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Hunting the Fox of Word Learning: Why ''Constraints'' Fail to Capture It

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It is often asserted that young children's word learning is guided by *constraints* or internal biases. Constraints are broadly described as ''any factor that favors some possibilities over others'' (Medin et al., 1990). Researchers have argued that specialized lexical constraints cause children to make some inferences about word meanings before others. An analysis shows that the concept *constraint* is not informative because it does not differentiate a circumscribed set of word learning behaviors. Defining constraints as innate and domain-specific does not remedy this problem. We cannot separate the effects of so-called constraints or biases from a wide range of cognitive and contextual influences on children's inferences about novel word meanings. This conclusion is supported by a selective review of these influences. The summary highlights our need for an explanatory framework that is sufficiently rich to capture the flexibility and diversity of children's word learning. The core of such a framework is summarized as a set of general characteristics of human word learning. These characteristics must serve as a starting point for any viable theory of word learning. Prescriptions for future development of a viable framework are suggested.

Word learning[1] is a complex and intractable problem for which researchers have offered a seemingly simple and powerful solution. The problem is that preschoolers' prolific acquisition of new words (averaging a half dozen per day; Carey, 1978) seems impossible given the radical indeterminacy of word meanings. A novel word has an indefinite number of possible meanings, and it is unlikely that children regularly receive information that unambiguously specifies a single meaning. Yet children often infer new words' correct or

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[1] Word learning includes a phonological representation, assignment to a form class, designation of intensional and extensional meaning, and associations among these components. For simplicity, however, ''word meaning'' will indicate mapping a lexeme onto a referent concept. We are typically interested in mappings that allow generalizing of the lexeme to novel referents.

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approximate meanings. How do children so readily solve these ''problems of induction'' (Quine, 1960)? The simple solution critiqued here is that children have internal biases or constraints to prefer some meanings above others.[2]

This solution has proved compelling. A database search yields over 50 journal articles from the last 10 years focusing on word learning constraints, biases, or principles. Recent textbooks and a *Handbook of child development* chapter define and discuss constraints (Berko Gleason, 1997; Hoff-Ginsburg, 1997; Woodward & Markman, 1997). By objective criteria, the concept ''constraint'' is firmly established in the parlance of child language research. It is therefore important to determine whether the concept is logically sound and empirically defensible and whether it adds to our knowledge of children's word learning.

What makes the concept of constraints attractive, useful, and compelling? It is instructive to approach this question historically because the concept was borrowed from other disciplines. In theoretical linguistics, *constraints* are circumscribed restrictions on syntactic transformations (Chomsky, 1965). For example, English speakers learn that double dative alteration is permissible for many oblique transitive verbs of movement or transference (e.g., ''She loaned the painting to the museum'' $\rightarrow$ ''She loaned the museum the painting''), but not certain semantically similar transitive verbs (e.g., ''She donated the painting to the museum'' $\rightarrow$ *''She donated the museum the painting''). No obvious cues reliably tell English speakers which verbs allow alteration. Thus, linguists believe, we must be constrained to learn very subtle linguistic distinctions (Pinker, 1994).

In the animal learning literature, in contrast, *constraint* denotes species-specific ''preparedness'' to respond to certain stimuli (e.g., Shettleworth, 1972). For example, Tinbergen (1951) showed that male stickleback fish respond aggressively to a misshapen model fish with a red belly like a real competitor, but not to a realistically shaped model with an unmarked belly. Stickleback defensive behavior is therefore a ''constrained'' response to a color stimulus. By analogy, one could argue that the human visual system ''constrains'' our interpretation of ambiguous visual arrays. Figure 1, for example, is seen as a superimposed triangle and rectangle rather than an 11-sided polygon. Such examples highlight the intuitive appeal of constraints: they seem to explain inferential systems' interpretive biases. Predictable stimulus-specific responses like these may be deeply ''canalized'' (i.e., likely to emerge across wide variations in background and experience; Waddington, 1957). But whether constraints can explain syntactic subtleties or piscine hostility, it is a separate question whether they can explain word learning (Kuczaj, 1990).

[2] Throughout this paper the term *constraint* is considered interchangeable with *bias, innate preference,* and *first principle*. This is consistent with uses of these terms in the literature.

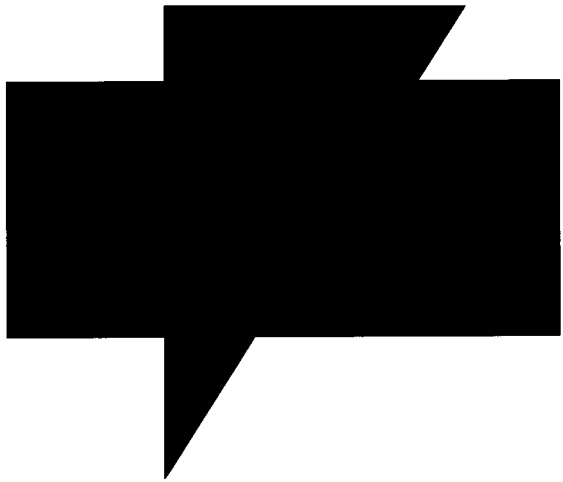

FIG. 1. Optical illusion: Our perceptual systems interpret the figure as two overlapping shapes (triangle and rectangle) rather than an 11-sided polygon.

Ellen Markman (1989) eloquently articulated the argument that children's inferences about word meanings are attributable to inductive constraints. She and her colleagues (e.g., Markman & Hutchinson, 1984; Markman & Wachtel, 1988) showed that children prefer certain interpretations of novel words. For example, when children hear a novel noun they tend to map it onto an unnamed object rather than a familiar, nameable one (e.g., a gyroscope rather than a cup). From such evidence Markman inferred a ''Mutual Exclusivity'' bias, by which preschoolers assume, at least initially, that words do not overlap, or that every object has only one name. Because parents typically use only one basic-level word for each object (Wales, Colman, & Pattison, 1983), such a bias could simplify learning and support correct inferences. This example illustrates how constraints seem to provide an elegant solution to an intractable learning problem. A finite set of discrete, simple, endogenous biases might explain children's inductive inferences in a way that simple associative learning mechanisms cannot (see Bloom, 1999).

The first half of this paper evaluates whether the concept *constraint* is theoretically useful, that is, whether it conveys unique information about word learning behaviors. This requires the resolution of several problematic questions, including the feasibility of a modal definition of constraints. I conclude that constraints provide not merely an incomplete account of word meaning, but no meaningful account whatsoever. Constraints accounts are meaningless not because children lack genetically canalized, nonrandom inductive tendencies. Rather, they are meaningless because *all* word learning is guided by canalized inferential tendencies, and developmental psychologists lack the means to differentiate a subset of these as ''constraints.'' The

second half of the paper reviews evidence that supports these arguments and conclusions.

A related argument is that constraints accounts are not effective explanatory devices. Constraints fulfill our desire for simple axioms; they are ''hedgehog'' theories. Maratsos and Deák (1995) adapted this concept from Archilochus' fragment ''the fox knows many things, but the hedgehog knows one big thing.'' Isaiah Berlin (1953) applied the metaphor to historians who seek simple, general explanations for diverse historical events (e.g., Dostoevsky) versus those who embrace the complex, unpredictable diversity of historical events (e.g., Pushkin). The distinction can be applied more broadly (e.g., Plato was a hedgehog; Aristotle a fox), and here it is applied to accounts of word learning. The final review supports the position that word learning is best considered a ''fox'': an inherently diverse set of behaviors related only because they contribute to a common product (i.e., lexical growth). By this view, constraints offer a misleading and simplistic account of word learning. Although word learning *must* depend on children's inductive biases, these are diverse, difficult to define, and contingent on complex patterns of information in the child's environment.

EVALUATING THE CONCEPT OF CONSTRAINTS ON WORD LEARNING

Is the Concept ''Constraint'' Scientifically Useful?

To evaluate whether constraints explain word learning, consider first the general definition of constraints as factors that resolve indeterminacy (Medin et al., 1990). Given that all word meanings are indeterminate, and given that children nonetheless learn them, some factor must resolve indeterminacy. The general claim that constraints guide word learning is thus uninformative and tautological.

To expand this assertion, assume that constraints (broadly construed) incontrovertibly exist. All organisms, including humans, are constrained in an infinite number of ways. Humans cannot, for example, see ultraviolet light, track scents, walk on ceilings, or hover in midair. To posit a constraint is to assert hypothetically that an organism might have been otherwise. The human traits that most obviously might have been otherwise are those that are most unique to our species. It is therefore natural to view language as constrained. Every nonhuman species reminds us that language is not an inevitable phenotype. In fact, though, *all* traits might have been otherwise, including those that seem less unique or ''special'' (for example, sensing light energy). Every trait is constrained in some way. The concept is therefore meaningless in its broad sense.

One possible response is that word learning is governed by specialized constraints. Although there are infinite constraints in the broad sense, only

a few control inferences about word meaning. The word learning literature, for example, has focused on fewer than a dozen hypothesized constraints (see Bloom, 1997, for critique). To evaluate this rebuttal, let us consider the range of constraints in the broad sense needed to fully account for children's and adults' inductive biases about word meanings. If we define constraints as any factor that favors some possible word meaning over others, then any nonrandom pattern of inferences about word meanings can be attributed to a constraint of some sort. What sorts of constraints would be needed? Could a parsimonious framework of constraints explain word learning? If so, we can continue to evoke constraints as we have, without a precise definition. Otherwise we must construct a circumscribed and theoretically coherent definition, to avoid the (tautological) broad meaning.

Kinds of Constraints

Typically we conceptualize constraints as mechanisms that bias children toward one of several plausible inferences about the meaning of a novel word. For example, the taxonomic constraint (Markman & Hutchinson, 1984; Waxman & Kosowski, 1990) addresses the discrepancy between preschoolers' attentiveness to thematic relations (e.g., ''dog'' and ''bone'') and their tendency to generalize nouns to entities that share some critical features (e.g., all dogs). Ignoring practical reasons why languages do not assign a word to every possible thematic relation, the implication is that children might do so if a specific constraint did not discourage it. Such *attention-guiding constraints* would increase children's attention to valid attributes, relations, entities, or events and decrease attention to those that might be erroneously chosen as referents.

Children must also assign different kinds of referents (i.e., attributes etc.) to a diverse range of words. Supplemental *control constraints* would be needed to help children select the relevant attention-guiding constraint for a given word. One set of control constraints would cause children to select different attributes based on a novel word's syntactic form class. For example, preschool children tend to generalize novel count nouns to objects and novel mass nouns to substances (McPherson, 1991). This requires control constraints to ''set'' the conditions for engaging more specific constraints–count noun-specific constraints, for example. Other control constraints would cause children to select referents according to speakers' nonverbal behaviors. Baldwin (1995), for example, showed that infants map a novel count noun onto an object they are looking at only when the speaker is looking at the same object.

A third type of constraint would be needed to explain how children's attention is guided to a preliminary set of possible attributes, relations, etc. Attention-guiding and control constraints would only help children choose from a *finite* set of hypothetical meanings. The set must be finite because

children's knowledge and cognitive resources are limited. Yet the problem of induction states that a word has an *infinite* number of possible meanings (Quine, 1960). The idea that children choose from a finite, tractable number of possible meanings presupposes boundaries within an infinite hypothesis ''space.'' What marks the boundaries of this space, leaving some hypotheses inconceivable or implausible? The answer is an indefinitely large set of *implicit* constraints. These would exclude, for example, possible but unlikely meanings like ''green until the year 2000, then blue'' (Goodman, 1955/1983). Such constraints would reflect, among other things, limits on the child's sensory, information processing, and conceptual resources.

Given that any plausible constraints-based account requires all three types of constraints, is a parsimonious framework possible? Perhaps, if relatively few constraints of each type are jointly sufficient to explain the full range of word learning tendencies. Unfortunately this is implausible: word learning would require an indeterminate number of constraints of each kind. With respect to attention-guiding constraints, for example, children would need a sufficient range of constraints to guide their attention away from every attribute, relation, entity, or event they might erroneously attend to. For example, we might hypothetically posit a ''dullness constraint'' that would prevent children from mapping count nouns onto only brightly colored objects, which are likely to attract attention but no more likely than drab things to be the referents of novel count nouns. Similarly, we would require as many control constraints as there are different categories of words—not only words for objects, but also for object properties, relations among objects, actions upon objects, etc. Finally, the number of implicit constraints needed cannot be estimated because the range of implausible meanings that is off-limits is, by its very nature, unimaginably diverse. In short, a commitment to word meaning constraints, broadly construed, erodes the parsimony that made constraints accounts attractive. Why is this important? Because it shows that nothing is gained from a *comprehensive* constraints account of word learning. The current favorite alternative is that constraints are but one mechanism of word learning among several (Bloom, 1997; Woodward & Markman, 1997). Yet this is an empty claim unless we specify *what counts as a constraint* (this argument will be delineated shortly).

The implausibility of a parsimonious constraints framework can be illustrated by considering the empirical proliferation of constraints needed to account for the data on a single inductive tendency. The Mutual Exclusivity (M.E.) constraint (Markman & Wachtel, 1988) purportedly predisposes children to restrict multiple words from the same referent. This attention-guiding constraint biases children to focus on unnamed objects or parts when they hear a new word. Evidence that children readily apply combinations of several known words to a single referent (Deák & Maratsos, 1998) indicates that the bias is elicited only by novel words or perhaps by new symbol map-

pings. This can be considered a control constraint. Evidence that children tend to map novel words onto unnamed objects is the principal empirical support for M.E. Yet this tendency increases with cognitive load (Liittschwager & Markman, 1994) and typicality of the nameable object (Merriman & Schuster, 1991). It decreases with familiarity of the unnamed referent (Merriman & Bowman, 1989) and with phonetic similarity between the novel word and the nameable item's name (Merriman & Schuster, 1991). These second-order contingencies can be considered auxiliary attention-guiding constraints. Note that other factors could be added (see, e.g., Merriman & Kutlesic, 1993; Savage & Au, 1996). Moreover, at least some of these contingencies change developmentally (e.g., Merriman & Schuster, 1991), implying additional control constraints activated by the development of cognitive or language abilities. Finally, we require implicit constraints that prevent children from, for example, mapping the word onto a part of one object plus the color of another. In sum, the data show that the tendency to disambiguate novel words cannot be captured by one or two constraints. Any word learning tendency is part of an extensive contingency-sensitive network of interacting inductive tendencies.

This example is by no means unique: a review of the literature on the ''shape bias''— children's tendency to map novel object count nouns onto same-shape taxons—reveals a similarly complex network of contingencies. At best, then, it makes less sense to speak of a discrete M.E. or shape bias than of indefinitely large sets of interacting sensitivities/proclivities which result in replicable patterns of inferences about word meaning.

A possible rebuttal is that this example confuses the issue by calling some tendencies ''constraint'' that are not proper constraints. This implies that we possess a principled way to identify which behavioral tendencies count as constraints. We possess none, however, and we cannot identify constraints by fiat. In a thorough review of recent word learning research, Woodward and Markman (1997) discuss four mechanisms of word meanings: internal constraints, pragmatic cues, syntactic cues, and contrast. Whereas this taxonomy might partly serve as an expository device, it implies that we can separate word learning constraints from other inductive tendencies. Yet responsiveness to pragmatic, syntactic, and contrast information depends partly on perceptual, social, and cognitive biases that can also be considered constraints broadly construed.

Summary

Constraint as currently used merely describes a word learning behavior—any behavior, in fact. To move from description to explanation, *constraints* must denote a coherent subset of word learning tendencies that can be differentiated from other tendencies. To transcend description we require testable criteria for determining whether a trait is caused by a constraint. The next

section explains why the concept *constraint* is misleading and is not redeemed by the current modal definition. That argument, along with the points already raised, is cause to reject the concept *constraint.*

Are Constraints Better Than Nothing?

