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Priming overgeneralizations in two- and four-year-old children*

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ABSTRACT

Overgeneralization occurs when a child uses the wrong word to name an object and is often observed in the early stages of word learning. We develop a method to elicit overgeneralizations in the laboratory by priming children to say the names of objects perceptually similar to known and unknown target objects. Experiment 1 examined 18 two-year-old children's labelling of familiar and unfamiliar objects, using a name that was previously produced. Experiment 2 compared the labelling of 30 two-year-olds and 39 four-year-olds when presented with completely novel objects. The findings suggest that the retrieved word is a blend of previous activation from the prior retrieval and activation engendered by the similarity of the test object to instances of the target category. We put forward a theoretical account of overgeneralization based on current models of adult language processing. The account suggests a common mechanism of activation and retrieval, which may explain not only momentary lapses in the correct selection of words, but other types of naming errors traditionally thought to

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reflect differences in children's underlying category representations or, perhaps, gaps in their knowledge of words.

INTRODUCTION

Children's early use of words is sometimes quite different from conventional adult usage. Words may be applied more broadly, as when 'ball' is used to refer to onions, doorknobs, and other round objects (Clark, 1993), or more narrowly, as when 'shoe' is used to refer to a child's sneakers, but not to his mother's high heels (Reich, 1976). Early research on children's word extensions relied primarily on diary studies in which linguistically-minded parents could provide rich descriptions of their children's inventive use of words. This valuable source of data generated a wealth of insight into the development of lexical categories and the pathway from context-bound word use to decontextualized word meaning (Barrett, Harris & Chasin, 1991). It also raised important theoretical questions about the nature and source of overgeneralization.

In this paper we investigate children's overgeneralization errors by inducing them experimentally. We use a picture-naming task to prime children to say words for objects that are structurally similar to the target object. Our aim is to provide a mechanistic account of overgeneralization by examining the processes through which words are selected for naming. The idea is that priming influences the subsequent retrieval of a word by activation that automatically spreads from prime to target via associative connections at the level of concept and word. These connections vary in strength due to the combined effects of the child's prior experience, just recent past, and immediate context. Based on this conceptual framework, we show that the correct and incorrect words children use when naming objects result from competing processes in a common language processing system.

We begin the paper with a brief review of existing interpretations of overgeneralization. We then present our alternative account, based on a dynamic model of activation and retrieval. Last, we describe two experiments in which predictions from the model can be tested.

Traditional views

Overgeneralization errors have been discussed in the developmental literature in three conflicting ways. First, an incorrect word may be a category error. Children may misapply a category label, calling a horse 'dog' because they misrepresent (relative to the adult standard) the category (e.g. Mervis, 1987). Much of the debate on the acquisition of word meaning stemming from this view has centred on the basis by which children

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abstract the set of semantic features relevant to a particular category. Clark (1973), for example, argued for perceptual similarity as the foundation for overgeneralization, particularly with regard to shape. In contrast, Nelson (1974) viewed functional similarity as the primary basis for children's extension of words to novel objects. Although subsequent research cast doubt on both these hypotheses (Bowerman, 1977; Barrett, 1978), the idea that children's word extensions reflect an incomplete semantic system is supported by findings of overgeneralizations in comprehension as well as production (Naigles & Gelman, 1995; Gelman, Croft, Fu, Clausner & Gottfried, 1998).

A second way in which overgeneralization errors have been discussed in the literature is as a pragmatic solution to an insufficient vocabulary (Bloom, 1973; Huttenlocher, 1974; Hoek, Ingram & Gibson, 1986). Children may offer known names for novel objects because they have limited resources with which to refer to things in the world. Thus they select a familiar word from another category, even though their underlying category representation is the same as adults. This interpretation is consistent with descriptions of adults' use of metaphor. Like children, adults may stretch the meaning of an old word to communicate a new idea for which they lack a name (Winner, 1988). Both the child's use of overgeneralization and the adult's use of metaphor convey meaning by highlighting the similarity between referents. For adults, metaphoric similarity typically involves a kind of relational mapping, as when we call a cloud a sponge (Gentner, 1983). Children, on the other hand, are more likely to generalize a familiar word to a novel object based on aspects of physical similarity. The surface similarity captured in these cases is most frequently shape-based (Samuelson & Smith, 2005), but may include other dimensions, as when a child calls a cloud a marshmallow. Taken together, the phenomena of overgeneralization and metaphor reflect the openness and flexibility of language. They suggest that the boundaries of a lexical category are not fixed, but rather are capable of undergoing rapid and creative transformation.

The final way in which overgeneralizations have been treated in the literature is as a retrieval error. Children may have mapped the right word to the right category, but at the moment of retrieval may select the wrong word. This word is most often perceptually or conceptually related to the target, but may include unrelated or phonologically similar words (Stemberger, 1989; Gershkoff-Stowe & Smith, 1997; Gershkoff-Stowe, 2001, 2002). The idea of overgeneralization as a retrieval error is supported by findings that children sometimes produce overgeneralizations despite correct receptive knowledge of the object's name (Huttenlocher, 1974; Naigles & Gelman, 1995). It is also supported by findings showing that during the early stages of rapid vocabulary growth, children are particularly

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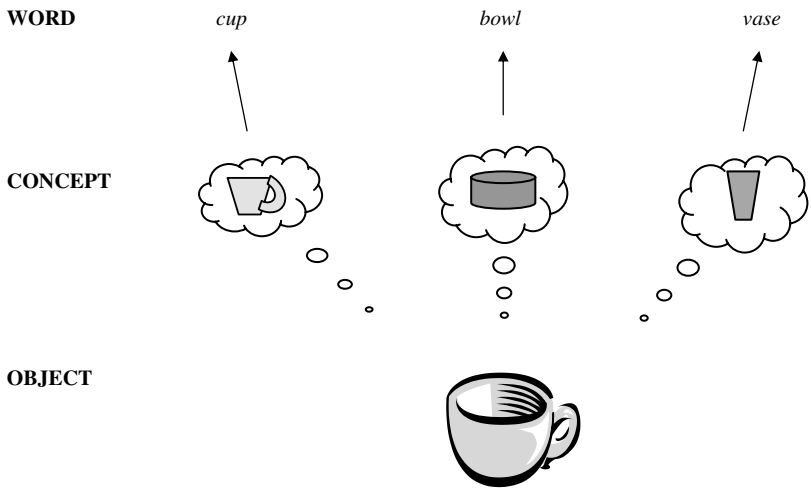


Fig. 1. Levels of processing and lexical competition involved in naming a perceived object.

vulnerable to retrieval errors, even when they have previously produced the correct names for the tested objects (Gershkoff-Stowe & Smith, 1997; see also Dapretto & Bjork, 2000).

