects used as test items when these were first presented to them. Importantly, this latter observation also speaks against the hypothesis that children in the prevocabulary spurt group might have been reluctant to extend known object labels (i.e., labels reported as produced by their parents) to the particular objects used in the present study and further suggests that the objects chosen as test items were good exemplars of their particular kind.

It also seems very unlikely that the increased ease with which labels were produced by children at the more advanced stages of lexical development may simply reflect a higher level of social competence (and relative ease with the experimental task demands) in these slightly older children. First, the age differences between children assigned to the prevocabulary and vocabulary spurt groups, as well as between children assigned to the vocabulary and the postvocabulary spurt groups, were not reliable. Second, children's performance on the experimental task was not reliably correlated with their age. Third, children in the three groups were equally likely to answer the experimenter's question "What's inside this box?" when they could see the object placed inside a transparent box. Finally, the same pattern of results was obtained after excluding from the analyses those children who failed to produce at least one of the object labels; that is, after excluding those children seemingly less willing to comply with the experimenter's requests.

The finding that the presence of visual cues facilitated word retrieval particularly for children in the early stage of lexical acquisition lends support to the notion that early in development, successful word retrieval may be contingent on the availability of significant contextual cues, as argued by Bloom (1993). Poor word retrieval abilities in the initial stage of lexical development, then, may limit the total number of words in young children's productive vocabularies, as well as constrain the range of situations in which these early words are likely to be produced. Enhanced word retrieval processes later in the second year may underlie children's new ability to talk about things that are not physically present (Ingram, 1978; Sachs, 1983) by allowing words to be retrieved successfully even in the absence of potent perceptual cues.

Data from children's spontaneous labeling activities during the naturalistic book-reading session provide additional evidence of significant changes in children's word retrieval processes in the period surrounding the vocabulary spurt from a different angle. Consistent with Gershkoff-Stowe and Smith's data (1997), when looking at a book with pictures of familiar objects, children who had recently begun to add many more words to their productive vocabularies made reliably more naming errors (i.e., mislabeling pictures of objects that had previously been labeled correctly by using the names of other objects that had also been used correctly before) than did children who had not yet begun to do so or who had been doing so for several months. Somewhat paradoxically, this rise and fall in naming errors in the period surrounding the vocabulary spurt—now observed in two independent investigations—is actually likely to reflect children's improved ability to retrieve words at this time.

As Gershkoff-Stowe and Smith (1997) have pointed out, in the initial stage of lexical development, children have very limited productive vocabularies with usually no more than a couple of words per semantic category. At this stage, the likelihood that objects would be named in close temporal contiguity during a book-reading session is rather low; thus, little competition should occur between lexical items at time of retrieval and hence few naming errors. With the onset of the vocabulary spurt, the number of words children can produce rises sharply. As children are able to label more pictures in a book, attempts to produce a given object name may occur while another object label is still activated after being recently retrieved, thereby leading to greater interference and competition between lexical items and more errors during word retrieval. After the initial period of increased word production, naming errors should again become less frequent as words are produced more and more often, so that the processes of selection and inhibition between competing lexical items become more efficient. In other words, each act of retrieval should strengthen the connections involved in retrieving a given word, thus making each entry in the lexicon less subject to interference (see Bjork & Bjork, 1992, for a discussion of the effect of retrieval practice).

Interference and competition between lexical items when word production first begins to accelerate could also explain why, when asked to say what was hidden in a given box during the experimental task used in the present study, children who had recently started to produce more and more words did not do as well as children who were well past the initial spurt in production. After correctly retrieving the label of one of the two objects hidden in a box, these children often repeated that object label when asked what else was hidden in that box. Perhaps such children, having just retrieved the name of one of the objects hidden in a box, were prevented from producing the label of the other object in that box because the first object name—in a sense, "primed" by its earlier retrieval— kept being retrieved, thus interfering with the retrieval of the other object label. Although the number of observations is too small to allow for statistical comparisons, this kind of behavior was especially characteristic of children who were in the midst of the vocabulary spurt.

Taken together, the present research findings provide converging evidence of significant changes in children's word retrieval processes late in the second year, at the time when children's productive vocabularies appear virtually to take off. Evidence from two different lines of research complements these findings by addressing the mechanisms that may be responsible for the changes in word retrieval processes observed in the current study. First, recent work in neural network modeling suggests that small and gradual changes in a network may lead to sharp nonlinearities in its behavior without the development of any new system. For instance, Plunkett, Sinha, Moller, and Strandsby (1992) have developed a connectionist model of vocabulary acquisition that exhibited dramatic nonlinearities in vocabulary growth mimicking the vocabulary spurt observed in children (as well as the asymmetry between comprehension and production), even though training of the model involved only small and continuous changes in the connection strengths within the network representations. Accordingly, the improved efficiency of word retrieval processes at the time of the vocabulary spurt may actually derive from the growth in productive vocabulary itself.

Second, research on the neural bases of early language acquisition provides evidence of a reorganization in the neural substrate of language processing at the time when most children display a vocabulary spurt. A study examining the pattern of auditory event-related potentials to spoken words in 13- to 20-month-old children (Mills, Coffey, & Neville, 1993a, 1993b) found that the brain responses discriminating between comprehended and unknown words were bilaterally and broadly distributed at 13–17 months of age, whereas they were limited to the temporal and parietal regions of the left hemisphere at 20 months of age. These changes in the pattern of cortical activity involved in language processing suggest that the neural system mediating early language comprehension—and perhaps production—may be distinct from a later emerging lateralized system whose engagement may be necessary for, but also contingent upon, the emergence of more advanced linguistic functions. Such reorganization in the neural substrate of language processing may be related to the many dramatic changes in children's language abilities occurring toward the end of the second year, such as the onset of the vocabulary spurt, the emergence of multiword combinations and inflectional morphology, and the advances in receptive skills that are also observed at this time (Mervis & Bertrand, 1994; Reznick & Goldfield, 1992).

In concluding, it is important to point out that the finding of a temporal relationship between changes at the neural level and advances in children's language abilities need not imply that this neural reorganization causes the developments observed at the behavioral level. Indeed, research indicates that language learning during a sensitive period may be critical for triggering the actualization of a lateralized, and presumably optimal, pattern of functional specialization for language processing (e.g., Neville, 1984). Thus, the remarkable linguistic achievements observed toward the end of the second year should not be seen to arise as a mere consequence of neurobiological changes that unfold according to a predetermined maturational timetable. Rather, the development of increasingly complex linguistic functions is better seen as emerging from the dynamic interaction between an organism endowed with a neural system especially well suited for the processing of linguistic information (e.g., Saffran, Aslin, & Newport, 1996) and a richly structured environment that provides the type of input needed for the development of mature linguistic representations. By integrating behavioral data of the kind presented in this paper with research findings from the fields of developmental neuroscience and computational neural network modeling, a multidisciplinary approach to the study of language acquisition promises to provide an increasingly complete and accurate picture of the mechanisms responsible for the impressive linguistic achievements that characterize the first few years of life.

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APPENDIX

OBJECTS PICTURED IN THE BOOKLET USED IN THE BOOK-READING SESSION

Barney	bear	orange
Cookie Monster	rabbit	strawberry
Big Bird	horse	cup
Mickey Mouse	elephant	spoon
Goofy	cow	plate
Donald Duck	giraffe	fork
Minnie Mouse	car	pot
dog	helicopter	knife
cat	airplane	keys
duck	train	block
fish	boat	crayon
pig	truck	ball
butterfly	motorcycle	flower
mouse	apple	clock
frog	banana	

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