If any tendency can be attributed to a constraint, why should we use such a theory-laden term rather than an atheoretic label like ''tendency?'' This is not merely a semantic conceit, because *constraint* carries a weighty implication. It implies an internal causal force; a mechanism hard-wired in the organism. Other possible terms, like *tendency,* are neutral with respect to causality and locus. Unless we can show that certain word learning behaviors stem from internal mechanisms, we should prefer an atheoretical designator that carries less theoretical baggage.

Implications of specific causal mechanisms are problematic because there is a tendency in psychology, a science that places value on prediction but relies heavily on correlational behavioral evidence and hypothetical constructs, to conflate descriptive and explanatory constructs. It is never necessary to posit a hypothetical construct for a phenomenon, because the phenomenon is self-defining. Without a specific underlying causal mechanism, hypothetical constructs serve as nominal place holders for the phenomena they describe. They can serve as mnemonic and social devices, but they do not by themselves clarify anything about the phenomenon. For example, children's tendency to map a new word onto an unnamed rather than a named category might be attributed to a hypothetical Mutual Exclusivity bias. At this point, though, the term *M.E. bias* merely stands for the phenomenon. The nominal construct is often reified, though, until it acquires an explanatory veneer (e.g., ''Suzy thought 'glix' is the word for that strange object because she has an M.E. bias''). The reification of a nominal construct tends to generate an illusion of understanding. The illusion is most seductive when the nominal place holder carries historical baggage that suggests an explanation. ''Constraint'' is such a seductive construct, because historically it has implied a biologically embodied, stimulus-specific causal mechanism.

To illustrate how *constraint* misleadingly implies a causal mechanism, consider an allegorical analogy. Imagine that in two species of birds, looming objects trigger similar defensive behaviors. We might posit a shared ''looming'' constraint (this is how we use behavioral evidence to posit word learning constraints). Imagine that researchers then discover the two species' looming responses stem from different mechanisms. In one species the response is triggered by a nonlinear increase in the rate of change in the ratio of light to dark regions in the visual field; in the other it is triggered by the concurrent firing of a majority of peripheral retinal edge receptors. Two different mechanisms cause similar behaviors. Do the species share a single constraint? Our current usage of the construct does not deny this possibility. Implicitly we do not expect to specify the cause of a behavioral response.

Constraints, as currently used, are descriptive constructs that masquerade as causal mechanisms.

For a construct to have explanatory force it must specify a falsifiable causal mechanism. Word learning constraints imply causal mechanisms that are (1) internal to the child (i.e., innate) and (2) domain-specific. Below I assess whether these criteria adequately differentiate a subset of word learning tendencies. Until now these criteria, when employed, have been assumed but not justified. If we instead submit a word learning tendency to rank description, we are free to ask questions about its cause, emergence, breadth, interactions with other tendencies, etc. The answers to these questions might eventually allow us to group tendencies with similar causal mechanisms, but no such regularities are apparent from available evidence.

The present challenge, then, is to evaluate the viability of a definition of *constraint.* If the definition does not pick out a coherent subset of word learning behaviors, it is not viable. Though no unanimous definition exists, a modal working definition can be derived from the literature. First, word learning constraints are sometimes conceived as deeply canalized traits that are biologically embodied in the child (Waddington, 1957), rather than in regularities in the input. The strongest and most specific version of this claim is that specific constraints are genetically innate.[3] Second, word learning constraints are thought to be special-purpose, domain-specific (i.e., lexical) mechanisms, not byproducts of general learning processes. These two criteria will be evaluated to determine whether they together specify a distinct subset of word learning tendencies.

Evaluating the Modal Definition of Constraints

Is the modal definition of constraint adequate to differentiate a specialized subset of word learning behaviors? Certainly innateness and domain specificity constitute a minimal definition.[4] Keil (1990) classified proposed inductive constraints in a matrix using innate versus acquired and domain-specific versus domain-general as features of the cells. This scheme implies that inductive constraints can have any combination of values on these dimensions. Such an expansive scheme shows how easily the concept loses meaning. To be minimally informative, *constraint* must denote a subset of cells in a feature matrix. If we restrict constraints to the [INNATE + DOMAIN-SPECIFIC] cell, can we derive a coherent set of word learning constraints?

[3] This is stronger than the more general claim that the causal locus is the organism. It implies that the causal locus is the product of natural selection, is heritable, is biologically specified, and is unlearned or minimally dependent on experience.

[4] Not every researcher agrees with this characterization (e.g., Smith, 1999). Thus, the definition evaluated here is modal, not unanimous. Nevertheless, some definition must be considered or we are left only with the deficient broad definition discussed previously.

The Nativist Assumption

The assumption that constraints have an endogenous causal locus carries two empirical implications. First, constraints should not depend on variable or low-probability experiences.[5] Second, they should show a normative maturational pattern. On the other hand, nativism does not imply complete interindividual consistency (as Nelson, 1988, asserted) because genotypes vary within a population (Mayr, 1982).

Because we know so little about how word learning tendencies are genetically constrained (Braine, 1994), ''innate'' can only mean something vague like ''caused to some degree by the organism's genotype.'' Yet it was never in doubt that word learning is partly dependent on the human genome, so a more specific meaning must be sought.

We cannot, of course, demand specification of a causal sequence from gene to behavior. Genes are material causes (in an Aristotelian sense), providing templates for polypeptides. A given gene is turned on or off to produce structural units (polypeptides) that ultimately affect phenotypes. The agents that turn genes on and off are Aristotelian efficient causes, and these include other genes as well as hormones and exogenous agents. The causal path from genotype to word learning phenotype inevitably includes environmental factors, and we can assume that *any* complex behavior is the product of tremendously complex interactions among genetic, environmental, and historical factors. What, then, is gained from the assertion that some word learning tendencies are innate? We cannot consider ''partly innate'' a distinctive feature of certain word learning tendencies. (This is a restatement of the point that any trait can be translated into a constraint, broadly construed.) Could we instead assume that some word learning tendencies are more deeply canalized than others? This is logically defensible, but we currently have no metric to measure depth of canalization, and for ethical and practical reasons we cannot assess the true range of reaction of different word learning phenotypes.

This difficulty is currently insurmountable. Given regularity in the human genome, regularity in the environment, and regularity in developmental experience (e.g., early language input), we cannot untangle the relative contributions of these factors. Various ''natural experiments'' involving feral children (Itard, 1801/1932; see Brown, 1958b), deaf children of hearing parents (Goldin-Meadow & Feldman, 1979), and apes trained to use symbols (e.g., Terrace, Petitto, Sanders, & Bever, 1979) confirm the foregone conclusion of a genetic contribution to language, but the contribution cannot be quantitatively estimated. The fact that language is not a generic mode of behavior

[5] Deeply canalized phenotypes are considered ''experience-expectant'' (Greenough et al., 1987), that is, dependent on patterns of experience that vary little across time or culture.

that emerges in any reasonably complex organism does not justify the conclusion that some word learning tendencies are genetically specified.

This does not mean that *in principle* we cannot use a criterion like ''range of reaction'' or ''depth of canalization'' to differentiate behavioral tendencies. Conceivably, cross-linguistic evidence on word learning tendencies, together with evidence from different clinical populations (see Bates, 1997) and different species, might allow us to identify word learning tendencies that are deeply canalized or experience-expectant (Greenough, Black, & Wallace, 1987). But this is at best an extraordinarily difficult proposal. For instance, there is evidence that the taxonomic bias (Markman, 1989), a bias to extend a novel object label to a class of similar objects, requires substantial experience with object names. Only chimpanzees trained to use symbols show the bias (Premack, 1990), and at least one feral child (Itard, 1801/1932) required prolonged training to acquire the bias. So the bias is experience-dependent, but does this mean it is deeply canalized? We can only tell by comparing it to other word learning tendencies. But what is the appropriate comparison? If language-trained chimpanzees failed to develop another bias, would we conclude that the latter is more experience-dependent and therefore less deeply canalized? Hardly, because we would first need to rule out the possibility that our particular methods for training the chimps provided the right kind of experience to develop the first bias, but not the right kind of experience for the second. We would also need to rule out that there is something about chimps in particular that allows the first bias to emerge, but not the second, in a captive environment. In general, when we consider how different phenotypes emerge, we cannot quantify relative depth of canalization.

In sum, it is conceptually impossible to separate endogenous from exogenous influences on behavioral phenotypes (Johnson, 1987), and it is impossible to impartially determine the relative depth of canalization of different phenotypes. These problems make innateness an ineffective criterion for separating constraints from other word learning tendencies.

The Domain-Specific Assumption

It is widely assumed that word learning constraints are domain-specific. That is, they apply only to a restricted range of stimuli: words. Some researchers treat domain-specific knowledge as a starting point for cognitive development (see Hirschfeld & Gelman, 1994). For example, Gelman (1990; Gelman & Brenneman, 1994), and Wynn (1992) argue that infants possess early-emerging principles of number. Spelke and Baillargeon (e.g., Baillargeon, 1993; Spelke, Breinlinger, Macomber, & Jakobson, 1992) argue that young infants are equipped to reason about the movement and locations of physical objects in space. Others argue that infants distinguish animate from inanimate kinds (e.g., Gergely, Nádasdy, Csibra, & Bíró, 1995; Spelke, Phil-

lips, & Woodward, 1995). Besides domain-specific expectations about objects, quantities, and animacy (Carey, 1996), infants are prepared to learn language, and this preparedness might rest on sensitivity to linguistic stimuli.[6]

Despite its current popularity, the idea of domain specificity is vague (Elman et al., 1996; Sternberg, 1989). There is no shared definition of ''domain'' (Ceci, 1989; Hirschfeld & Gelman, 1994). Some researchers (e.g., Chi & Koeske, 1983) apply ''domain'' to very focused skills (e.g., chess), but even excluding this sense it is unclear what counts as a domain. The natural boundaries between domains of knowledge have not been identified, and perceived boundaries may be subjective or merely conventional. Without criteria for parsing domains, we risk creating idiosyncratic boundaries drawn according to theoretical elegance, aesthetic preference, unexamined assumptions, or habit. Moreover, we could hypothetically subdivide content areas until word learning is no longer a coherent domain. We might posit, for example, independent modules governing noun learning and verb learning or more specialized units for learning causative versus stative verbs, count versus mass nouns, etc. Taken to its extreme, the result is a separate domain for every inductive tendency and the consequent erosion of a parsimonious theory.

Another problem is that the content of a domain must be at least somewhat abstract, and the more abstract the content, the more similarities can be found across domains. As an illustration, consider the hypothetical assertion that naïve or ''folk'' physics, biology, and psychology are distinct domains. At more abstract levels, between-domain content may invoke similar reasoning schemas. For example, an abstract schema of additivity might govern naïve concepts of mass (physics), metabolism (biology), and psychopathologic risk factors (psychology). An abstract ''threshold'' schema might govern naïve concepts of resistance (physics), species survival (biology), and frustration–aggression (psychology). Although the idea that cross-domain content rests on common abstract schemas can be taken to extremes (as in Piaget's theory), there must be *some* content-general schemes. Otherwise mathematics, deductive logic, metaphor, and analogy would not exist. Humans employ both content-specific *and* abstract content-general knowledge, yet we lack an adequate characterization of how these are synthesized, in part because we lack coherent criteria for identifying the boundaries between domains.

The evidence for domain-specific word learning tendencies is mixed. Take, for example, children's tendency to map novel words onto unnamed referents (i.e., the disambiguation effect). Perhaps this is a response specific

[6] In this discussion, ''domain'' means hypothetical domain. Any hypothesized domain must be shown to be psychologically distinct. Cognitive and behavioral responses to stimuli in a proposed domain must be qualitatively distinct from responses to other, contrasting, domains. In other words, an interdomain boundary must be established empirically.

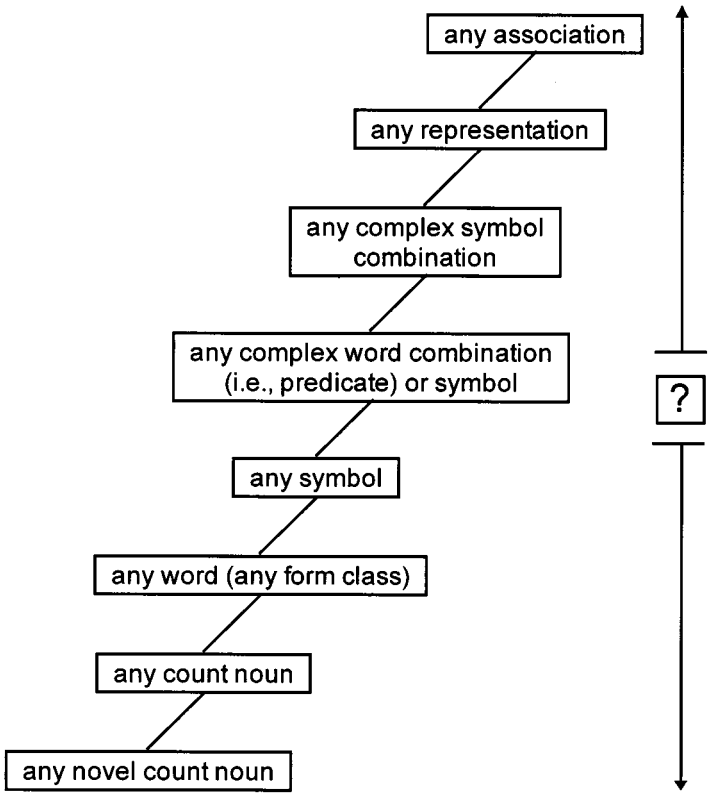

FIG. 2. The breadth of a word learning tendency must be empirically established before claims of domain specificity can be made: A tendency such as disambiguation might apply to only novel count nouns, only count nouns in general, only words, etc.

to novel words, thus a domain-specific constraint. However, a novel word belongs to many more and less inclusive stimulus categories. The precise stimulus category that elicits disambiguation has not been determined. It might be only object and action words, or all words, or, more broadly, all symbols, or any novel stimulus. This ambiguity is represented in Fig 2. The disambiguation effect has been shown only in a small class of stimuli (i.e., count nouns and action verbs), so until its parameters or ''breadth'' are established, any claims of domain specificity are merely speculative. The problem with speculation is illustrated by Markson and Bloom's (1997) test of ''fast mapping,'' originally conceived as a specific ability to learn new words from a single exposure (Carey, 1978). The authors exposed children to a novel word (''koba''), as well as a novel fact (''My uncle gave these to me'') and event (placing a sticker on an object). More 3- and 4-year-olds immediately

recalled the novel fact than the novel word or event, and after a week children remembered the novel fact and novel word equally often. Apparently ''fast mapping'' is not specific to words. Even if we identify inductive tendencies strictly limited to word learning, it would not be a foregone conclusion that these constitute a specialized class of biases with a common cause or origin.

Is there evidence for a group of tendencies with similar breadth? Perhaps. Several researchers have suggested that hearing a count noun object label causes children to apprehend the object differently. For example, Gelman and Markman (1986) found that although preschoolers often infer that similar looking objects share properties, 4-year-olds generalize novel properties across dissimilar looking items (e.g., dolphin and dog), if those objects are given the same count noun label (''mammal''). Similarly, Markman and Hutchinson (1984) and Waxman and colleagues (Waxman & Kosowski, 1990; Waxman & Markow, 1995) argue that count nouns direct infants' and preschoolers' attention to taxonomic (e.g., dog and wolf) rather than thematic (e.g., dog and bone) groupings. Most of these studies use a ''no-word'' or novel adjective control condition to show that count nouns in particular reduce children's preference for thematic relations. This suggests a domain-specific bias to attend to within-category groupings in response to object labels.

Closer examination, however, raises questions about this conclusion. With respect to Gelman and Markman's findings, Deák and Bauer (1995, 1996) found that several factors besides object labels direct preschoolers' attention away from appearances to subtle ''same-kind'' relations. For example, when the experimenter modeled explanations referring to same-kind relations, children subsequently focused on same-kind relations in different problems. Also, the question ''Which of these is the same kind of thing as . . .?'' caused preschoolers to group different looking same-kind objects, compared to the question ''Which of these is most like . . .?'' Both effects were obtained without category labels. Other factors, including more rich, detailed stimuli and questions about specific nonobvious attributes, also increase taxonomic sorting (Deák & Bauer, 1996).