A lexical processing account

The model of overgeneralization we advance in the present research builds on this third view, namely, that all forms of overgeneralization may be understood as retrieval phenomena (see Gershkoff-Stowe, 2001, 2002). Our proposal is based on current understandings of competitive processes of lexical access as described in the adult literature (e.g. Dell, 1986; Rapp & Goldrick, 2000). In general, labelling a seen object consists of two steps (Johnson, Pavio & Clark, 1996). First, the perceived object must activate the concept (or memory) of similar things. As illustrated in Figure 1, the target concept (e.g. cup) along with related and similar concepts (e.g. bowl, vase) will be activated. These activated concepts will in turn activate the corresponding word forms. Which word is produced is a result of competition among activated forms. The form with the most activation wins.

Three factors are known to influence activation strengths, both from object to concept and from concept to word. First, activation increases as a function of the similarity of the object to known instances of the concept (Huttenlocher & Kubicek, 1983; Martin, Weisberg & Saffran, 1989). For example, a prototypical horse might be expected to lead to

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greater activation of the horse concept and the word 'horse' than a small pony; a Great Dane might be expected to lead to greater activation of 'horse' than, say a small poodle. Second, activation strength is also a function of practice; well-known category labels yield stronger activation than less well-known ones. The evidence for this idea is the finding that lexical access in adults is faster, more robust, and less vulnerable to interference given words of higher frequency and earlier ages of acquisition (Brown & Watson, 1987). Finally, activation strength depends on context. This is because activation endures over time (Cohen & Dehaene, 1998) and also spreads to related concepts and words (Dell, Burger & Svec, 1997). Thus the strength of activation of the word 'horse' upon seeing a horse will depend on the activation from the perceived object and also any lingering activation from just previously named objects. The evidence for this factor is the ubiquitous phenomenon of priming (Meyer & Schvaneveldt, 1971; Anderson, 1983). Lingering activation from previous retrievals influences the competition for lexical selection by enhancing the activation levels of some competitors over others. Gershkoff-Stowe (2001; see also, Gershkoff-Stowe & Smith, 1997) argues that young children in the early stages of vocabulary growth may be particularly vulnerable to these context effects because many links between objects and concepts and concepts and words are relatively unpracticed and thus weaker competitors with lower activations. Thus by this account, we see in the early period of rapid lexical growth relatively many naming errors and 'overgeneralizations.'

The processes that underlie lexical selection potentially unify all three accounts of children's overgeneralization, as illustrated in Figure 2a–c. Errors that might properly be called category errors (Figure 2a) arise when a particular object activates a similar category (e.g. a vase activating the cup concept). Similarly, a naming error might serve a pragmatic purpose (Figure 2b) when a novel object activates word candidates and the child uses a known name to direct a listener's attention to the object of interest. Finally, word selection in the case of both lesser-known and better-known lexical categories will depend on context – on priming and interference from previously activated concepts and words (Figure 2c). In this way, the processes of lexical selection bring together long-term knowledge of lexical categories and momentary task influences into a unified account.

If this analysis is right, then children's naming of both known and novel objects should be influenced by context in the same way. Two experiments test this hypothesis by presenting children with familiar, unfamiliar, or completely novel objects and asking them to name the objects. Prior to the naming test, we manipulated the activation strengths of potential lexical competitors by priming them. Specifically, we showed children pictures of well-known objects that resembled the test objects in overall shape and

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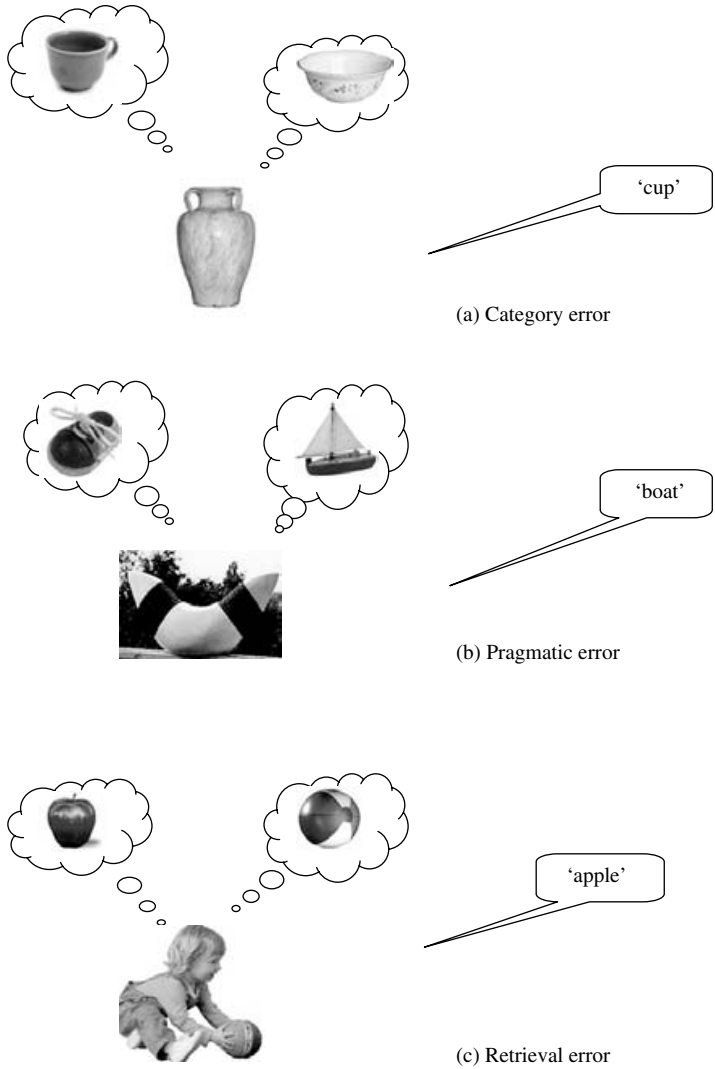


Fig. 2. Activation and retrieval as common processes in three accounts of overgeneralization.

asked them to produce the names. If the processes that underlie lexical access are the same in young children and adults, and if these processes are in operation both when young children name familiar and unfamiliar things, then this priming task should influence children's selection of object labels in both cases. In Experiment 1, we examine two-year-old children's naming of familiar and unfamiliar objects. Experiment 2 compares

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Priming task



What is this?
(*dinosaur*)



What is this?
(*drum*)



What is this?
(*truck*)

Object naming task



What is this?

Fig. 3. The priming and object-naming task in Experiment 1.

two-year-old and four-year-old children's naming of completely novel (nonce) objects.

EXPERIMENT 1

Figure 3 illustrates the structure of the task. The child is first shown three pictures and asked to name them. For example, the child sees a dinosaur, a drum, and a dump truck. The naming of these pictures should result in residual activation of each concept and word. Immediately following the priming task, the child is shown a 3-dimensional test object (e.g. cake) and asked to name it. Will the child err by producing a primed name? If so, we expect the object that shares salient perceptual characteristics with the test object – in this case, the drum – to be the name most frequently offered.

Half the children received the trial as illustrated in Figure 3, with the picture of the perceptually similar drum included in the priming set. The other half received a trial in which the picture of the drum was replaced with a picture of a perceptually similar cup. If the priming task influences children's selection of candidate words, then the naming errors of the

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children in the two priming conditions should differ. Children who named the drum picture in the priming phase should be more likely to call the cake 'drum' than to call it 'cup'; children who named the cup in the priming phase should be more likely to call the cake 'cup' than 'drum.' The key experimental question is whether priming influences word selection in the same way for familiar objects with known names and for unfamiliar objects with unknown names. If so, this would suggest that the same processes underlie retrieval errors involving known lexical categories, and category and pragmatic errors involving unknown lexical categories.

METHOD

Participants

Eighteen children (half female) between the ages of 1;8 and 2;3 participated ($M = 1;11$). They had no prior history of cognitive or language impairment. Children were recruited through public birth records from a predominantly Caucasian, middle class community in the Midwest. Five additional children were tested, but did not contribute data to the final analyses; two were excluded because they were bilingual, two did not produce any names (in the priming task), and one was excluded because of experimenter error.

Stimuli and design

The stimuli consisted of 24 pictures for use in the priming phase of the experiment and 12 3-dimensional test objects. The test objects were either toy or real objects and were prototypical instances of the category. Half the children were randomly assigned to the Familiar Test Object condition and half were assigned to the Unfamiliar Test Object condition. The 24 pictures were colourful realistic photos, also prototypical, and mounted individually on cardstock and laminated. Twelve of the pictures were filler items representing the following categories: grapes, hamburger, horse, tree, dinosaur, truck, fork, plane, bike, toothbrush, keys, and fish. The other 12 pictures were the target primes – objects that were perceptually similar in shape to the target object. Two sets of target primes were used: Prime Set A and Prime Set B. Within each condition, five children received Set A and four children received Set B. The sets were matched on similarity to the test objects, based on adult judgments as described below.

Table 1 presents the details of the design. Each test object was paired with a prime from Set A (for half the children) and a different prime from Set B (for the remaining children). In addition, the same prime was assigned to one Familiar test object and one Unfamiliar test object. Thus, for children in the Familiar condition, cake was primed by either cup

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TABLE 1. *Familiar and Unfamiliar test objects and Prime Sets A and B used in Experiment* 1

Test objects		Prime	
Familiar	Unfamiliar	Set A	Set B
cake	pencil sharpener	cup	drum
sled	hook	shoe	boat
corn	chili pepper	cheese	banana
scissors	pink furry headband	puppet	pig
bug	ornament	ball	apple

(Set A) or drum (Set B) and for children in the Unfamiliar condition, pencil sharpener was primed by either cup (Set A) or drum (Set B). The Familiar and Unfamiliar test objects receiving the same prime were selected to be roughly equivalent in shape (e.g. cake and pencil sharpener) as were the two target primes (e.g. cup and drum). The remaining 12 pictures served as filler items and were perceptually dissimilar to the test objects. To summarize, children saw a total of 6 test objects (Familiar or Unfamiliar) and 6 priming pictures (Set A or Set B). All children saw the same 12 filler items. The pictures were randomly assembled into 6 triads, each consisting of one target prime and two fillers.

Adult similarity judgments

The similarities of the primes and fillers to the test objects were measured by asking 24 undergraduates to rate the likeness of the 6 Familiar and 6 Unfamiliar test objects (12 observers for each condition) to the 24 pictures used in the experiment. Each observer was instructed to judge the degree of similarity of the test object to each picture by assigning a number on a scale ranging from 1 (low similarity) to 10 (high similarity). The mean similarity of the priming categories to the Familiar test objects was 5·58 ($S.D. = 1{\cdot}21$) and to the Unfamiliar test objects was 5·76 ($S.D. = 0{\cdot}98$); neither these nor the mean ratings for Set A and Set B primes within each condition differed reliably, $F < 1{\cdot}00$. The judged similarity of the test objects to the fillers was 1·85 ($S.D. = 0{\cdot}73$) in the Familiar condition and 1·32 ($S.D. = 1{\cdot}79$) in the Unfamiliar condition. These also did not differ reliably, $F < 1{\cdot}00$.

Procedure

There were six test trials, each consisting of two parts as illustrated in Figure 2. First the child was shown each of the three pictures in the

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priming set (the target prime and two fillers), one at a time. The child was asked to name each picture with the question, 'What is this?' If the child did not offer the name, the experimenter supplied the label and asked the child to repeat it. Children readily repeated the picture labels when asked. The order of the three pictures – filler 1, filler 2, and target prime – was counterbalanced across the six trials such that the target prime occurred equally often in the first, middle, and last position. We chose to do this rather than have the target priming picture always occur last to minimize the possibility that children would simply repeat a previously said word or explicitly notice the similarity between the target prime and the test object. Although this counterbalanced order might be expected to lessen the influence of the target primes, past research suggests that the influence of a previously retrieved word on naming errors extends over a considerable temporal delay (see Gershkoff-Stowe, 2001).