There is also evidence that a shift from thematic to taxonomic relations is not caused only by count noun object labels. Smiley and Brown (1979) and Bauer and Mandler (1989) showed that preschoolers' preference for one or the other relation is influenced by instructions and social reinforcement (see also D'Entrement & Dunham, 1992; Waxman & Namy, 1997). Such findings challenge the idea of a ''default'' thematic preference that is disabled by category labels. Also, some studies have found that 12- to 15-month-olds learn to associate nonword stimuli (musical patterns, sounds made by objects, and gestures), as well as words, with object categories (Namy & Waxman, 1998; Roberts & Jacob, 1991; Woodward & Hoyne, 1999). Appar-

ently it is not until late in the 2nd year that words are specifically associated with taxonomic relations. Available evidence therefore suggests that count nouns do not have *a priori* privilege to draw young children's attention to object categories.

Recently it has been suggested that word learning tendencies are the products of general learning mechanisms. Smith (1999) has demonstrated that the shape bias, a tendency to extend novel count nouns to same-shape artifacts, can be trained and is facilitated by exposure to shape-defined object labels. Thus, preschoolers' inferences about novel object words might be a product of contingency learning rather than innate domain-specific biases. In fact, many behaviors attributed to domain-specific word learning biases could be explained by a general capacity to learn conditional responses [e.g., IF (count noun) THEN ⟨attend to property X⟩ ELSE IF (adjective) THEN ⟨attend to property Y⟩]. Merriman (1999) has also argued that general cognitive processes, particularly competitive activation and selective attention, can account for behaviors attributed to the Mutual Exclusivity bias. Finally, Markman (1992) explores the idea that several proposed word learning constraints rest on general properties of associative learning.

In sum, the concept of domain specificity is vague, and empirically it has received mixed support. We cannot judge whether words are a special stimulus type because we have not defined what counts as ''special.'' We seldom specify the stimulus class that triggers a particular response from an organism, and we do not know whether children are specially prepared to associate words with certain inductive responses or whether such responses result from general contingency learning. Available evidence suggests that inductive responses to words also can be evoked by other stimuli. Thus, while domain specificity is hypothetically testable, so far there is no evidence of a coherent group of inductive biases specifically generated by novel words. Domain specificity therefore is not a criterion that distinguishes a discrete set of word learning constraints.

Summary

The criteria of innateness and domain specificity do not define a circumscribed subset of word learning tendencies. In practice, then, *constraint* is a redescription of behavioral regularities, but one that implies an innate causal locus and limited breadth. The fact that these criteria are not viable does not mean that humans are blank slates, equally receptive to all regularities in the environment. To the contrary, children's thinking is highly structured, and when this structure interacts with a structured environment and structured language input, predictable word learning tendencies emerge. There is no justification, however, for attributing some tendencies to internal, canalized constraints. Recent statements imply that constraints are a viable explanation—or at least partial explanation—for children's word learning.

The most widely studied constraints are cast as causal figures against a contextual ground. This is misleading because there is no mechanism to stand in contrast with constraints. That is, every word learning tendency rests partly on traits that are products of the human genome. Every tendency also depends partly on exposure to patterned stimuli, for example, regular linguistic input. Finally, every tendency depends on a fundamental capacity to learn subtle, contingent regularities in the physical and social environment. That is, whereas unrestricted associative learning cannot account for the adult lexicon, contingency learning can. If children can abstract specific regularities, then contingency learning can account for many inductive responses now attributed to constraints. For example, if children can induce that novel words preceded by an indefinite article (i.e., ''a glix'') tend to refer to objects with the same shape, they will make serviceable inferences about novel count nouns. Of course, this presumes a structured cognitive system predisposed to associate phonological forms (i.e., lexeme) with proximate particles (e.g., indefinite articles), and to notice shapes of objects, and to induce categories of objects in the environment. It also presumes a social organism that is motivated to attend to sounds emitted by adults and to attempt to communicate with adults. What, then, is the principal force in word learning: innate domain-specific mechanisms, or flexible application of a structured cognitive system by a social organism to learn contingent associations in patterned linguistic input? The former concept, *constraint*, is poorly defined, it falsely implies a causal mechanism, and it cannot yield a parsimonious account of the complex contingent responses abundant in word learning. This calls for theory of word learning unburdened by this theoretical albatross.

Alternative Conceptions of Constraints

A possible rebuttal to this conclusion is that although the modal definition of constraints (i.e., word learning tendencies that are innate and domain-specific) is fundamentally flawed, an alternative definition might identify a coherent subset of word learning tendencies. While this is hypothetically possible, few alternatives have been proposed. Some are less precise—for example, Keil (1990) defines constraint as ''any factor intrinsic to a learner that results in a nonrandom selection of the logically possible characterizations of an informational pattern'' (p. 136). That is, constraints are innate but not necessarily domain-specific (see also Markman, 1992). Brown (1990) characterizes constraints as ''predispositions to learn about certain privileged classes of information'' (p. 130), and Gelman (1990) defines them as ''domain-specific organizing structures that direct attention to the data that bear on . . . a particular cognitive domain'' (p. 5). Here, and elsewhere (e.g., Golinkoff et al., 1994; Merriman, 1999), constraints are domain-specific but not necessarily innate. Thus, the literature defines constraints as innate, domain-specific, or both (Maratsos, 1992). Of course, if both in-

nateness and domain specificity are jointly insufficient, either criterion alone will also be insufficient.

Nelson's Criteria

Nelson (1988) argues that constraints should be invariant across situations and individuals. This renders constraints easily falsifiable, but as Behrend (1990) points out, constraints might be probabilistic. This would be adaptive because an invariant bias will sometimes lead children to infer incorrect word meanings. However, Nelson's argument raises a legitimate concern over the difficulty of falsifying a proposed constraint that is both (1) probabilistic in its occurrence and (2) subject to an unspecified number of auxiliary contingencies. Nelson also points out that many studies find only moderate or small effects of hypothesized biases. For example, in Markman and Hutchinson's (1984) strongest demonstration of the taxonomic bias children made 63% taxonomic (versus thematic) choices in the novel-word condition versus 37% in the no-word condition. Nelson suggested that such a modest effect could not have a substantial effect on word learning. It is difficult, though, to make *a priori* pronouncements about optimal effect sizes. A modest bias might push a child toward correct responses in fairly unambiguous situations, but prevent incorrect inferences in highly conflicting situations. What is the optimal power or robustness of an inductive tendency? This is a crucial question, but the answer depends on a careful description of the environment, specifying how often the tendency will cause misleading inferences, and the consequences of such mistakes. Without carefully planned seminaturalistic studies of word learning, and analyses of how often a tendency *should* be invoked, it is difficult to evaluate the role of a weak inductive tendency in lexical development. Perhaps, given the diversity of word meanings children must acquire, a large number of weak tendencies is a better arsenal than a small number of strong tendencies.

Bloom (1997), raising a concern similar to Nelson's, argues that experimental studies of word learning constraints artificially ignore the social and linguistic context of word learning. Bloom fails, however, to construct a convincing argument against laboratory studies (see Mook, 1983). Laboratory studies certainly can reveal inductive tendencies that operate outside of the laboratory, but their ''boundary conditions'' must be established by systematically manipulating contextual variables. Only a combination of careful experimental and seminaturalistic studies can establish an inductive tendency's triggering conditions and robustness. The claim that ''observations of children learning language in everyday contexts . . . are . . . more compelling for guiding both theory and research'' (Bloom, 1997, p. 330) ignores the fact that many naturalistic studies are difficult to interpret. For example, they seldom allow unambiguous separation of simple effects and interactions, and they are not guaranteed to generalize to other naturalistic contexts any better than experimental studies. Thus, although both Nelson

(1988) and Bloom (1997) challenge the impact of hypothesized word learning constraints on children's everyday word learning, neither challenge is convincing. Moreover, the challenges subscribe to the fallacious assumption that it is meaningful to conceptualize constraints or biases as a particular sort of mechanism.

What, then, of Nelson's criterion that a constraint should be observable in all normally developing children? This implies that phenotypic variability can result only from environmental factors. Yet evolutionary theory argues the opposite: heritable, canalized phenotypes *normally* vary within a population (Mayr, 1982). Even if some children do not display an inductive tendency, we cannot conclude that the tendency emerges independently of genotype. After all, we would not argue that genes play no role in social dominance, even though this is a complex phenotype that varies across individuals in a population. Any language trait also varies across children *and* is partially due to genetic factors. Sizeable, moderately stable, and early-emerging individual differences in lexical development (Anglin, 1993; Bates, Dale, & Thal, 1995) are found in relatively homogeneous samples (e.g., middle-class monolingual American children). Because no study has examined word learning in a large, diverse sample of children across different times and contexts, we know little about the interindividual prevalence or intraindividual stability of word learning tendencies. When individual differences are found, it remains to be determined whether they result from variability in the environment (i.e., language input), in individual information processing traits, or in both (Bates et al., 1995; Miller & Klee, 1995; Pine, 1995). Because interindividual variability is itself so difficult to interpret, a compelling rationale is needed to accept variability (or lack thereof) as a defining feature of constraints.

Although there is no convincing rationale for categorizing word learning tendencies on the basis of effect size or variability, Nelson's proposal has the advantage that effect size and variability (i.e., prevalence) are easier to assess than innateness and domain specificity. Moreover, it is terribly important to establish the robustness and variability of any inductive tendency—a point revisited in the final section. The conclusion nonetheless stands that we lack theoretically defensible defining criteria for a coherent set of word learning constraints. This leaves us with no substantive comprehensive explanation for children's word learning tendencies. More precisely, it shows that we have never had one. In part, this is because the complexities of the data make oversimplification almost inevitable. The remainder of this paper outlines the empirical complexities that must be accounted for by any viable theory of word learning.

THE FOX OF WORD LEARNING: A SYNTHETIC REVIEW

Constraints frameworks (e.g., Golinkoff et al., 1994; Markman, 1989) represent a class of theories that Maratsos and Deák (1995) called

''hedgehogs.'' Such theories reduce complex behavioral patterns to a few simple principles. Yet some phenomena, for instance, word learning, are so complex, diverse, and contingency sensitive that they cannot be reduced to axioms without ignoring important systematic variance. These phenomena call for ''fox'' theories, frameworks that attempt to capture complex systems. Although fox theories are not as elegant or memorable as hedgehogs, they account for the variability and diversity of a behavioral system. The importance of accounting for behavioral variance is cogently argued by Siegler (1996).

The following review provides support for the argument that word learning tendencies can only be explained in terms of complex systems of interactive contingencies among properties of the child and of the environment. This review also supports the conclusion of the previous section, that is, we do not understand these interactions well enough to identify subsets of related word learning tendencies. What follows, then, is not a comprehensive review of the word learning literature, but a selective survey of evidence consistent with these arguments.

The first part of the review describes evidence of cognitive and perceptual processes that affect children's inferences about novel word meanings. The second part reviews regularities in physical and social information that are exploited for word learning. These sections together outline a framework of word learning tendencies. The framework is grounded in the child's cognitive structure, the structure of the physical and social environment, and the interaction of the two. The third section focuses on this interaction, showing that complex contingencies between input and inference are the rule rather than the exception in word learning. This in turn supports the argument for more complex, fox-like theories of word learning.

Specification of Cognitive and Perceptual Factors Impacting Word Learning

Macnamara (1972) and Olson (1970), in two seminal papers, argued that children's word learning and usage can be understood only in the context of cognitive skills and conceptual knowledge. In the intervening quarter century there have been many studies of the relations between cognitive factors and semantics, but these seldom directly address theories of word learning. We lack a unified account of how children's cognitive tendencies and limitations affect word learning. Such an account ideally would answer how word learning relies on general perceptual and cognitive processes. However, before we can obtain this answer we must ask the right kinds of questions.

An example illustrates the kinds of questions we must answer about the role of cognitive attributes in word learning. Markman (1992) hypothesized that the M.E. constraint (i.e., tendency to allow only one name for an object) is a manifestation of a general preference for one-to-one representational mappings. In fact, it was once believed that young children lack the ability

to simultaneously represent multiple categories (see Flavell et al., 1986)—one possible representational limitation that would generate M.E. As it happens, this hypothesis appears partly but not wholly correct: Deák and colleagues have shown that preschoolers' bias to restrict multiple names for an entity is partial, and it is evoked only during word learning. First, Deák and Maratsos (1998) showed that 3-year-olds readily apply novel combinations of familiar words to the same referent (e.g., ''crayon'' and ''dinosaur''). Subsequently, Deák, Yen, and Pettit (in preparation) showed that after preschoolers learned a new word for an object, they produced fewer familiar words for it; yet they still produced a mean total of two words per object. Thus, restricting multiple names reflects neither a representational limitation nor a one-to-one bias, but a partial restriction or conservatism when learning a new word–object mapping. This might be a response to cognitive load (see Liittschwager & Markman, 1994) or a reflection of pragmatic biases (Savage & Au, 1996). Intriguing evidence comes from a recent report (Diesendruck & Markson, unpublished) that preschoolers are biased to map only a single fact, as well as a single word, onto a given object. This illustrates the need to assess how cognitive limitations generate word learning tendencies by varying stimuli, task, and learning context.

Information Processing Characteristics

Elman (1993) suggests that limited cognitive capacity might facilitate some aspects of language acquisition. Although Elman did not address word learning, it seems plausible that a limited capacity for forming or maintaining complex representations (of words, referents, and associations) would impact word learning. Young children are believed to have less cognitive capacity than older children and adults (Dempster, 1981; Gathercole & Adams, 1993), although the question ''capacity for what'' is complex and often ambiguous (Chapman, 1987). If capacity refers to short-term memory span, there is some empirical evidence of an effect on word learning. Gathercole, Willis, Emslie, and Baddeley (1992) reported cross-lagged correlations among phonological STS (Baddeley, 1986), vocabulary, and nonverbal intelligence in a longitudinal sample of 4- to 8-year-olds. With other factors controlled, phonological span (assessed by nonword repetition) at age 4 accounted for 18% of the variance in receptive vocabulary at age 5; the converse correlation was lower and not significant. More recently, Gathercole, Hitch, Service, and Martin (1997) found moderate correlations between individual children's phonological span and novel word learning. Thus, there is a relation between word learning and phonological STS. However, Deák and Maratsos (1998) found no clear evidence that capacity for complex conceptual representations is limited in 3- to 5-year-olds.

To map word meanings correctly, children must attend to and encode relevant information about possible referents. With respect to objects and their

properties, there is evidence that preschoolers attend to and encode stimulus properties differently than older children. For example, in perceptual sorting tasks preschoolers often treat separable stimulus dimensions (e.g., hue and shape) as integral (Garner, 1983; Lane & Pearson, 1982). For this reason Smith (1989) argued that children are incapable of selective attention prior to about age five. Merriman (1999), however, argues that early word learning depends on limited-capacity selective attention to stimulus dimensions. In fact, children often generalize words according to a single complex dimension (e.g., shape) of multidimensional objects (Deák, in press; Landau et al., 1988; Smith et al., 1996). For example, novel count nouns are often generalized only to same-shape objects, not same-size or same-material ones (Landau et al., 1988). Does this indicate that selective attention is more readily available to young children in word learning than in other tasks (e.g., perceptual sorting)? It has been suggested that category names have a special capacity to direct children's attention to abstract taxonomic classes of objects (Waxman & Markow, 1995). As noted above, though, evidence does not indicate that a specific lexical attentive mechanism is needed (e.g., Deák & Bauer, 1995). Deák and Bauer (1996), for example, compelled children to focus on nonobvious taxonomic groupings by asking specific questions about unnamed stimuli. For example, children who were told that a shell-shaped soap ''is made from lye'' generalized that property to a rectangular bar of soap, not a porcelain shell. Apparently, the phrase ''made of'' compelled children to focus on perceptible attributes (e.g., reflectance; texture; hardness) that indicate a shared, complex attribute (i.e., material). That is, the child's understanding of the question or problem—not the addition of a category name—compelled children to focus on a nonobvious category (see also Deák et al., 1999; McCarrell & Callanan, 1995).