Immediately after the child named the last picture in the priming set, the experimenter removed the picture and placed a test object in front of the child. The child was then asked to name the object. If the child did not respond immediately, the experimenter repeated the request. Following the child's response, or after 10 seconds, the experimenter proceeded to the next trial. The child's spoken responses were written down during the experiment. The responses were also recorded on videotape and checked against the experimenter's record.

Word comprehension

After the six test trials, children were presented with a comprehension task designed to measure their receptive knowledge of the correct names for the test objects. On each of six comprehension trials, the child was asked to indicate an object by name. (e.g. 'Where's the cake? Show me the cake.') The child indicated the response by choosing between three alternatives; each alternative – the two distracters and the correct choice – was selected from the test objects used in the experiment for that child.

RESULTS AND DISCUSSION

We first examine children's familiarity with the test object names in the two conditions and compare their performance in the word comprehension task to the number of correct productions during the main test phase. Next we analyse the incidence and type of errors children produced following priming. Last, we test for the effects of priming by directly comparing the frequency with which a particular label was offered for an object when it was primed versus when it was not. For coding purposes, we included as a correct production labels at the basic, superordinate, and subordinate levels.

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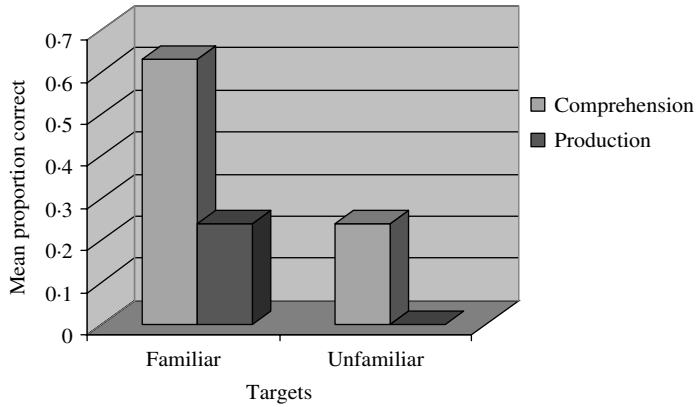


Fig. 4. Mean proportion of correct responses in the comprehension and production tasks as a function of condition.

We did not count as correct descriptions of the objects, such as their shape, colour, or size.

Comprehension and production of test object labels

Critical to the main experimental question is whether the names of the test objects in the Familiar condition were better known to the children than the names of the test objects in the Unfamiliar condition. The data are presented in Figure 4. The mean proportion of correct choices in the comprehension task was 0·63 for the Familiar test objects compared to 0·24 for the Unfamiliar objects (below chance of 0·33). Similarly, although correct productions were infrequent for the names of the Familiar test objects ($M = 0{\cdot}24$), they were nonexistent for the Unfamiliar ones ($M = 0$). A (2) condition × (2) task analysis of variance for a mixed design confirmed a reliable main effect of condition, $F(1, 16) = 12{\cdot}71$, $p = 0{\cdot}003$. Children's knowledge of the test object names was greater in the Familiar condition than the Unfamiliar condition. The analysis also indicated a reliable main effect of task, $F(1, 16) = 46{\cdot}37$, $p < 0{\cdot}001$. Children's comprehension exceeded their successful production of these same object names, at least in a production task that requires children to produce many object names in succession. There was no significant condition by task interaction.

Types of naming responses

When children did not produce the correct object label, they could make two kinds of errors: they could say nothing or they could offer a wrong word. Children failed to provide a naming response 26% of the time in

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TABLE 2. *Mean proportion of correct responses, omissions, and types of naming errors in Experiment 1 for Familiar and Unfamiliar test objects*

	Correct	Omission	Extraneous	Control	Target	Filler
Familiar	0·24	0·26	0·35	0·04	0·09	0·02
Unfamiliar	0·00	0·48	0·33	0·04	0·13	0·02

the Familiar test object condition and 48% of the time in the Unfamiliar test object condition. They offered a wrong label on 50% of the trials for the Familiar objects and on 52% of the trials for the Unfamiliar objects.

Further breakdown of children's naming responses is given in Table 2. We classified the errors into four types: EXTRANEOUS, CONTROL, TARGET PRIME, and FILLER. Extraneous errors are defined as object names that the participants were not previously exposed to during the course of the experiment. Also extraneous, but reported separately, are the six control words which children did not say or hear in the priming task (i.e. Set B for participants who received Set A and Set A for participants who received Set B). The prime errors include the six target primes used in each condition (i.e. Set A for participants who received Set A and Set B for participants who received Set B). Also primed, but reported separately are the 12 filler words used in both conditions. As shown, the extraneous errors constituted the largest proportion of overgeneralization for both conditions. The majority of these errors were visually related (e.g. cake →hat) and/or semantically related to the test object (e.g. sled→boat). This finding supports the assumption that overgeneralization is marked by information gained previously and stored in long-term memory. Of particular interest to the present study, however, are the prime errors. The key question is whether priming operates similarly for both known and unknown objects.

Priming effects

The measure of priming effects in this experiment is the comparison of the frequency with which a particular label was offered for an object when it was primed versus when it was not primed. Thus for children who received Set A primes, the prime labels are the Set A primes in Table 1 and the control labels are the Set B primes; for children who received the Set B primes, the prime labels are the Set B primes in Table 1 and the control labels are the Set A primes. A two-factor analysis of variance with repeated measures was used to examine the effects of word familiarity on priming. The analysis revealed only a main effect of kind of error (prime vs. control), $F(1, 16) = 4{\cdot}65$, $p < 0{\cdot}05$. Neither the effect of condition nor the interaction approached significance (in both cases, $F < 1{\cdot}00$).

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These results tell us, first, that the prior labelling of the pictures in the priming set influenced children's lexical selection when asked to name the test objects. Although the incidence of priming-related errors was small, children erroneously offered a particular name for the objects when that name was primed as opposed to when it was not primed. Second, the results tell us that interference from the prior activation of the lexical item (i.e. having said 'drum') was necessary for the naming error; the similarity of the object to the primed category was not sufficient in and of itself. Third, the findings strongly suggest that the processes that lead to the selection and activation of an erroneous name are the same both when the object is familiar and its name is known (at least as measured by comprehension) and when the object is unfamiliar and its name is not known. In both cases, the context, that is, the just previously activated word influenced lexical selection.

As suggested by the relatively high rate of extraneous errors in both conditions, the findings also indicate that concepts and words in long-term memory have a potent influence on lexical selection. Even very young children, with relatively short developmental histories draw upon their prior knowledge of the perceptual and conceptual relations between objects stored previously. This result fits with many models of adult lexical access in which words that share semantic or associative features obtain additional strength as activation spreads automatically throughout the network. One consequence of this spreading activation is that a related word will sometimes reach threshold prior to the target word; hence an error will occur (Dell, 1986; Dell, Schwartz, Martin, Saffran & Gagnon, 1997; Rapp & Goldrick, 2000). Thus the same processes of activation and lexical competition appear common to adults as well as children.

Previous discussions of children's overgeneralizations have distinguished whether the object name is known (typically measured by comprehension) or whether it is unknown, and these two kinds of overgeneralizations have been discussed as possibly reflecting different underlying processes. The present results suggest that the underlying processes of lexical selection in both cases may be the same. In particular, the word produced at any given moment in time is likely to be a joint product of (1) how well-practiced the links are between object, concept, and word, (2) the similarity of the object to other candidate categories, and (3) the context effects which potentiate some competitors over others.

EXPERIMENT 2

By standard accounts, lexical access is a competitive process. This implies that when a child names an object, the child is choosing between potential

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names that have been activated. Two principal sources of activation are (1) the similarity of the object to instances of known lexical categories in long-term memory and (2) lingering activation from recently activated concepts and words (Gershkoff-Stowe, 2001). In the everyday lives of children (and adults) these sources of activation typically point to a single lexical candidate. For example, when one is looking at a horse, the previous conversation is likely to be about horses or related categories. In Experiment 2, we put these two sources of activation into competition in order to gain insight into the processes of lexical access in younger and older children.

We illustrate the experimental design in Figure 5. The child is shown a novel test object. Its perceptual properties will presumably activate a number of competitors. For the object in the figure, for example, the child is reminded of the concept snake and thus the word is activated strongly. Other perceptually similar objects, such as bagel and slide, are also activated, but only weakly for this particular child. Which one of these competitors wins will depend on both the activation strength from similarity and from the previous context. In Figure 5a, 'snake' receives additional activation from priming, but in Figure 5b, 'bagel' receives additional activation from priming. Thus in case A, priming and similarity should combine to yield the production of 'snake.' In case B, a conflict arises. This conflict situation offers insight into the relative contributions of similarity and priming.

The purpose of Experiment 2 is to test the role of similarity and priming by comparing children's naming when primed by pictures that are higher in similarity to the test objects to pictures that are lower in similarity. Included in the design is a third group of children who are primed by pictures unrelated to the test objects. The prediction is that children in the control group will generate more extraneous naming responses in the absence of competing activation from related primes.

As illustrated in Figure 5, we chose to use entirely novel test objects in this experiment. We did so for three reasons: First, the results of Experiment 1 suggest that the influence of primes on young children's lexical selections does not depend on the familiarity of the to-be-named object. Second, laboratory constructed objects allow us to be certain of the novelty of the test objects to the children. And third, novelty is essential to compare lexical selection in older and younger children, given differences in their knowledge base of words and concepts.

The specific test objects and lexical targets used in Experiment 2 were selected from observations of children's spontaneous overgeneralizations in other experiments directed to issues of early category learning (Landau, Smith & Jones, 1988; Samuelson & Smith, 2005). In each of these previous experiments, children were presented with novel laboratory constructed

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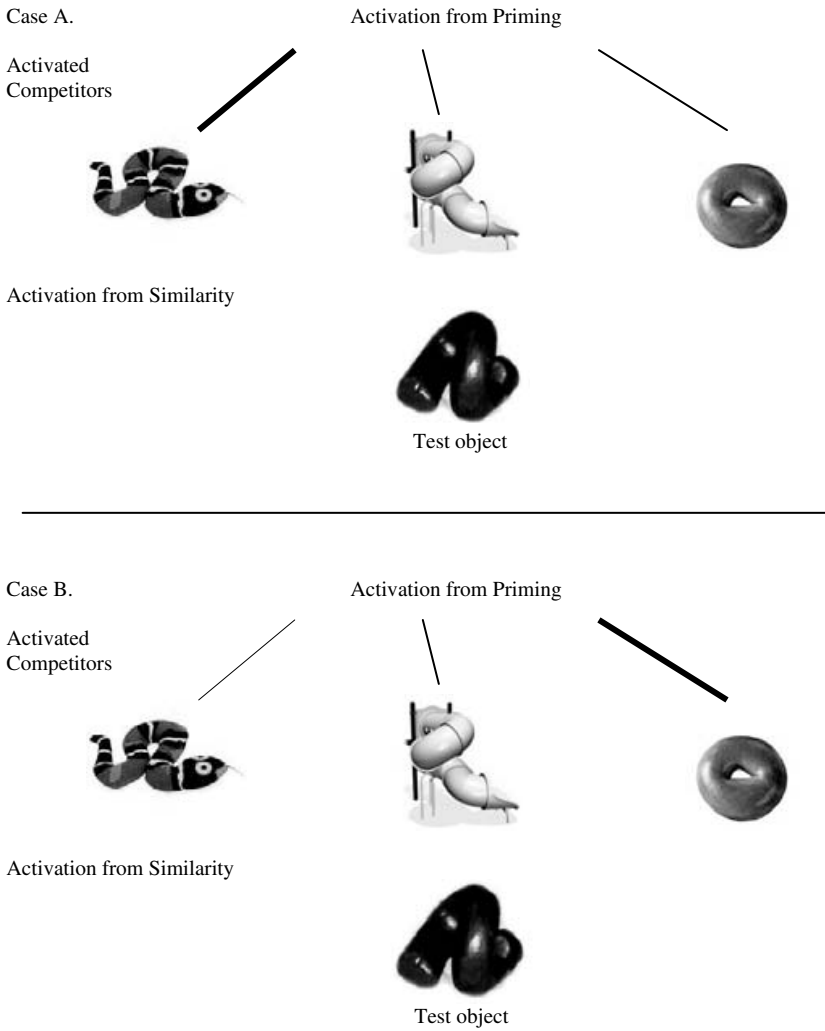