These results suggest that preschoolers can selectively attend to complex, meaningful features of objects, in word learning or other tasks, whether or not they can selectively attend to less meaningful, simpler dimensions in perceptual sorting tasks. In sum, available evidence suggests that preschoolers can selectively attend to complex, meaningful stimulus attributes to make inductive inferences, including but not limited to inferences about word meanings. These inferences are guided by a variety of contextual factors that impact children's understanding of the problem at hand. These contextual factors include novel words, instructions, modeling, social reinforcement, predicate cues, and other factors.

Category Structure

Most words refer to categories: kinds of objects, concepts, events, actions, transformations, or relations. Certain object and event categories (e.g., ''bottle,'' ''bye-bye'') tend to emerge among children's first words (Barrett, 1995). Others words are underrepresented even in older children' lexicons.

There are many possible reasons children learn some words and not others (e.g., frequency; relevance to the child's goals; interest; see Bloom, 1997). Among these is the possibility that some categories are difficult to learn because they are abstract or semantically complex. Even adults more readily learn simple than complex categories (Medin, Wattenmaker, & Hampson, 1987). However, because young children do learn some abstract words and low-frequency words for specific categories (Beals & Tabors, 1995), it is unclear how abstractness and complexity impact word learning. Some of children's first words (e.g., ''bye-bye''; ''allgone''), for example, label very abstract concepts. Regardless, word learning might be limited by the familiarity, abstractness, or complexity of underlying concepts.

This issue has been addressed in a debate about whether a concept's abstractness affects how easily its name is learned. Rosch (1978) found that some tasks show a cognitive advantage for categories of an intermediate level of abstraction, the *basic-level.* For example, the category label *car* is more often used, quickly verified, and easily identified than the superordinate *vehicle* or the subordinate *sedan.* This suggests that children should learn basic-level categories more easily than more abstract categories, and early evidence supported this hypothesis (Mervis & Crisafi, 1982; Mervis & Pani, 1980). For example, young children know far more basic-level than sub- and superordinate category labels (Anglin, 1977; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). This implies a cognitive advantage in learning basic-level words. Mandler, Bauer, and McDonough (1991) and Mandler and McDonough (1998), however, showed that infants recognize differences between more abstract categories (e.g., animal vs. vehicle) before they recognize basic-level distinctions (e.g., dogs vs. rabbits). Similarly, toddlers' first words are sometimes more inclusive than the adult basic-level term (Mervis, 1987). Also, preschoolers do not always map novel words onto basic-level categories (Callanan, Repp, McCarthy, & Latzke, 1994). Thus, it seems that by the time children know many object labels, they know some basic-level as well as sub- and superordinate categories. Why, then, are basic-level words overrepresented in early lexicons?

Certainly part of the answer is that adults typically use basic-level words to name objects for children (Blewitt, 1983; Wales et al., 1983). There are exceptions, of course: for example, White (1982) found that adults tend to use basic-level words (e.g., ''bird'') for typical category members (e.g., robins, sparrows), but subordinates (e.g., ''ostrich,'' ''penguin'') for atypical members (see also Adams & Bullock, 1986). This reveals an interaction between category abstractness and typicality in children's lexical input. White (1982) found that this affects word learning: 5-year-olds tend to interpret a novel word as basic-level unless exemplars are atypical, in which case children interpret it as a subordinate.

In addition, there might be a conceptual advantage of basic-level concepts: Wales et al. (1983) found that parents use 45% basic level, 30% subordinate,

and 25% superordinate words to name pictures of common items for their 2- and 4-year-olds. In response, 2- and 4-year-olds produce, respectively, 98 and 83% basic level words. Thus, preschoolers ''overregularize'' the basic-level advantage. Perhaps children are more sensitive than adults to the cognitive propensities that generate the basic-level advantage. For example, a greater relative gain in intra- versus intercategory coherence is realized when moving from the superordinate to the basic-level than from the basic- to the subordinate level. Moreover, basic-level words preserve the maximum *necessary* specificity in most conversational contexts (Brown, 1958a). Superordinate words, in contrast, are vague, and subordinates provide unnecessary information, often with longer locutions (e.g., compound nouns) that might be harder to produce. Unnecessary use of super- and subordinates might confuse listeners, who expect speakers to obey maxims of informativeness and economy (Grice, 1975). Basic-level naming adheres to an unwritten agreement to respect cognitive economy, and children willingly enter this contract. The basic-level tendency also ''anchors'' more elaborate word learning. Parents systematically teach older preschoolers sub- and superordinate category names, using basic-level words in specific formulas to contextualize the new words (e.g., ''A penguin is a funny kind of bird''; Adams & Bullock, 1986; Callanan, 1985, 1990).

Besides category abstractness and typicality, word learning is impacted by familiarity or exposure to a category. Merriman et al. (1995) found that preschoolers tend to map novel words onto unnamed object types, even when familiarized with tokens of that type. Thus, children encode *category* novelty per se and use it to select referents of novel words.

Recently some researchers have suggested that children generalize labels differently for referents of different ontological classes. Jones et al. (1991) found that preschoolers generalize novel words for artifacts according to shape and novel words for animal-like objects (i.e., stimuli with ''googly eyes'') according to shape *and* texture. Thus, the tendency to focus on certain attributes (e.g., shape) is contingent on ontological kind. The finding was equivocal, however: children showed the same effect when the eyes were replaced by small ducks. A more compelling finding is that children generalize novel words to organisms with different shapes if those shapes can be interpreted as different postures of the same ''species'' (Becker & Ward, 1991). Other studies (e.g., Dickinson, 1989; McPherson, 1991) have shown that children tend to map novel mass nouns onto substances and novel count nouns onto countable objects. Such findings indicate that children use a distinction between the ontological classes ''creatures,'' ''things,'' and ''stuff'' to guide their inferences about the likely referents of novel words. Similarly, children distinguish between kinds of things, their attributes, and their locations when making inferences about novel nouns, adjectives, and prepositions (Landau & Stecker, 1990; Smith et al., 1992).

How does young children's sensitivity to conceptual and perceptual struc-

ture influence word learning? This is a complex issue, in part because conceptual structure cannot be directly inferred from word use. At one time it was thought that early naming errors, especially over- and underextension, reflected immature conceptual structures. For example Clark (1973), noting that toddlers overextend ''ball'' to a round candle, argued that perceptible categories (e.g., spherical things) define children's first undifferentiated object categories. (However, this does not explain children's first verbs; Behrend, 1995; Maratsos & Deák, 1995). This would suggest that young children, who might not make fine perceptual distinctions (Gibson & Gibson, 1955), overextend words because they do not differentiate similar looking subclasses. In this vein, Mervis (1987) found that infants' ''basic-level'' categories are often broader than adults' (e.g., ''kitty-cat'' encompasses lions and leopards). There are three caveats to this generalization, though. First, it is now clear that naming errors stem from pragmatic convenience as well as category errors (e.g., Rescorla, 1980; Thompson & Chapman, 1977). For example, if a child does not know the word *cracker,* the utterance ''want cookie'' will likely serve effectively. Second, we cannot assume that overextensions are more common than underextensions, because the former are more easily detected. Third, even 3-month-olds can perceptually discriminate similar looking classes (e.g., horse vs. zebra; Eimas & Quinn, 1994). In spite of these caveats, infants and toddlers probably invest less effort in mapping separate words onto subtly different subcategories, unless they receive specific input to do so. Ultimately, learning the subtle distinction between cognate categories like *Honda Accord* and *Toyota Camry* will be less useful for toddlers than learning to distinguish, and label, more distant cousins like *car* and *bus.*[7]

Category complexity has also been hypothesized to affect children's word learning. Gentner (1982) observed that many of children's first words are object names and proper names, and relatively fewer are words for actions and relations. She argued that concrete nouns are conceptually simpler, or less complex, than relational words (e.g., verbs). This issue is contentious (see Au, Dapretto, & Song, 1994; Gopnik & Choi, 1995; Maratsos, 1991; Tardif, Shatz, & Naigles, 1997), and it is not clear that complexity accounts for the greater prevalence of object names than verbs in young children's lexicon. It is difficult to resolve this question because it is difficult to quantify complexity, and because children sometimes learn only partial word meanings, which reduces complexity, yet they appear to use the word correctly.

Finally, children learn words for some concepts more easily than others

[7] There is another way physical similarity might affect word learning. Failure to discriminate phonemes (e.g, Garnica, 1973; Velleman, 1988) might prevent children from learning new words that sound like known words. However, because most semantically related words differ by several phonemes (Barton, 1980; Gerken, Murphy, & Aslin, 1995), it seems unlikely that phonetic similarity has a pervasive effect on word learning (but see Charles-Luce & Luce, 1990; Merriman & Schuster, 1991).

for reasons that remain unexplained. For example, although 3-year-olds can recognize, discriminate, and match focal colors, they have significantly more difficulty learning color–word associations than shape–word associations (Bornstein, 1985).

Conceptual Knowledge

In addition to category boundaries, children's within-category conceptual knowledge influences word learning. Intuition suggests that the completeness and correctness of a child's word meaning must be limited by the completeness and correctness of the underlying concept. This limitation might not be reflected in children's word use, because using a word might not depend on having a well-formed underlying concept. For example, some infants first use disappearance words (i.e., ''allgone'') before they first pass object permanence tests (Corrigan, 1978; Gopnik & Meltzoff, 1986, 1987). This might be due to limitations of object permanence tests, but it also might indicate that children are willing to use words despite having only partial knowledge of the meanings. These data raise difficult questions about what it means to ''know'' a concept and whether conceptual knowledge is ever independent of its expression.

Lexical growth is linked to conceptual development, and this is most clearly seen in the novice-to-expert shift. (For validation, listen to a conversation between experts in an unfamiliar field.) Chi and colleagues (e.g., Chi, Hutchinson, & Robin, 1989; Chi & Koeske, 1983) actually identified child dinosaur experts according to productive vocabulary of dinosaur names, reflecting the common use of lexical richness as an index of domain knowledge. ''Expert'' children (vocabulary-defined) had more extensive factual knowledge and made more sophisticated inferences about novel dinosaurs. Thus, expertise correlates with vocabulary as well as depth and breadth of semantic knowledge. Relatively little is known, however, about the relation between conceptual development, word learning, and intelligence. Johnson and Mervis (1994) found that individual children's extent of learning about shorebirds was correlated with receptive vocabulary (PPVT). This raises the question: does conceptual development depend on word learning or vice versa?

Related questions concern deficits of conceptual knowledge and word learning. Autistic children's understanding of social and mental phenomena is impaired compared to mental age-matched nonautistic children (Baron-Cohen, Tager-Flusberg, & Cohen, 1993). Normal use of personal pronouns requires basic understanding of intersubjectivity, which relies on some basic social distinctions. Personal pronouns are subject to both reversal errors (e.g., calling myself ''you'' instead of ''me'') and case errors (e.g., *''Me love you.''). Normally developing children, children with autism, and children with Down's Syndrome all make some case errors (Budwig, 1995). However, children with autism make many reversal errors compared to nonautis-

tic children of the same mental age (Tager-Flusberg, 1994). By comparison, autistic children's knowledge of basic-level and superordinate category labels is similar to mental age-matched children with Down's Syndrome (Tager-Flusberg, 1985), so pronoun reversals seem to reflect a limited conceptual deficit. Lee, Hobson, and Chiat (1994) found that autistic children with a Verbal Age (VA) of 4 make reversal errors, whereas those with VA of six do not. Because normal 4-year-olds have mastered personal pronouns (Budwig, 1995), this suggests that autistic children's mastery of the pronoun system is delayed, not prevented, by social knowledge deficits.

Such examples show the interdependence of conceptual knowledge and lexical development. Some outstanding questions are whether conceptual and lexical growth rely on different inductive mechanisms, and the extent to which conceptual growth compels word learning, versus the extent to which word learning compels conceptual growth.

Reflections on cognitive variables and word learning. Clearly children's cognitive abilities and knowledge interact extensively with word learning. We are far from understanding precisely how perceptual sensitivity, cognitive skills and limitations, and conceptual knowledge determine children's learning or failure to learn specific words. One limitation is that many of our results are correlational, involving variables (e.g., phonological span) that estimate a hypothetical underlying capacity. Such data are grist for the theoretical mill, but they do not elucidate how these capacities facilitate or limit word learning. Other problems plague studies of conceptual knowledge and acquisition of specific words (e.g., ''allgone'')—for example, reliance on single measures of multifaceted concepts (e.g., object permanence) and failure to separate word comprehension from word use. Finally, whereas category structure (e.g., abstractness; typicality) almost certainly impacts word learning, this has not been evaluated experimentally, and naturalistic data are uninformative because the input (i.e., exposure to more vs. less abstract words) is uncontrolled.

Despite these difficulties, this review suggests diverse effects of children's cognitive processes and conceptual knowledge on word learning. There is evidence that word learning is guided by general learning mechanisms sensitive to repetition and frequency (e.g., Nelson & Bonvillian, 1973; Huttenlocher et al., 1991; Smith, 1999). Is there also evidence of language-specific mechanisms? Although we cannot assume that all word learning is due to general cognitive processes, there is little compelling direct evidence of language-specific processes. In the interest of parsimony, it is judicious to consider general mechanisms first, even if ultimately some combination of general cognitive and specific word learning mechanisms is needed to explain word learning.

Environmental Structure Supporting Word Learning

Children's information processing propensities can only guide word learning in the context of regular patterns of information in the environment. This

section reviews the types of ecological structures that children learn and utilize to support inferences about word meaning. These include regularities in the linguistic, social, and physical environment.

Linguistic Regularities

Preschool children learn to attend to a wide range of predictable linguistic cues that reduce the range of possible meanings of a novel word. Children are sensitive to phonological/prosodic, syntactic, semantic, and pragmatic regularities.

Phonological and prosodic regularities. These help children parse word boundaries and determine a word's form class, both of which are prerequisites for learning word meanings. Within the extensive literature on early phonological processing (see Morgan & Demuth, 1996), a few findings stand out. First, infants are capable of ''statistical learning'' (Saffran, Aslin, & Newport, 1996), which permits them to segment words. The impact of word segmentation on word learning is implied by Plunkett's (1993) report that of two Danish infants, the mother of the infant who learned fewer words had less precise articulation. Apparently articulatory clarity impacts word segmentation and thereby word learning.

Prosodic structure also appears to help children parse and learn novel words. Fernald and Mazzie (1991) found that parents prosodically emphasize new words in *infant-directed speech* (IDS), a speech mode typified by higher mean pitch frequency, wider frequency range, and pitch contours that vary with the nature of the message (Cooper, 1997; Fernald, 1993; Fernald et al., 1989; Fernald & Simon, 1984). Prosodic emphasis might facilitate word learning. Babies prefer to listen to IDS by the same age (4 months) at which they discriminate familiar words (e.g., their own name) from stress-matched foils (Mandel, Jusczyk, & Pisoni, 1995). IDS is tailored to draw infants' attention and ultimately help them learn the sound patterns of familiar words, setting the stage for acquisition of word meanings.

Children might also avoid using, and perhaps analyzing, hard-to-pronounce words (Schwartz & Leonard, 1982). Children's first words are mostly easy to pronounce (Leonard, Schwartz, Morris, & Chapman, 1981) and this may be partly because languages assign easy-to-pronounce words to concepts relevant to infants. We cannot currently draw strong conclusions about the effects of pronounceability on word learning (partly because available data do not address children's *comprehension* of hard-to-pronounce words), but a viable hypothesis is that some or all children are less likely to try to infer the meanings of hard-to-pronounce words.