Fig. 5. Lexical access as a competitive process involving activation from similarity relations and prior retrievals. The bold line indicates stronger activation.

objects for familiarization prior to a novel noun generalization task. The two-year-olds in these experiments sometimes spontaneously labeled the nonce objects with an English name. We collected a corpus of these overgeneralizations from a variety of experiments. For Experiment 2, we selected both low and high similarity target words, as well as the specific test objects from this corpus.

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Experiment 2 also compares the lexical selections of two-year-olds and four-year-olds. Gershkoff-Stowe (2001) has suggested that young children's lexical access may be more vulnerable to influence from just previously activated words. This follows from the idea that inhibition among competitors is a factor in lexical selection and the possibility that such inhibition is less potent for younger than older children, either because such processes are a function of practice in lexical retrieval or perhaps, for maturational reasons (Dapretto & Bjork, 2000; see also Diamond, 1989). Alternatively, processes of lexical selection may differ developmentally only as a function of knowledge; given equivalent knowledge of the object, younger and older children's processes of lexical access may not differ.

METHOD

Participants

Thirty two-year-olds ($M = 2;2$; range = 1;10–2;7) and 39 four-year-olds ($M = 4;1$; range = 3;5–4;11) participated. Half the children at each level were female. Fifteen additional children (13 two-year-olds and two four-year-olds) were tested but did not contribute data: one was bilingual; the remaining children failed to complete the task or did not name (or repeat the name) for at least 50% of the priming pictures.

Stimuli and design

The test objects were selected from stimuli used in prior studies of two-year-olds' word learning. Each test object was one that a child had spontaneously named with an English noun. Table 3 shows the eight test objects and target names for each novel object. The target primes were assembled into three sets according to adult similarity ratings, as described below.

The priming set for each object consisted of three pictures: the priming picture depicted a prototypical instance of the to-be-primed category and the two filler pictures depicted unrelated objects as in Experiment 1.

Adult similarity ratings

We selected priming pictures that, by our intuitions, were highly similar, less similar, or unrelated to each target object. We confirmed our intuitions by asking 20 adults to rank order the similarity of each novel target to the selected lexical category (high, low, or unrelated) for that object. Raters were specifically instructed to consider the similarity of the object to the kinds of things named by the word. The mean rank of the object to the named category was 14·03 for the High Similarity set, 28·35 for the

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TABLE 3. *High and low similarity and unrelated prime target names for the eight novel objects in Experiment 2*

Target name			
High similarity	Low similarity	Unrelated	Novel object
fish	ball	crayon	
tree	frog	cup	
airplane	duck	cake	
boat	shoe	telephone	
lamp	puppet	tricycle	
monster	dinosaur	toothbrush	
horse	gun	keys	
snake	bagel	cheese	

Low Similarity set, and 49·13 for the Unrelated control set. The Kruskal–Wallis test was conducted to evaluate differences among the three sets. The test, which was corrected for tied ranks, was significant, χ^2 (2, $N=20$) = 41·18, $p<0·001$. Pairwise comparisons among the three sets were confirmed using the Mann–Whitney U test, $p<0·001$ in each case.

Procedure

Children at each age level were randomly assigned to one of three conditions: High Similarity prime, Low Similarity prime, and Unrelated prime control. All other aspects of the procedure were identical to Experiment 1, except that there were eight rather than six trials and no comprehension test was given since none of the test objects had a known name.

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TABLE 4. *Mean frequency* (*and* S.D.) *of naming responses given to the novel objects in Experiment* 2 *for the High Similarity, Low Similarity, and Unrelated control conditions as a function of age*

Age (yrs.)	Similarity		
	High	Low	Unrelated
2	6·60 (2·46)	6·70 (1·77)	5·50 (2·68)
4	8·20 (3·34)	7·10 (2·67)	8·50 (3·71)

RESULTS AND DISCUSSION

Production of test object labels

Given the real but unfamiliar objects of Experiment 1, children often did not provide a name for a test object when asked. In contrast, given the made-up objects of Experiment 2, children typically offered a name and sometimes offered more than one name. We scored all offered names, using the coding procedure described in Experiment 1. Table 4 presents the mean number of naming responses provided for the test objects in each of the three experimental conditions separately for the older and younger groups of children. A (2) × (3) between-subjects analysis of variance revealed a reliable main effect of age, $F(1, 63) = 5{\cdot}68$, $p = 0{\cdot}02$; four-year-olds generated significantly more names for the test objects than two-year-olds. No other main effects or interactions approached significance. Children in the High Similarity and Low Similarity prime conditions offered object labels as often as did children in the Unrelated control condition.

Types of naming responses

Table 5 gives the breakdown of omissions, extraneous responses, and labels that were the high prime target, low prime target, unrelated prime target, or filler item as a function of similarity condition and age. The proportions of PRIMED words (that is, saying the high prime target in the High Similarity condition) are indicated in bold. The table shows that, as before, the labels children produced were most often extraneous words. These were primarily names for things that shared some similarity to the nonce objects. For instance, children called the snake-like test object pictured in Figure 5 by a variety of names, including 'rock,' 'pretzel,' 'donut,' 'worm,' and 'snail.' The proportion of word productions that were extraneous was submitted to a (2) age × (3) condition analysis of variance for a between-subject design. The analysis revealed a main effect of age

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TABLE 5. *Mean proportion of omissions and of naming error types in Experiment 2 for the High Similarity, Low Similarity, and Unrelated Control test objects by age*

			Prime target			
	Omission	Extraneous	High	Low	Unrelated	Filler
			Two-year-olds			
High similarity	0·25	0·51	**0·42**	0·05	0·00	0·01
Low Similarity	0·23	0·55	0·15	**0·24**	0·00	0·06
Unrelated control	0·38	0·67	0·21	0·09	**0·02**	0·10
			Four-year-olds			
High smilarity	0·25	0·51	**0·34**	0·03	0·00	0·12
Low similarity	0·23	0·55	0·14	**0·08**	0·00	0·00
Unrelated control	0·38	0·67	0·15	0·03	**0·01**	0·01

$F(1, 63) = 5{\cdot}84$, $p = 0{\cdot}019$ and a main effect of condition, $F(2, 63) = 6{\cdot}16$, $p < 0{\cdot}004$. The interaction was not reliable. *Post hoc* pairwise comparisons indicate that significantly more extraneous productions were made in both the Low Similarity condition ($M = 0{\cdot}68$) and Unrelated condition ($M = 0{\cdot}76$) than in the High Similarity condition ($M = 0{\cdot}53$). Also, four-year-olds ($M = 0{\cdot}71$) made more of these productions than two-year-olds ($M = 0{\cdot}58$).

One key question about the children's naming responses is how recent activations of similar categories influenced their lexical choices. Children's productions of the primed word in each condition (i.e. the prime in bold) fit the idea of spreading activation that propagates through the system based on similarity, but they also indicate potentially informative developmental differences. The proportion of productions that were target primes was submitted to an analysis of variance for a (2) age × (3) prime type design. The analysis revealed a main effect of similarity, $F(2, 63) = 46{\cdot}7$, $p < 0{\cdot}001$ and an effect of age, $F(1, 63) = 7{\cdot}08$, $p = 0{\cdot}01$. There was no significant interaction effect. As is apparent in Table 5 and as indicated by pairwise *post hoc* comparisons, children were more likely to produce the High Similarity target prime ($M = 0{\cdot}38$) than either the Low Similarity prime ($M = 0{\cdot}15$) or Unrelated prime ($M = 0{\cdot}02$), which did not differ from each other. Younger children ($M = 0{\cdot}23$) were also more likely to produce the primed targets than were older children ($M = 0{\cdot}14$).

Effects of priming

A relevant empirical question is whether children's productions in the experimental task really were primed – the result of lingering activation from the words produced prior to the naming of the nonce stimulus objects.

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The design includes a means to address this question. Specifically, we ask how frequently the High Similarity target was produced when it was primed (the High Similarity Prime condition) and when it was not (the Low Similarity and Unrelated Prime conditions). Analogously, we ask how frequently the Low Similarity target was produced when it was primed (the Low Similarity Prime condition) and not (the High Similarity and Unrelated Prime conditions). If similarity of the ambiguous test object to the target category is all that matters, then there should be no difference in the number of times children offered the high and low similarity prime targets in the three conditions. Contrary to this prediction, however, a (2) age × (2) High/Low similarity target × (3) priming condition revealed that children produced the targets as names for the nonce objects more when those names were primed than when were not, $F(1, 63) = 20{\cdot}27$, $p < 0{\cdot}001$. In addition, there was a significant target by condition interaction, $F(2, 63) = 12{\cdot}31$, $p < 0{\cdot}001$, due to the fact that children infrequently produced both the High and Low Similarity targets in the Unrelated Prime condition and also because priming had a bigger effect in the High than in the Low Similarity Prime condition (Tukeys, $p < 0{\cdot}05$). Finally, the analysis yielded an effect of age that approached conventional levels of statistical significance, $F(1, 63) = 3{\cdot}89$, $p = 0{\cdot}053$; older children produced fewer similarity targets than younger children. This result fits with the previous finding on the rate of extraneous responses, suggesting that older children may be less susceptible to priming and more inclined to select words from long-term memory, at least in the current task.

Perseverative naming

One final effect, observed in the present experiment but not in Experiment 1, was the tendency for children to perseverate a single label to multiple test objects. For example, one child offered the word 'boat' for the boat-shaped object in the High Similarity condition, but then used the same word to name the next object even though it had a very different shape. Sixty percent of the two-year-olds (18/30) produced a total of 27 perseverative errors, while 44% of the four-year-olds (17/39) produced 22 errors in total. Perseverative naming occurred across all three conditions, though as shown in Figure 6, two-year-olds perseverated most often in the Low Similarity condition whereas four-year-olds perseverated most often in the Unrelated condition. A (2) × (3) ANOVA revealed a significant age by condition interaction effect, $F(2, 63) = 3{\cdot}36$, $p = 0{\cdot}04$.

Together, the findings support three main conclusions. First, children's lexical selections are influenced by both similarity and recent activation. This is particularly evident in the names offered by the children in the Low Similarity condition. Here both target names were offered nearly

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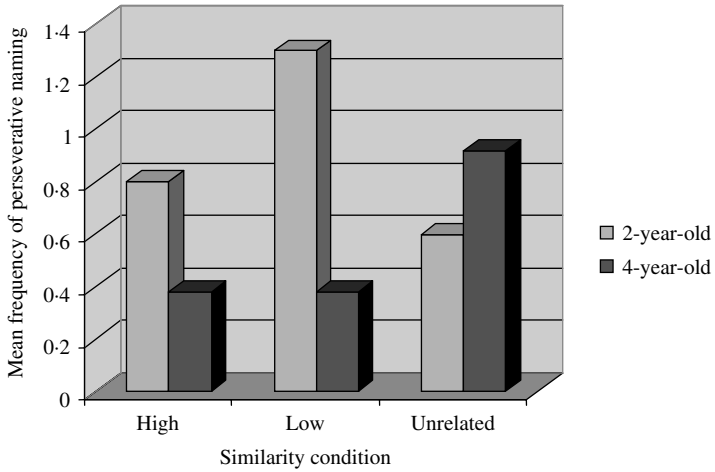


Fig. 6. Mean frequency of perseverative naming in Experiment 2 as a function of age and condition.

equally often, the primed name of the low similarity target and the unprimed name of the high similarity target. Second, these two sources of activation combine, and indeed, appear to do so additively. This conclusion is supported by the frequency with which children in the High Similarity prime condition offered the high similarity target which, particularly for the younger children, is roughly the sum of the frequencies with which the primed and high similarity targets were offered by children in the Low Similarity condition. The role of similarity is also highlighted by the fact that children rarely offered one of the filler names for the test object in any of the three conditions, nor did they offer one of the perceptually dissimilar primes in the Unrelated condition. This suggests that priming enhances competitors that have been activated by similarity to the current input. Finally, at both age levels, children offered names of similar things for these novel objects and at both age levels, children's lexical selections were influenced by previous word productions. However, even with equivalent knowledge of the experimental objects, younger children showed a bigger effect of transient cues than older children. This is apparent in Table 5 and is also supported by the increased rate of perseverative naming among the two-year-olds.