Syntactic regularities. Children attend to information about a novel word's grammatical category. These syntactic cues permit gross inferences about a word's meaning. For example, the quantifier ''some'' in ''Give me some *gloop*'' implies a substance or ''stuff'' (Brown, 1957). Gleitman (1990) argues that syntactic cues powerfully guide children's inferences about possible word meanings. For example, English verbs that take a sentence comple-

ment (e.g., ''Mary *knew* [the others would arrive soon]'') typically are mental verbs. In contrast, verbs that take a direct and oblique object (e.g., ''John *took* [his son to rehearsal]'') typically are verbs of transfer, and verbs that take either a complement or two objects typically are verbs of communication (e.g., ''Susan *explained* [how to build a campfire]''; ''Mike *distributed* [the memo to the committee]''). English speakers are sensitive to these patterns (Fisher, Gleitman, & Gleitman, 1991), and even 24-month-olds distinguish transitive versus intransitive structure when learning novel verbs (Naigles, 1990). The power of ''syntactic bootstrapping'' is unknown, though. Maratsos and Deák (1995) argue that syntax could not reliably help children precisely narrow down verb meanings. However, syntactic cues probably help children to infer a grammatical class that is correlated with certain meanings or referents (e.g., object kinds, attributes, or actions). This, combined with other cues (e.g., semantics, see below), can powerfully guide children's inferences.

Semantic regularities. Children's inferences about word meanings are informed by the meaning of constituents (i.e., words and phrases) proximal to a novel word. Some constituents are specific phrases or formulas. For example, Carey and Bartlett (Carey, 1978) asked children to retrieve a tray, ''. . . not the red one, the chromium one.'' Children often chose the nonred tray, presumably because of the implied contrast between novel and familiar color words. Au and Markman (1987) later showed a better controlled albeit small contrast effect. Others (e.g., Callanan, 1989; Gottfried & Tonks, 1996) have shown that children use inclusion statements (e.g., ''A(n) [*X*] is a kind of [*Y*]'') to infer the meaning of *X*. Adults may provide other, diverse semantic cues to a word's meaning (see, e.g., Banigan & Mervis, 1988; Callanan, 1990; DeBaryshe & Whitehurst, 1986). Although at one time it was believed that young children could not use semantic context to infer word meaning, it is now clear that even 2- and 3-year-olds can utilize semantic cues (Deák, in press; Goodman, McDonough, & Brown, 1998). Nonetheless, as children get older and their verbal comprehension increases, they can use more abstract and complex contextual semantic cues to infer novel word meanings (Keil, 1979; Werner & Kaplan, 1952).

Integrating Semantic and Syntactic Context: Predicate Cues. A novel word's semantic and syntactic ''surroundings'' constitute its local *predicate context.* For example, in the utterance, ''We drank some steaming *toddy,*'' the predicate context includes both syntactic cues (e.g., ''some,'' specifying a mass noun) and semantic cues (e.g., ''drank,'' implying a potable) which together powerfully limit the meaning of ''toddy.'' Note, though, that predicate (i.e., semantic + syntactic) context is highly variable, changing regularly across utterances. Children therefore require flexible inductive mechanisms to adapt to changing predicate cues. Yet 3-year-olds often perseverate when making inferences to answer successive questions about a stimulus array (e.g., Flavell et al., 1986). Indeed, preschoolers tend to perseverate

across even simple, obvious changes in inference tasks (Zelazo, Frye, & Rapus, 1996). This suggests that preschoolers might not flexibly adapt inferences about successive word meanings to different predicate cues. Because young children sometimes hear several unfamiliar words within brief periods, inflexibility might impact word learning. Deák (in press) tested 3- to 6-year-olds' ability to infer different meanings in response to changing predicate cues. Children generalized several novel words for the same objects. Each word was preceded by one of three predicates: ''is made of,'' ''has a,'' or ''looks like a.'' Depending on the predicate used, children should generalize each word to another object with the same material, the same part, or the same body shape as the original object. Although 3-year-olds made more predicate-appropriate inferences than expected, flexibility increased significantly between 3 and 6 years. Some preschoolers, instead of responding flexibly, perseverated, making the same inference about every word regardless of predicate context. Although we have not conclusively established the reasons for children's perseveration, we have some evidence. For example, 3-year-olds respond to predicate cues more often when there is a longer delay between successive words for an object. This suggests that preschoolers have difficulty inhibiting recent inferences for word learning. Other evidence suggests that when children are overconfident in their first inference, they perseverate that response. This suggests that failure to recognize the indeterminacy of each novel word negatively impacts word learning. In spite of these difficulties, it is clear that children 3 years or younger sometimes use predicate cues to infer meaning. In fact, it might be that when making inferences about single words (as opposed to series of words), predicate cues constitute the principle sources of information about meaning.

Pragmatic regularities. Children are sensitive to diverse, complex pragmatic regularities in adults' speech (see Ninio & Snow, 1996), and they rely on these regularities to guide inferences about word meanings. For example, speakers tend to name new rather than old or ''given'' topics. Parents manifest this tendency: when reading to toddlers, they pose questions about new rather than given topics (Fernald & Mazzie, 1991). Children learn to expect this: 2-year-olds map a novel word onto an object that is new to a speaker rather than an object that is familiar (Akhtar, Carpenter, & Tomasello, 1996).

Children also use signs of a speaker's attention to interpret novel words. By 12 months of age infants follow an adults' gaze (Butterworth & Jarrett, 1991; Deák, Flom, & Pick, submitted for review; Scaife & Bruner, 1975), a sign of the adult's focus of attention. Whether infants make mentalistic interpretations of gaze, evidence suggests that infants monitor other people's gaze and use the information for word learning. First, Baldwin (1993, 1995) showed that older infants map a novel word onto an object the speaker was looking at, not one the infant was looking at. Infants presumably expect speakers to refer to the object of their attention. Second, joint attention

emerges several months before children begin speaking, and both joint attention and language are impaired in autistic children (Sigman & Kasari, 1995). Finally, individual children's vocabulary is correlated with amount of time spent in joint attention with a caregiver (Tomasello & Farrar, 1986; Tomasello & Todd, 1983). It seems that infants use speakers' gaze to interpret acts of reference.

Recent evidence also suggests that toddlers' inferences about speakers' mental states impact word learning. For example, if an adult acts surprised while naming one of several unseen objects, 2-year-olds map the word onto an object the adult did not see previously (Akhtar et al., 1996). Similarly, children map novel verbs onto intentional but not accidental actions (Tomasello & Barton, 1994). Apparently preschoolers use information about a speaker's knowledge, affect, and attention to infer novel word meanings.

Just as children integrate syntactic and semantic (i.e., predicate) cues to infer novel word meanings, they rely on semantic information presented in particular pragmatic contexts. Chapman, Leonard, and Mervis (1986) found that parents respond to child's inappropriate labels (e.g., calling a lion ''kitty'') by providing the correct name and defining features (e.g., ''That's a lion. See? It has a furry mane and big teeth!''). Feedback that provides semantic information might play a substantial role in lexical development. Adults extensively structure their use of unfamiliar words when speaking to children (Ninio & Snow, 1996), and children benefit from this structure. For example, Fernald and Mazzie (1991) note that parents' questions place novel words in sentence-final position, making the words more salient or memorable (Aslin, 1992; Golinkoff & Alioto, 1995). In conversation, parents repeat utterances when children fail to respond correctly (Newport, Gleitman, & Gleitman 1977), increasing children's opportunity to acquire novel words. Thus, parents structure conversations to help their children encode and learn new words. Conversely, infants are prepared to learn complex social–linguistic contingencies and more generally to acquire a shared system of coordinated, reciprocal social exchange.

Social Regularities

The range of nonverbal social variables that impact word learning is probably quite broad, although (research on pragmatic knowledge aside) there is little compelling research on social variables. It is important to distinguish social variables that contribute to individual differences in word learning from those that are fairly consistent across normally developing children. It is also important to realize that associations between social patterns or variables and word learning invariably raise questions about the perceptual and cognitive variables that mediate these associations. The findings reviewed below therefore speak to the cognitive concomitants of word meanings as loudly as they speak to the social nature of word learning.

Caregiver and family characteristics. The effect of social characteristics of caregivers on lexical development has received some attention over the past several decades. Nelson (1973) found that parental education modestly predicts children's word learning ''style'' (i.e., whether a child learns proportionately single words or unanalyzed phrasal formulas). The effect is probably mediated by the amount of maternal speech heard, which predicts children's vocabulary (Huttenlocher et al., 1991). Vocabulary is also correlated with exposure to print material (Cunningham & Stanovich, 1991), which is likely related to parents' education. In general, though, the effects of family demographics on vocabulary are quite small (Fenson et al., 1994). Also, most caregiver effects are hard to interpret because they are correlational. For example, associations between parent characteristics and children's lexical growth are confounded with both speech exposure and heritable cognitive traits. It is unknown how these affect word learning.

Child characteristics. The social interactions that impact language exposure are also contingent on child characteristics such as gender. Reese and Fivush (1993) found that parents talk longer and more elaborately with daughters than sons about past events. Dunn, Bretherton, and Munn (1987) found that mothers talk more about internal states (including emotion and mental words) to girls, who in turn talk more about emotions to others. These findings suggest that gender differences in vocabulary may be attributed partly to exposure to certain classes of words (e.g., mental and emotion state words). These gender differences in exposure reflect adult interlocutors' gender stereotypes and contribute to gender socialization.

Values. Some effects of the social environment on children's word learning are the result of cultural values. Goodnow (1990) describes how the internalization of social values impacts the development of cognitive products such as drawings. Children are socialized to value not only different aspects of graphic art, but also different aspects of overt language. Across social groups, verbose exposition, storytelling, concise argumentation, a copious vocabulary, and witty repartee are differently valued and rewarded (Hymes, 1974, Chap. 1; Schieffelin & Ochs, 1986). This likely affects children's cognitive investment in word learning versus other aspects of language growth. For example, toddlers whose caregivers expend time and effort naming objects, reading books, etc. might learn that knowing names for things is highly valued and allocate cognitive resources accordingly. Later, adolescents who have been socialized to strive to attend a competitive college might work to develop strategies for learning low-frequency vocabulary words. Such motivational forces probably account for some of the large individual differences in adolescents' vocabulary size (Anglin, 1993). Here, again, the effect is confounded with exposure to words, and there are likely interactions among motivation, cognitive factors, and environmental resources.

Affiliative propensity. Overarching other social influences on word learning is a general prerequisite of language learning, an *affiliative propensity.* Normally developing children are intrinsically motivated to engage in reciprocal interactions with adults (Locke, 1993, Chap. 8). For example, infants point out interesting events or objects to adults (Franco & Butterworth, 1996) and follow adults' gaze and pointing. Toddlers and preschoolers are motivated to tell others about their internal states, desires, and beliefs, and they monitor similar information from others. This propensity impels infants to perpetuate dyadic interactions that confer no obvious survival or material benefit. These interactions include face-to-face turn-taking games and routines, or ''formats'' (Bruner, 1982). In older children and adults the propensity is manifested in prolonged conversations with no apparent purpose except maintaining or reinforcing affiliative social bonds. Some, though by no means all, word learning occurs during these affiliative exchanges (see Ninio & Snow, 1996, for review). For example, the author's 7-year-old son often asks the meanings of unfamiliar words uttered by his parents. This reveals his motivation to understand and be understood by others, a key feature of the affiliative propensity. Mutual understanding requires a shared lexicon, and the affiliative propensity motivates the partner with a smaller lexicon to learn words used by the more knowledgeable partner.

Other byproducts of the affiliative propensity are less apparent. For example, children learn words from overhearing, a fact often overlooked by language researchers. The few available experimental studies show that children learn words through overhearing or ''eavesdropping'' (Akhtar, Jipson, & Callanan, 1998; Oshima-Takane, 1988), and anecdotal reports suggest that children can achieve considerable receptive competence in a second language largely by overhearing adults (Akhtar, personal communication). The prevalence of overheard speech raises many intriguing questions about language learning (e.g., Dunn & Shatz, 1989), one of which is: Why would an infant attend to incoherent strings of sounds from adults' (or children's) mouths? The infant would not begin with insight that these sounds are meaningful. Part of the answer is that normally developing infants are disposed to attend to others' social behaviors, to encode and sometimes imitate those behaviors, and to interject themselves into social interactions through babbling, vocalizing, motor activity, and facial expressions (see Adamson, 1995, for review). Thus, the motivation to eavesdrop reveals a key motivational engine of word learning and language development.

Physical Regularities

Aspects of the physical stimulus array influence children's word learning. Although there is considerable research on the effects of stimulus variables on children's attention, induction, and categorization, we know little about the direct or indirect effect of stimulus structure on word learning. Moreover, these effects probably differ considerably depending on a novel word's syn-

tactic and semantic class. Nevertheless, there is evidence that some general stimulus variables, such as salience and novelty, impact word learning.

Salience. Some objects and events in the stimulus array, and some attributes of objects and events, are more interesting or attention-getting than others. Although salience is vaguely defined, it seems to affect children's inferences about word meanings. Examples of overextension, for instance, suggest that toddlers generalize object names according to salient physical attributes. However, overextended attributes are idiosyncratic (e.g., one child generalized ''moon'' to round things but ''snow'' to white things; Bowerman, 1976), making it difficult to predict how and when salience will affect word learning. Also, it is extremely difficult to assess salience independently of other variables, because salience is inherently sensitive to context and task differences.

One line of inquiry acknowledges this context specificity by detailing how attribute salience is dependent on a novel word's syntactic class. Smith et al. (1992) found that 36-month-olds generalized a novel count noun to same-shape objects, even if objects were painted with glitter to emphasize their color. In this condition, however, children generalized a novel adjective to same-color objects. Recent data suggest a more complex system. The count noun shape bias is moderated by variables including ontological kind (i.e., artifact, animal or substance; Jones et al., 1991; Soja, Carey, & Spelke, 1991), shape complexity (Imai & Gentner, 1997), and matching parts (Deák, in press; Smith et al., 1996). These qualifications invalidate a simple contingency model such as: IF [count noun] THEN ⟨attend to SHAPE⟩. Instead, an accurate model would look like: IF [count noun] AND [artifact] AND [simple shape] AND [all parts match OR main body is large relative to mismatching parts] THEN ⟨attend to SHAPE⟩ ELSE IF [count noun] AND [animal] AND . . . THEN ⟨attend to SHAPE and TEXTURE⟩. . . . ELSE IF [adjective] AND [artifact] AND [illuminated or shiny surface] THEN ⟨attend to COLOR⟩, etc. Although researchers have investigated only a few such contingencies, further research could flesh out an elaborate set of contingencies that could be described as decision trees. These trees, when complete, would be quite deep and wide, with many levels and branches at each level. This revisits the problem of constraints approaches: To guide the child's inductive search of a decision tree, one constraint is necessary at each branching point. Given the number of branches necessary to include all syntactic and semantic word classes, an unwieldly host of constraints would be required.

Stimulus novelty. Novelty also affects how children interpret novel words. Merriman et al. (1995) hypothesize that children implicitly monitor the novelty of words and potential referents, and are predisposed to map words onto referents of similar novelty. The role of novelty is, however, fairly complex. For example, there are separate effects of type and token novelty (Merriman & Bowman, 1989) which change with the child's age. The fact that type novelty has an independent effect (i.e., preschoolers extend novel words

to unnamed *types* even if tokens are familiar) suggests that children somehow infer or extrapolate the novelty of an unseen category from as few as one exemplar. This shows children's readiness to infer a hypothetical object kind. A general-purpose, undifferentiated associative mechanism could not achieve this because an infinite range of categories can be inferred from a single exemplar (Goodman, 1983). Thus, data on novelty matching indirectly show preschoolers' preparedness to induce categories as referents of words.