GENERAL DISCUSSION

The results from Experiment 1 and 2 provide new information about the young word learner's overgeneralizations and the processes that give rise

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to such naming errors. In particular, a competitive model of lexical selection appears appropriate for children's word productions just as it is for adults' lexical selections. And these competitive processes appear to underlie children's name productions both when the named object is common and known to the children and when it unfamiliar or truly novel. In each of these cases, the similarity of the object to candidate categories is a strong determiner of the name produced. Further, lingering activation from recently activated concepts and words also enters into the competition for selection such that children are more likely to offer wrongly a name for an object when that name has recently been produced by the child.

The facts are important for thinking about the meaning of overgeneralizations and what they tell us about children's early categories. Children's overgeneralizations have interested developmental researchers as possible windows into the structure of children's categories. The misnaming of a horse 'doggie' seems prima facie evidence that the child believes horse and dog to be the same kind of thing, deserving the same name. This idea lies at the heart of debates about whether overgeneralizations are specific to production but not comprehension (and thus potentially retrieval errors) and whether they might be pragmatic solutions to lexical gaps. If children's naming errors reflect competitive processes of word selection, then they are not indicative of underlying category knowledge.

The three stimulus conditions in the present two experiments – familiar objects, unfamiliar objects, and completely novel nonce objects – span this range of possibilities, from 'retrieval errors' that are misnamings of objects with comprehended names in Experiment 1, to 'category errors' such as a child's labelling of the ornament 'ball' in Experiment 1, to the 'pragmatic' solutions of offering the best name possible for a nonce object in Experiment 2. Yet as different as these all seem, they may all be generated by the very same processes – a product of similarity, previous activation, and the strength of established links between object, concept, and word. In our view, the lesson to be drawn from these results is not that category errors do not exist. Nor do the results imply that overgeneralizations can not tell us about children's early lexical categories. Rather, the lesson to be drawn may be that the relevant category knowledge is graded and embedded in the very processes of lexical selection and production. What children know about lexical categories – about what is and is not a dog, for example – resides in the strength of the links between objects, concepts, and words, in the range of similarities that activate those links, and in the strength of activations and thus their vulnerability to context effects.

The present results also indicate that given comparable knowledge about the to-be-named object, the processes that give rise to lexical selections

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by two-year-olds are qualitatively the same as they are for four-year-olds. Similarity and priming have the same effects on the names both groups of children offer for nonce objects. Importantly, however, older children appear to be less influenced by priming than younger children. This result is consistent with previous work by Gershkoff-Stowe (2001), indicating that novice word learners have a greater susceptibility to lexical competition from previous retrievals than practiced word learners. One possibility is that younger children have fewer and less robust connections between words and concepts. Thus, they may be less adept at inhibiting a previously activated word, allowing it to stay active longer. Future work is needed to determine the precise underlying mechanisms of retrieval. The implication is, however, that young word learners' greater propensity for overgeneralization and retrieval errors is a product of the strength of their lexical knowledge and not the fundamental processes of lexical selection.

This theoretical framework also provides new insights into the typical advantage of comprehension over production in tests of young children's word knowledge. Comprehension is perhaps best understood not as a better measure of children's word knowledge, but rather as one requiring less activation strength (Gray, 2003). In production tasks, children must produce the word given the perceptual information provided by the object. In comprehension tasks, children have two sources of information – word and typically several choice objects. Because information flows in both directions in the comprehension task, activations that are too weak to lead to correct productions may nonetheless lead to correct comprehension. This appears to be the case in Experiment 1. In that experiment, children were quite accurate in measures of their receptive knowledge of the familiar object names, but often were unable to produce the names of those same objects.

The present experiments also make a contribution by introducing a method that should yield even finer grained insights into lexical category development. In these experiments, we examined global effects of similarity and priming over the whole set of links from object to concept to word. However, the method could be used to examine separately the object to concept links and the concept to word links. Further, it would be informative to examine different kinds of primes. In the present study, the prime targets were selected by their perceptual (and primarily shape) similarity to the test objects. We observed clear effects of priming. However, other primes – semantic, thematic, and taxonomic – could have stronger and/or developmentally changing effects. The present method thus may prove useful in providing greater detail about the structures of the early lexicon and processes of lexical access and selection.

Finally, the present results indicate that children's lexical categories tend to be applied more liberally than those of most adults. That is, younger

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children appear to have a broader shape similarity, leading to a certain promiscuousness associated with naming ambiguous objects. Recent findings by Goldstone & Son (2005) with adults and Sandhofer & Smith (2004) with four-year-olds support this interpretation. Their studies indicate that the shape complexity and familiarity of an object affect how individuals represent and, hence extend, words to novel objects. Simple abstract forms, much like the nonce objects used in Experiment 2, more readily activate memories of objects in perceptually similar categories than the highly familiar and complex objects that children typically encounter in their everyday lives. This fact may also help to explain why children generated multiple objects names in Experiment 2 relative to Experiment 1.

In conclusion, the findings from this research present evidence for a unified understanding of children's early overgeneralizations, one that is grounded in processes of lexical selection. The word the child produces at any given moment to label an object is the product of the child's knowledge about the object and category, the strength of the link from that concept to a word, and the contextually relevant (and thus activated) concepts and words. Thus the study of lexical access and selection in the early stages of word learning promises new insights into the development of categories and the lexicon.

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