Reflections on Information Regularities

The evidence reviewed here shows that young children exploit a wide range of regularities, including structured linguistic, social, and physical information, for word learning. The findings reveal parallel internal factors that determine which regularities the child will notice and utilize. These include cognitive and learning abilities, conceptual knowledge, and social motivations. As children induce regularities, they generate networks of contingent associations that can be modeled as complex contingency trees.

A critical question is whether the induction of contingency trees is caused by designated word learning mechanisms or by a more general learning process. I suspect the latter, for complex contingencies also can be seen in a host of other psychological phenomena, ranging from preverbal infants' responses to caregivers, to preschoolers' social structures, and to adults' visual target finding, word retrieval, and category induction. Note, though, that the ubiquity of complex contingencies in primate behavior does not preclude specialized word learning mechanisms. There remains a question of how and why children attend to and learn certain words. Infants and toddlers are exposed to a wide range of activities, routines, events, and social exchanges; locations and spatial relations; and substances, objects, and organisms with a diverse array of nameable attributes. Infants do not equally readily learn words for all of these possible referents.

For example, most infants know the word ''peekaboo'' before their first birthday (all examples are taken from Fenson et al., 1994, Appendix B). Yet it is not until 8 months later, on average, that most infants know the word ''lunch.'' To explain this we might hypothesize that the concept ''lunch'' is not relevant to infants who are fed on demand, whereas ''peekaboo'' denotes a pleasurable social exchange. Also, the word ''peekaboo'' is reliably, repeatedly uttered by adults while playing the game, whereas ''lunch'' probably is not reliably, repeatedly uttered by adults when feeding infants. Thus, there are plausible hypotheses for this discrepancy in age of learning. But consider another example: most infants know ''peekaboo'' months before they know the word ''diaper.'' This is not, presumably, because adults play peekaboo more often than they change infants' diapers. Also, parents probably say ''diaper'' while changing said object, and infants should be motivated to learn the word because it is reinforcing to have a dirty diaper changed. Clearly it is harder to posit a simple, compelling account for this

discrepancy on the basis of frequency, reinforcement, or relevance. Even if some other speculative explanation can be spun, it will not apply to a third example: most infants know ''kitty'' several months before they know ''puppy'' or ''squirrel.'' Probably infants encounter dogs and squirrels, and hear them named, at least as often as they hear ''kitty.'' Also, cats, dogs, and squirrels are probably equally interesting to infants, so there is no compelling explanation for this discrepancy. Though the validity of these examples might be questioned because they are derived from maternal reports (see Tomasello & Mervis, 1994; Yoder, Warren, & Biggar, 1997), the point is that general accounts of why children learn some words before others have a sheen of *post hoc* convenience. Why, for example, does social information (e.g., adult's gaze) sometimes override what the infant is interested in (Baldwin, 1993)? Why do semantic cues about a novel word's meaning sometimes override previous inferences about the same object (Deák, 1995)? Why, when learning action verbs, are toddlers less sensitive to variability of the instrument than variability of the action (Behrend, 1995)?

The point is that although perceptual, cognitive, social, and motivational forces can account for much of word learning, it is not clear that they can explain the vagaries of learning or failing to learn specific words, or learning some words more readily than others, without introducing torturous *post hoc* contortions. ''Explanations'' that refer to frequency and relevance (Bloom, 1997) merely beg the question and ignore complex empirical patterns. For example, Hughes-Wagner and Deák (in preparation) tried to teach preschoolers four novel words for clay creatures. The stimuli and training activities were designed to be interesting to children. The experimenter said each word 28 times in clear ostensive contexts, called children's attention to relevant features, and pointed out differences between the named categories. Children were encouraged to name exemplars and they received feedback. Nonetheless, immediate posttest showed that 4- and 5-year-olds learned, on average, fewer than two of the four words. More notably, detailed post tests revealed that even for those words that preschoolers had ''learned'' (i.e., produced), they seldom induced stable meanings, and when they did, the meanings were idiosyncratic and at odds with the evidence given in training! This evidence suggests that although children sometimes correctly infer word meanings (or partial meanings) from a single exposure (i.e., fast mapping, Carey, 1978), in other circumstances they fail to induce a correct meaning in spite of repetitive, simplified input.

Empirical discrepancies such as these make it difficult to infer whether dedicated word learning mechanisms exist. One problem is that we lack basic data on the learnability of words. For a given word, how much and what type of exposure, in what contexts, does an infant or preschooler need to induce the correct meaning? Until we know this, we cannot establish how features of a word, its referent, the naming context, the speaker, and the child jointly determine learning. Data on learnability is needed before we

can specify children's readiness to induce word meanings from available information and thereby infer the mechanisms conferring this readiness.

Prescriptions and Conclusions

Our original question was whether innate, specialized word learning constraints can explain word learning. Having answered this in the negative, we should ask why, if complex multivariate contingencies are the norm, researchers have focused on single-factor biases or constraints.

To answer this let us broaden our view and consider the vast set of phenomena that scientists try to explain. We can hypothetically divide this set into phenomena that yield to a few relatively simple explanatory axioms (e.g., relations among the mass, velocity, and energy of large bodies in motion) versus those so complex that they cannot be summarized by a concise set of axioms. The former yield to hedgehog theories, whereas the latter require more complex fox theories (Maratsos & Deák, 1995). What sorts of behavioral phenomena require fox theories? Although we cannot determine this *a priori*, consider, for example, that discourse pragmatics are unlikely to be adequately explained by a few simple axioms. It is also unlikely that future undergraduates will memorize, say, the Five Laws of Human Problem-Solving. Such phenomena are characterized by the flexible activation of diverse behaviors across diverse contexts and across the life span.

Consider next the actual theories we apply to phenomena. Fox theories are not typically applied to homogenous and complex phenomena. Rather, hedgehog theories are overapplied. This is a consequence of the scientific community's historical value and incentive system. Hedgehog theories are easy to remember, easy to report, easy to describe in textbooks, etc. In contrast, it is far more difficult to meaningfully capture and systematize fox-like phenomena. Furthermore, whereas we have good prototypes for hedgehog theories (e.g., Newton's laws of motion), we have few compelling examples of fox theories. I conclude with (a) prescriptions for future research aimed at developing theories to capture word learning and (b) a summary of well-supported generalizations about word learning that comprise a starting point for any viable theory.

Prescriptions

Constraints accounts of word learning are hedgehogs. They posit a set of internal, specialized mechanisms that are causal ''kernels'' of inductive behaviors. Yet word learning requires a theory that respects its fox-like empirical complexity. The rudiments of such a theory are given below; first, though, we consider what kinds of empirical evidence are needed for a satisfying theory. Future research must address four issues more thoroughly in order to understand the genesis of complex inductive word learning tendencies.

Test the contextual boundaries of word learning tendencies. Once a tendency has been identified we must ask theoretically motivated questions about the situations that evoke it. For example, if an inductive tendency is a response to high cognitive load, it must be tested under varying concurrent processing demands (e.g., Liittschwager & Markman, 1994). If it is a generalized response to regularities in adults' language use, we must ascertain through observation that it emerges from conversational experience (e.g., Tomasello & Barton, 1994). Some questions will require testing children's inferences in different linguistic contexts (e.g., Waxman & Markow, 1995; Deák, in press). Such work will ''foliate'' the contingency trees described above and allow us to identify variables that affect a broad range of inductive tendencies in word learning.

Test the breadth of tendencies. To understand what stimuli trigger or elicit an inductive tendency, we must test it with words from different form classes, as well as nonlexical symbols, facts, sounds, etc. Merriman et al.'s (1993) finding that the disambiguation effect (i.e., mapping novel words onto unnamed referents) applies to action verbs as well as object nouns exemplifies this research strategy, as does Markson and Bloom's (1997) finding that children ''fast map'' novel facts as well as novel words. Such tests tell us whether an inductive tendency stems from general cognitive processes and limitations or from specialized linguistic mechanisms.

Test the prevalence of tendencies. Because we typically test word learning in restricted population samples, we seldom know whether an inductive tendency obtains across individuals (with, e.g., different cognitive and social phenotypes) or across cultural and language groups. More cross-linguistic research on word learning is needed. There are few examples, but consider tests of Gentner's (1982) argument that concrete nouns are conceptually simpler and therefore easier to learn than verbs. Gopnik and Choi (1995) argued that Korean infants' lexicons are not dominated by nouns because their mothers emphasize relational words in conversation, in contrast with American mothers, who emphasize object words. In addition, Korean syntax emphasizes verbs (Tardif, Shatz, & Naigles, 1997). Au et al. (1994), however, showed that Korean children initially learn more object words. This suggests that the conceptual simplicity of concrete object names overrides differences in input frequency (see Maratsos, 1991; Woodward & Markman, 1997 for discussion). This indicates that cross-linguistic evidence can reveal a species-wide cognitive trait, or a prevalent word learning-specific mechanism.

Also underrepresented is evidence on the prevalence of word learning strategies across diverse children within a language group (but see Bates et al., 1995; Miller & Klee, 1995). This includes evidence from children with developmental delays and disabilities. Because some children have specific or general language impairments, and others have disabilities typified by specific or general cognitive or social deficits, comparison of these groups

might reveal the nature of word learning tendencies. Most research on individual differences in language development has compared performance on summative measures (e.g., vocabulary tests such as the CDI or PPVT), which fail to reveal differences in word learning processes. Experimental tests of word learning tendencies across children with different abilities will be critical for understanding inductive processes that underlie, or impair, lexical development.

Test the emergence of tendencies. The concept *constraint* does not engender questions about how a word learning tendency emerges because it implies that such tendencies are caused by canalized, specialized mechanisms. What little evidence exists does not support the view that inductive word learning tendencies are ''programmed'' to turn on at a set maturational point. For example, Premack (1990) showed that symbol-trained (but not untrained) chimpanzees generalized a novel symbol to a category of similar looking items. Besides suggesting that the so-called taxonomic bias (Markman, 1989) requires a certain amount of reinforced experience using symbols, it also suggests that the tendency is neither genotype-specific nor dependent on a complete language learning facility. Smith (1999) recently found that the tendency to generalize novel object nouns to same-shape objects emerges after a critical amount of learning. A longitudinal study showed that the shape bias emerged after children had a productive vocabulary of 50 object words or 80 total words (mostly concrete object names), and a training study showed that the onset of the tendency could be accelerated by focused experience with shape-based categories and labels. Such findings set the stage for more research on experiential and maturational antecedents of word learning tendencies. Such research is difficult, however, because many experiential factors cannot ethically be manipulated. It will therefore require great creativity to discover causal prerequisites in the emergence of word learning tendencies.

Conclusions: Starting Points for Theories of Word Learning

Child language researchers face a daunting task: explaining how children acquire a lexicon of thousands of words, each with infinite possible meanings, within a few years. For the last decade the dominant explanation for word learning focused on children's internal constraints: mechanisms construed or implied to be genetically triggered traits specialized for word learning. This account fails for several reasons: the broad construal of constraints is practically meaningless, and the modal definition is implausible and misleading. Attributing inductive tendencies to constraints misleadingly implies that something is known about a causal mechanism. None of these problems are alleviated by attributing word learning to constraints in conjunction with other mechanisms, because we lack defensible criteria by which to separate constraints from other mechanisms. A more satisfactory tact is to approach word learning tendencies with agnosticism and to explicitly ask questions

about contextual boundaries, breadth, prevalence, and emergence. Constraints frameworks have nonetheless maintained prominence because they satisfy a desire for simple, axiomatic ''hedgehog'' theories. As we have seen, though, the picture of constraints accounts as parsimonious is illusory, because a host of implicit and undefined constraints is needed to fully explain the available evidence.

The dismissal of constraints as theoretically empty leaves us with no serious comprehensive theory of word learning. We can be partly satisfied with a clearer understanding of the limitations of a popular theoretical approach, but it would be more satisfying to provide at least the rudiments of a viable theory. What generalizations can be made about children's word learning? First, as argued above, the evidence suggests that human word learning is a particular kind of ''fox.'' It does not seem to emerge from a small set of special-purpose mechanisms, but from a set (of unknown size) of general, adaptable characteristics, which combine with great complexity to permit flexible induction of a diverse array of word meanings. These characteristics include the following.

Affiliative propensity. As described above, this overarching motive is manifested as a number of behaviors that change developmentally, but which consistently foster communicative interactions and perpetuate interpersonal relationships. With respect to word learning, the propensity compels infants to seek language input and invest cognitive effort in comprehending others' words and utterances. This might be connected to a broader motive to reduce uncertainty about the environment. That is, attempting to infer people's future behavior from their speech acts shows how the motive to affiliate and the motive to reduce uncertainty mutually support children's efforts to interpret the meanings of other people's speech acts.

Intersubjective capacity. This is the propensity to interpret other people's behaviors as the products of unobservable mental events. During infancy it manifests itself in joint attentive behaviors (reviewed above) which support language learning. With respect to word learning, the propensity compels infants to associate a word with the object of the speaker's attention. More generally, older children use this capacity to interpret speech acts in light of the speaker's unobservable internal states or experiences. The fact that toddlers acquire and correctly use words for unobservable mental and affective states, and relate these to people's behaviors (Bretherton, McNew, & Beeghly-Smith, 1981), is powerful evidence that an intersubjective capacity supports the induction of some extremely abstract and underdetermined word meanings.

Representational/symbolic capacity. Humans readily grasp ''stand for'' relations, including very abstract ones (e.g., adults readily accept that a Greek letter can represent an abstraction standing for any possible solution to a mathematical formula involving several other Greek letters). The fact that 1-year-olds accept verbal symbols for individuals (''mommy''), object classes

(‘‘bottle’’), social interactions (‘‘peekaboo’’), changes in spatial relations (‘‘up’’), and changes in location (‘‘bye-bye’’) shows that this capacity is quite flexible, robust, and early-emerging.

Complex contingency learning. Word learning rests on the ability to acquire associations that are contingent on conjunctions of contextual factors. These can be represented as decision trees in which combinations of features limit inferences about novel words. Although we do not know how complex children's contingency trees can become, there are several empirical demonstrations of children's sensitivity to multiple variables that simultaneously vary across learning episodes. For example, children's tendency to generalize novel words for objects or object properties according to shape depends on stimulus variables such as attribute salience, number of matching parts, and ontological categories; linguistic variables such as syntactic and semantic cues; task variables such as previous inferences about the objects; and child variables such as age and language spoken (e.g., Becker & Ward, 1991; Deák, in press; Imai & Gentner, 1997; Jones et al., 1991; Landau et al., 1988, 1992; Smith et al., 1992, 1996; Soja et al., 1991).

Category induction and metaphorical extension. This is the propensity to induce a broader class of entities, attributes, or events from a very small number of examples. It has many implications for word learning, notably because almost all words, with the exceptions of proper names and articles, refer to categories. Moreover, metaphoric extension of words is endemic in semantics (Lakoff, 1987), including child language. Thus, the capacity to induce taxonomic kinds and to notice and name abstract similarities is a hallmark of language both children and adults.

Cognitive limitations. Word learning is subject to limits on perceptual discrimination, attention, memory, and reasoning. These limitations, and individual differences thereof, impact word learning. For example, memory limitations (especially in STS) affect the rate of vocabulary growth (Gathercole et al., 1992, 1997). There is also evidence that developmental and individual differences in other cognitive capacities, such as cognitive inhibition (Deák, in press) and selective encoding (Merriman, 1999), impact word learning.

Any viable theory of word learning must begin with these six fundamental characteristics. Additional special-purpose word learning mechanisms might play a role, but for the sake of parsimony it should first be shown that these general characteristics cannot jointly account for word learning.

Although I have painted word learning as a diverse, context-sensitive system, only six characteristics are initially proposed. Is such a simple characterization consistent with arguments that word learning is a fox-like system? The answer reveals something of the nature of the fox: Word learning might stem not from an abundance of mechanisms (remember that evolution is a fundamentally conservative process) but a few powerful, adaptive mechanisms that interact, in a variable and diverse environment, to produce an wide range of well-tuned inductive behaviors. A small number of contingent

mechanisms, interacting in different combinations, can give rise to a highly flexible inductive capacity. Yet this cumulative generativity does not yield profligate, reckless inferences about word meanings. Children can be quite conservative in their inductive generalizations of novel words (Hughes-Wagner & Deák, in preparation), and this conservatism can readily coexist with inductive generativity, assuming that the inductive mechanisms pass potential (i.e. activated) responses through a ''filter'' that eliminates low-certainty or high-conflict inferences by means of a threshold function. Finally, we must remember that there may be specific, special-purpose word learning mechanisms that operate in conjunction with these general mechanisms.

This discussion has focused squarely on word learning and the concept *constraint*, but the analysis informs debates about induction in general. For example, the metaphor of fox and hedgehog theories might shed light on how we theorize about other psychological phenomena, particularly those dealing with learning and development. The social and cognitive demands to fit phenomena into hedgehog theories deserve further exploration. The failure of hedgehog theories to explain children's word learning can serve as a cautionary tale for other theoretical enterprises. We now need a didactic sequel: a viable theory of word learning that attempts to explain the empirical complexities of inductive word learning tendencies in terms of children's perceptual, cognitive, social, and motivational traits, their species-specific capacity to learn language, and their richly structured physical, social, and linguistic environment.

REFERENCES

Adams, A. K., & Bullock, D. (1986). Apprenticeship in word use: Social convergence processes in learning categorically related nouns. In S. A. Kuczaj & M. D. Barrett (Eds.), *The development of word meaning* (pp. 155–197). New York: Springer-Verlag.

Adamson, L. (1995). *Communication development during infancy*. Boulder, CO: Westview.

Akhtar, N., Carpenter, M., & Tomasello, M. (1996). The role of discourse novelty in early word learning. *Child Development,* **67,** 635–645.

Akhtar, N., Jipson, J. L., & Callanan, M. A. (1998, April). *Learning words through eavesdropping.* Poster presented to the International Society on Infant Studies, Atlanta, GA.

Anglin, J. M. (1977). *Word, object, and conceptual development.* New York: Norton.

Anglin, J. M. (1993). Vocabulary development: A morphological analysis. *Monographs of the Society for Research in Child Development* **58**(10). [serial no. 238]

Aslin, R. N. (1992). Segmentation of fluent speech into words: Learning models and the role of maternal input. In B. de Boysson-Bardies, S. de Schonen, P. Jusczyk, P. McNeilage, & J. Morton (Eds.), *Speech and face processing in the first year of life.* Dordrecht: Kluwer.

Au, T. K., Dapretto, M., & Song, Y. (1994). Input vs. constraints: Early word acquisition in Korean and English. *Journal of Memory and Language,* **33,** 567–582.

Au, T. K., & Glusman, M. (1990). The principle of mutual exclusivity in word learning: To honor or not to honor? *Child Development,* **61,** 1474–1490.

Au, T. K., & Markman, E. M. (1987). Acquiring word meanings via linguistic contrast. *Cognitive Development,* **2,** 217–236.

Baddeley, A. D. (1986). *Human memory: Theory and practice.* Boston: Allyn & Bacon.

Baillargeon, R. (1993). The object concept revisited: New directions in the investigation of infants' physical knowledge. In C. E. Granrud (Ed.), *Visual perception and cognition in infancy.* Hillsdale, NJ: Erlbaum.

Baldwin, D. A. (1989). Priorities in children's expectations about object label references: Form over color. *Child Development,* **60,** 1291–1306.

Baldwin, D. A. (1995). Understanding the link between joint attention and language. In C. Moore & P. Dunham (Eds.), *Joint attention: Its origins and role in development.* Hillsdale, NJ: Erlbaum.

Banigan, R. L. & Mervis, C. B. (1988). Role of adult input in young children's category evolution: II an experimental study. *Journal of Child Language,* **15,** 493–504.

Baron-Cohen, S., Tager-Flusberg, H., & Cohen, D. J. (Eds.) (1993). *Understanding other minds: Perspectives from autism.* Oxford: Univ. Press.

Barrett, M. (1995). Early lexical development. In P. Fletcher & B. MacWhinney (Eds.), *The handbook of child language.* Oxford: Blackwell.

Barton, D. P. (1980). Phonemic perception in children. In G. Yeni-Komshian, J. F. Kavanagh, & C. A. Ferguson (Eds.), *Child phonology: Vol. 2, Perception.* New York: Academic Press.

Bates, E. (1997). Origins of language disorders: A comparative approach. *Developmental Neuropsychology,* **13,** 447–476.

Bates, E., Dale, P. S., & Thal, D. (1995). Individual differences and their implications for theories of language development. In P. Fletcher & B. MacWhinney (Eds.), *The handbook of child language* (pp. 96–151). Oxford: Blackwell.

Bauer, P. J., & Mandler, J. M. (1989). Taxonomies and triads: Conceptual organization in one- to two-year-olds. *Cognitive Psychology,* **21,** 156–184.

Beals, D. E., & Tabors, P. O. (1995). Arboretum, bureaucratic and carbohydrates: Preschoolers' exposure to rare vocabulary at home. *First Language,* **15,** 57–76.

Becker, A. H., & Ward, T. B. (1991). Children's use of shape in extending novel labels to animate objects: Identity versus postural change. *Cognitive Development,* **6,** 3–16.

Behrend, D. (1990). Constraints and development: A reply to Nelson (1988). *Cognitive Development,* **5,** 313–330.

Behrend, D. A. (1995). Processes involved in the initial mapping of verb meanings. In M. Tomasello & W. Merriman (Eds.), *Beyond names for things: Children's acquisition of verbs.* Hillsdale, NJ: Erlbaum.

Berko Gleason, J. (1997). *The development of language,* 2nd ed. Boston: Allyn & Bacon.

Berlin, I. (1953/1992). *The hedgehog and the fox.* London: Orion.

Blewitt, P. (1983). ''Dog'' vs. ''collie'': Vocabulary in speech to young children. *Developmental Psychology,* **19,** 1474–1490.

Bloom, L. (1997). Language acquisition in its developmental context. In D. Kuhn & R. Siegler (Eds.), *The handbook of child psychology: Vol. 2, Cognition, perception, and language.* New York: Wiley.

Bloom, P. (1999). Theories of word learning: Rationalist alternatives to associationism. In T. Bhatia & W. Ritchie (Eds.), *Handbook of language acquisition.* New York: Academic Press.

Bloom, P., & Markson, L. (1998). Capacities underlying word learning. *Trends in Cognitive Science,* **2,** 67–73.

Bornstein, M. H. (1985). Colour-name versus shape-name learning in young children. *Journal of Child Language,* **12,** 387–393.

Bowerman, M. (1976). Semantic factors in the acquisition of rules for word use and sentence construction. In D. M. Morehead & A. E. Morehead (Eds.), *Normal and deficient child language* (pp. 99–179). Baltimore, MD: Univ. Park Press.

Braine, M. D. S. (1994). Is nativism sufficient? *Journal of Child Language,* **21,** 9–32.

Bretherton, I., McNew, S., & Beeghly-Smith, M. (1981). Early person knowledge as expressed in gestural and verbal communication: When do infants acquire a ''theory of mind?'' In M. Lamb & L. Sherrod (Eds.), *Infant social cognition.* Hillsdale, NJ: Erlbaum.

Brown, A. L. (1990). Domain-specific principles affect learning and transfer in children. *Cognitive Science,* **14,** 107–133.

Brown, R. (1957). Linguistic determinism and the parts of speech. *Journal of Abnormal and Social Psychology,* **55,** 1–5.

Brown, R. (1958a). How shall a thing be called? *Psychological Review,* **65,** 14–21.

Brown, R. (1958b). *Words and things.* Glencoe, IL: Free Press.

Bruner, J. (1982). Formats of language acquisition. *American Journal of Semiotics,* **1,** 1–16.

Budwig, N. (1995). *A developmental-functionalist approach to child language.* Mahwah, NJ: Erlbaum.

Butterworth, G. E., & Jarrett, N. L. M. (1991). What minds have in common is space: Spatial mechanisms serving joint visual attention in infancy. *British Journal of Developmental Psychology,* **9,** 55–72.

Callanan, M. A. (1985). How parents label objects for young children: The role of input in the acquisition of category hierarchies. *Child Development,* **56,** 508–523.

Callanan, M. A. (1989). Development of object categories and inclusion relations: Preschoolers' hypotheses about word meaning. *Developmental Psychology,* **25,** 207–216.

Callanan, M. A. (1990). Parents' descriptions of objects: Potential data for children's inferences about category properties. *Cognitive Development,* **5,** 101–122.

Callanan, M. A., Repp, A. M., McCarthy, M. G., & Latzke, M. A. (1994). Children's hypotheses about word meanings: Is there a basic level constraint? *Journal of Experimental Child Psychology,* **57,** 108–138.

Carey, S. (1978). The child as a word learning. In M. Halle, J. Bresnan, & G. Miller (Eds.), *Linguistic theory and psychological reality.* Cambridge, MA: MIT Press.

Carey, S. (1996, June). *Sources of conceptual development.* Presentation at the Annual Symposium of the Jean Piaget Society, Philadelphia, PA.

Ceci, S. J. (1989). On domain specificity. . .more or less: General and specific constraints on cognitive development. *Merrill-Palmer Quarterly,* **35,** 131–142.

Chapman, K. L., Leonard, L. B., & Mervis, C. B. (1986). The effect of feedback on young children's inappropriate word usage. *Journal of Child Language,* **13,** 101–117.

Chapman, M. (1987). Piaget, attentional capacity, and the functional implications of formal structure. In H. Reese (Ed.), *Advances in Child Development and Behavior,* Vol. 20. San Diego: Academic Press.

Charles-Luce, J., & Luce, P. A. (1990). Similarity neighbourhoods of words in young children's lexicons. *Journal of Child Language,* **17,** 205–215.

Chi, M. T. H. (1978). Knowledge structures and memory development. In R. Siegler (Ed.), *Children's thinking: What develops?* Hillsdale, NJ: Erlbaum.

Chi, M. T. H., & Koeske, R. D. (1983). Network representations of a child's dinosaur knowledge. *Developmental Psychology,* **19,** 29–39.

Chi, M. T. H., Hutchinson, J. E., & Robin, A. F. (1989). How inferences about novel domain-

related concepts can be constrained by structured knowledge. *Merrill-Palmer Quarterly,* **35,** 27–62.

Chomsky, N. (1965). *Aspects of the theory of syntax.* Cambridge: MIT.

Clark, E. V. (1973). What's in a word? On the child's acquisition of semantics in his first language. In T. E. Moore (Ed.), *Cognitive development and the acquisition of language.* New York: Academic Press.

Clark, E. V. (1987). The principle of contrast: A constraint on language acquisition. In B. MacWhinney (Ed.), *Mechanisms of language acquisition.* Hillsdale, NJ: Erlbaum.

Cooper, R. P. (1997). An ecological approach to infants' perception of information contours as meaningful aspects of speech. In C. Dent-Read & P. Zukow-Goldring (Eds.), *Evolving explanations of development.* Washington, DC: Am. Psychol. Assoc.

Corrigan, R. (1978). Language development as related to stage 6 object permanence development. *Journal of Child Language,* **5,** 173–189.

Cunningham, A. E., & Stanovich, K. E. (1991). Tracking the unique effects of print exposure in children: Associations with vocabulary, general knowledge, and spelling. *Journal of Educational Psychology,* **83,** 264–274.

Deák, G. O. in press. The growth of flexible problem-solving: How children infer word meanings using semantic context. *Journal of Cognition and Development.*

Deák, G., & Bauer, P. J. (1995). The effects of task comprehension on preschoolers' and adults' categorization choices. *Journal of Experimental Child Psychology,* **60,** 393–427.

Deák, G., & Bauer, P. J. (1996). The dynamics of preschoolers' categorization choices. *Child Development,* **67,** 740–767.

Deák, G., Flom, R. A., & Pick, A. D. *Effects of gesture and target on 12- and 18-month-olds' joint visual attention to objects in front of or behind them.* [submitted for review]

Deák, G. O., & Maratsos, M. (1998). On having complex representations of things: Preschoolers use multiple words for objects and people. *Developmental Psychology,* **34,** 224–240.

Deák, G., Ray, S., & Pick, A. D. (1999, October). *The development of consistent & flexible induction: Why preschoolers sort by shape or function.* Paper presented at the meeting of the Cognitive Development Society, Chapel Hill, NC, October 1999.

Deák, G. O., Yen, L., & Pettit, J. *Semantic elaboration via flexible categorization: Integrating known and novel words for objects.* [in preparation]

DeBaryshe, B. D., & Whitehurst, G. J. (1986). Intraverbal acquisition of semantic concepts by preschoolers. *Journal of Experimental Child Psychology,* **42,** 169–186.

Dempster, F. N. (1981). Memory span: Sources of individual and developmental differences. *Psychological Bulletin,* **89,** 63–100.

D'Entrement, B., & Dunham, P. (1992). The noun-category bias phenomenon in three-year-olds: Taxonomic constraint or translation? *Cognitive Development,* **7,** 47–62.

Dickinson, D. K. (1988). Learning names for materials: Factors constraining and limiting hypotheses about word meaning. *Cognitive Development,* **3,** 15–35.

Dickinson, D. K. (1989). Development of preschool children's ability to identify common materials. *Merrill-Palmer Quarterly,* **35,** 165–180.

Dunn, J., Bretherton, I., & Munn, P. (1987). Conversations about feeling states between mothers and their young children. *Developmental Psychology,* **23,** 132–139.

Dunn, J., & Shatz, M. (1989). Becoming a conversationalist despite (or because of) having an older sibling. *Child Development,* **60,** 399–410.

Eimas, P. D., & Quinn, P. C. (1994). Studies on the formation of perceptually-based categories in young infants. *Child Development,* **65,** 903–917.

Elman, J. L. (1993). Learning and development in neural networks: The importance of starting small. *Cognition,* **48,** 71–99.

Elman, J. L., Bates, E. A., Johnson, M. H., Karmiloff-Smith, A., Parisi, D., & Plunkett, K. (1996). *Rethinking innateness: A connectionist perspective on development.* Cambridge, MA: MIT.

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., & Pethick, S. J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development,* **59**(5). [serial No. 242]

Fernald, A. (1993). Approval and disapproval: Infant responsiveness to vocal affect in familiar and unfamiliar languages. *Child Development,* **64,** 657–674.

Fernald, A., & Mazzie, C. (1991). Prosody and focus in speech to infants and adults. *Developmental Psychology,* **27,** 209–221.

Fernald, A., & Simon, T. (1984). Expanded intonation contours in mothers' speech to newborns. *Developmental Psychology,* **20,** 104–113.

Fernald, A., Taeschner, T., Dunn, J., Papousek, M., de Boysson-Bardies, B., & Fukui, I. (1989). A cross-language study of prosodic modifications in mothers' and fathers' speech to preverbal infants. *Journal of Child Language,* **16,** 477–501.

Fisher, C., Gleitman, H., & Gleitman, L. (1991). Relationships between verb meaning and their syntactic structures. *Cognitive Psychology,* **23,** 331–392.

Flavell, J. H., Green, F. L., & Flavell, E. R. (1986). Development of knowledge about the appearance-reality distinction. *Monographs of the Society for Research on Child Development,* **51.** [1, serial No. 212]

Franco, F., & Butterworth, G. E. (1996). Pointing and social awareness: Declaring and requesting in the second year. *Journal of Child Language,* **23,** 307–336.

Gallistel, C. R., Brown, A. L., Carey, S., Gelman, R., & Keil, F. C. (1991). Lessons from animal learning for the study of cognitive development. In S. Carey & R. Gelman (Eds.), *The epigenesis of mind: Essays on biology and cognition.* Hillsdale, NJ: Erlbaum.

Garner, W. R. (1983). Asymmetric interactions of stimulus dimensions in perceptual information processing. In T. Tighe & B. Shepp (Eds.), *Perception, cognition, and development: Interactional analyses.* Hillsdale, NJ: Erlbaum.

Garnica, O. K. (1973). The development of phonemic speech perception. In T. E. Moore (Ed.), *Cognitive development and the acquisition of language.* New York: Academic Press.

Gathercole, S. E., & Adams, A. (1993). Phonological working memory in very young children. *Developmental Psychology,* **29,** 770–778.

Gathercole, S. E., Hitch, G. J., Service, E., & Martin, A. J. (1997). Phonological short-term memory and new word learning in children. *Developmental Psychology,* **33,** 966–979.

Gathercole, S. E., Willis, C., Emslie, H., & Baddeley, A. D. (1992). Phonological memory and vocabulary development during the early school years: A longitudinal study. *Developmental Psychology,* **28,** 887–898.

Gelman, R. (1990). First principles organize attention to and learning about relevant data: Number and the animate-inanimate distinction as examples. *Cognitive Science,* **14,** 79–106.

Gelman, R., & Brenneman, K. (1994). First principles can support both universal and culture-specific learning about number and music. In L. A. Hirschfeld & S. A. Gelman (Eds.), *Mapping the mind: Domain specificity in cognition and culture.* New York: Cambridge Univ. Press.

Gelman, S. A., & Markman, E. M. (1986). Categories and induction in young children. *Cognition,* **23,** 183–209.

Gentner, D. (1978). A study of early word meaning using artificial objects: What looks like

a jiggy but acts like a zimbo? *Papers and Reports on Child Language Development,* **15,** 1–6.

Gentner, D. (1982). Why nouns are learned before verbs: Linguistic relativity versus natural partitioning. In S. A. Kuczaj II (Ed.), *Language development,* Vol. 2. Hillsdale, NJ: Erlbaum.

Gergely, G., Nádasdy, Z., Csibra, G., & Bíró, S. (1995). Taking the intentional stance at 12 months of age. *Cognition,* **56,** 165–193.

Gerken, L., Murphy, W. D., & Aslin, R. N. (1995). Three- and four-year-olds' perceptual confusions for spoken words. *Perception and Psychophysics,* **57,** 475–486.

Gibson, J. J., & Gibson, E. J. (1955). Perceptual learning: Differentiation or enrichment? *Psychological Review,* **62,** 32–41.

Gleitman, L. R. (1990). The structural sources of word meaning. *Language Acquisition,* **1,** 3–55.

Goldin-Meadow, S., & Feldman, H. (1979). The development of language-like communication without a language model. *Science,* **197,** 401–403.

Golinkoff, R. M., & Alioto, A. (1995). Infant-directed speech facilitates lexical learning in adults hearing Chinese: Implications for language acquisition. *Journal of Child Language,* **22,** 703–726.

Golinkoff, R. M., & Hirsh-Pasek, K. (1998, April). Debate on lexical principles. 11th Biennial International Conference on Infant Studies, Atlanta, GA.

Golinkoff, R. M., Mervis, C. B., & Hirsh-Pasek, K. (1994). Early object labels: The case for lexical principles. *Journal of Child Language,* **21,** 125–155.

Goodman, J. C., McDonough, L., & Brown, N. B. (1998). The role of semantic context and memory in the acquisition of novel nouns. *Child Development,* **69,** 1330–1344.

Goodman, N. (1955/1983). *Fact, fiction, and forecast,* 4th ed. Cambridge, MA: Harvard.

Goodnow, J. (1990). Using sociology to extend psychological accounts of cognitive development. *Human Development,* **33,** 81–107.

Gopnik, A., & Choi, S. (1995). Names, relational words, and cognitive development in English and Korean speakers: Nouns are not always learned before verbs. In M. Tomasello & W. Merriman (Eds.), *Beyond names for things.* Hillsdale, NJ: Erlbaum.

Gopnik, A., & Meltzoff, A. (1986). Relations between semantic and cognitive development in the one-word stage: The specificity hypothesis. *Child Development,* **57,** 1040–1053.

Gopnik, A., & Meltzoff, A. (1987). The development of categorization in the second year and its relation to other cognitive and linguistic development. *Child Development,* **58,** 1523–1531.

Gottfried, G. M., & Tonks, S. J. M. (1996). Specifying the relation between novel and known: Input affects the acquisition of novel color terms. *Child Development,* **67,** 850–866.

Greenough, W. T., Black, J. E., & Wallace, C. S. (1987). Experience and brain development. *Child Development,* **58,** 539–559.

Grice, H. P. (1975). Logic and conversation. In P. Cole & J. Morgan (Eds.), *Syntax and semantics 3: Pragmatics.* New York: Academic Press.

Heibeck, T. H., & Markman, E. M. (1987). World learning in children: An examination of fast mapping. *Child Development,* **58,** 1021–1034.

Hirschfeld, L. A., & Gelman, S. A., Eds. (1994). *Mapping the mind: Domain specificity in cognition and culture.* New York: Cambridge Univ. Press.

Hoff-Ginsberg, E. (1997). *Language development.* Pacific Grove, CA: Brooks/Cole.

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Lyons, T. (1991). Early vocabulary

growth: Relation to language input and gender. *Developmental Psychology,* **27,** 236–248.

Hymes, D. (1974) *Foundations in sociolinguistics: An ethnographic approach.* Philadelphia: Univ. of Pennsylvania.

Imai, M., & Gentner, D. (1997). A cross-linguistic study of early word meaning: Universal ontology and linguistic influence. *Cognition,* **62,** 169–200.

Itard, J. M. G. (1801/1932). *The wild boy of Aveyron.* New York: Century.

Johnson, K. E., & Mervis, C. B. (1994). Microgenetic analysis of first steps in children's acquisition of expertise on shorebirds. *Developmental Psychology,* **30,** 418–435.

Johnson, T. D. (1987). The persistence of dichotomies in the study of behavioral development. *Developmental Review,* **7,** 149–182.

Jones, S., Smith, L., & Landau, B. (1991). Object properties and knowledge in early lexical learning. *Child Development,* **62,** 499–516.

Keil, F. C. (1979). *Semantic and conceptual development: An ontological perspective.* Cambridge, MA: Harvard.

Keil, F. C. (1981). Constraints on knowledge and cognitive development. *Psychological Review,* **88,** 197–227.

Keil, F. C. (1990). Constraints on constraints: Surveying the epigenetic landscape. *Cognitive Science,* **14,** 135–168.

Kuczaj, S. A. (1990). Constraining constraint theories. *Cognitive Development,* **5,** 341–344.

Lakoff, G. (1987). *Women, fire, and dangerous things.* Chicago: Univ. Press.

Landau, B., & Stecker, D. (1990). Objects and places: Geometric and syntactic representation in early lexical learning. *Cognitive Development,* **5,** 287–312.

Landau, K. B., Smith, L. B., & Jones, S. S. (1988). The importance of shape in early lexical learning. *Cognitive Development,* **3,** 299–321.

Landau, B., Smith, L. B., & Jones, S. S. (1992). Syntactic context and the shape bias in children's and adults' lexical learning. *Journal of Memory and Language,* **31,** 807–825.

Lane, D. M., & Pearson, D. A. (1982). The development of selective attention. *Merrill-Palmer Quarterly,* **28**(3), 317–337.

Lee, A., Hobson, R. P., & Chiat, S. (1994). I, you, me, and autism: An experimental study. *Journal of Autism and Developmental Disorders,* **24,** 155–176.

Leonard, L. B., Schwartz, R. G., Morris, B., & Chapman, K. (1981). Factors influencing early lexical acquisition: Lexical orientation and phonological composition. *Child Development,* **52,** 882–887.

Liittschwager, J. C., & Markman, E. M. (1994). Sixteen- and 24-month-olds' use of mutual exclusivity as a default assumption in second-label learning. *Developmental Psychology,* **6,** 955–968.

Locke, J. (1993). *The child's path to spoken language* (pp. 323–348). Cambridge, MA: Harvard.

Macnamara, J. (1972). The cognitive basis of language learning in children. *Psychological Review,* **79,** 1–13.

Mandel, D. R., Jusczyk, P. W., & Pisoni, D. B. (1995). Infants' recognition of the sound patterns of their own names. *Psychological Science,* **6,** 314–317.

Mandler, J. M., Bauer, P. J., & McDonough, L. (1991). Separating the sheep from the goats: Differentiating global categories. *Cognitive Psychology,* **23,** 263–298.

Mandler, J. M., & McDonough, L. (1998). Studies in inductive inference in infancy. *Cognitive Psychology,* **37,** 60–96.

Maratsos, M. P. (1991). How the acquisition of nouns may be different from that of verbs.

In N. A. Krasnegor, D. M. Rumbaugh, R. L. Schiefelbusch, & M. Studderd-Kennedy (Eds.), *Biological and behavioral determinants of language development.* Hillsdale, NJ: Erlbaum.

Maratsos, M. (1992). Constraints, modules, and domain specificity: An introduction. In M. R. Gunnar & M. Maratsos (Eds.), *The Minnesota Symposium on Child Psychology,* Vol. 25. Hillsdale, NJ: Erlbaum.

Maratsos, M., & Deák, G. (1995). Hedgehogs, foxes, and the acquisition of verb meaning. In M. Tomasello & W. Merriman (Eds.), *Beyond names for things: Children's acquisition of verbs.* Hillsdale, NJ: Erlbaum.

Markman, E. M. (1989). *Categorization and naming in children: Problems of induction.* Cambridge: MIT.

Markman, E. M. (1992). Constraints on word learning: Speculations about their nature, origins, and domain specificity. In M. R. Gunnar & M. Maratsos (Eds.), *The Minnesota Symposium on Child Psychology,* Vol. 25. Hillsdale, NJ: Erlbaum.

Markman, E. M. (1994). Constraints on word meaning in early language acquisition. *Lingua,* **92,** 199–227.

Markman, E. M., & Hutchinson, J. (1984). Children's sensitivity to constraints on word meaning: Taxonomic versus thematic relations. *Cognitive Psychology,* **61,** 1–27.

Markman, E. M., & Wachtel, G. F. (1988). Children's use of mutual exclusivity to constrain the meanings of words. *Cognitive Psychology,* **20,** 121–157.

Markson, L., & Bloom, P. (1997). Evidence against a dedicated system for word learning in children. *Nature,* **385,** 813–815.

Mayr, E. (1982). *The growth of biological thought.* Cambridge: Harvard.

McCarrell, N. S., & Callanan, M. A. (1995). Form-function correspondences in children's inference. *Child Development,* **66,** 532–546.

McPherson, L. M. P. (1991). A little goes a long way: Evidence for a perceptual basis of learning for the noun categories COUNT and MASS. *Journal of Child Language,* **18,** 315–338.

Medin, D. L., Ahn, W.-K., Bettger, J., Florian, J., Goldstone, R., et al. (1990). Soft takeoffs—soft landings. *Cognitive Science,* **14,** 169–178.

Medin, D. L., Wattenmaker, W. D., & Hampson, S. E. (1987). Family resemblance, conceptual cohesiveness, and category construction. *Cognitive Psychology,* **19,** 242–279.

Merriman, W. E. (1999). Competition, attention, and young children's lexical processing. In MacWhinney (Ed.), *The emergence of language.* Mahwah, NJ: Erlbaum.

Merriman, W. E., & Bowman, L. L. (1989). The mutual exclusivity bias in children's word learning. *Monographs of the Society for Research on Child Development.* **54.** [3–4, serial No. 220]

Merriman, W. E., & Kutlesic, V. (1993). Bilingual and monolingual children's use of two lexical acquisition heuristics. *Applied Psycholinguistics,* **14,** 229–249.

Merriman, W. E., Marazita, J., & Jarvis, L. H. (1993). Four-year-olds' disambiguation of action and object word reference. *Journal of Experimental Child Psychology,* **56,** 412–430.

Merriman, W. E., Marazita, J., & Jarvis, L. (1995). Children's disposition to map new words onto new referents. In M. Tomasello & W. E. Merriman (Eds.), *Beyond names for things: Young children's acquisition of verbs.* Hillsdale, NJ: Erlbaum.

Merriman, W. E., & Schuster, J. M. (1991). Young children's disambiguation of object name reference. *Child Development,* **62,** 1288–1301.

Mervis, C. B. (1987). Child-Basic object categories and early lexical development. In U. Neisser (Ed.), *Concepts and conceptual development.* Cambridge: Univ. Press.

Mervis, C. B., & Crisafi, M. A. (1982). Order of acquisition of subordinate-, basic-, and superordinate-level categories. *Child Development,* **53,** 258–266.

Mervis, C. B., & Mervis, C. A. (1982). Leopards are kitty-cats: Object labeling by mothers for their thirteen-month-olds. *Child Development,* **53,** 267–273.

Mervis, C. B., & Pani, J. R. (1980). Acquisition of basic-level categories. *Cognitive Psychology,* **12,** 496–522.

Miller, J. F., & Klee, T. (1995). Computational approaches to the analysis of language impairment. In P. Fletcher & B. MacWhinney (Eds.), *The handbook of child language* (pp. 545–572). Oxford: Blackwell.

Mook, D. G. (1983). In defense of external invalidity. *American Psychologist,* **38,** 379–387.

Morgan, J. L., & Demuth, K. (Eds.) (1996). *Signal to syntax.* Mahwah, NJ: Erlbaum.

Naigles, L. (1990). Children use syntax to learn verb meanings. *Journal of Child Language,* **17,** 357–374.

Namy, L. L., & Waxman, S. R. (1998). Words and gestures: Infants' interpretations of different forms of symbolic reference. *Child Development,* **69,** 295–308.

Nelson, K. (1973). Structure and strategy in learning to talk. *Monographs of the Society for Research in Child Development,* **38**(1–2). [serial No. 149]

Nelson, K. (1988). Constraints on word learning? *Cognitive Development,* **3,** 221–246.

Nelson, K. E., Bonvillian, J. (1973). Concepts and words in the 18-month-old: Acquiring concept names under controlled conditions. *Cognition,* **2,** 435–450.

Newport, E. L. (1991). Constraining concepts of the critical period for language. In S. Carey & R. Gelman (Eds.), *The epigenesis of mind* (pp. 111–130). Hillsdale, NJ: Erlbaum.

Newport, E. L., Gleitman, H., & Gleitman, L. R. (1977). Mother, I'd rather do it myself: Some effects and non-effects of maternal speech style. In C. E. Snow & C. A. Ferguson (Eds.), *Talking to children: Language input and acquisition.* Cambridge: Cambridge Univ. Press.

Ninio, A., & Snow, C. E. (1996). *Pragmatic development.* Boulder, CO: Westview.

Olson, D. (1970). Language and thought: Aspects of a cognitive theory of semantics. *Psychological Review,* **77,** 257–273.

Oshima-Takane, Y. (1988). Children learn from speech not addressed to them: The case of personal pronouns. *Journal of Child Language,* **15,** 95–108.

Pine, J. M. (1995). Variation in vocabulary development as a function of birth order. *Child Development,* **66,** 272–281.

Pinker, S. (1994). *The language instinct.* New York: Morrow.

Pinker, S., & Bloom, P. (1990). Natural language and natural selection. *Behavioral and Brain Sciences,* **13,** 707–784.

Plunkett, K. (1993). Lexical segmentation and vocabulary growth in early language acquisition. *Journal of Child Language,* **20,** 43–60.

Premack, D. (1990). Words: What are they, and do animals have them? *Cognition,* **37,** 197–212.

Quine, W. V. O. (1960). *Word and object.* Cambridge, MA: MIT Press.

Reese, E., & Fivush, R. (1993). Parental styles of talking about the past. *Developmental Psychology,* **29,** 596–606.

Rescorla, L. (1980). Overextension in early language development. *Journal of Child Language,* **7,** 321–335.

Roberts, K., & Jacob, M. (1991). Linguistic versus attentional influences on nonlinguistic categorization in 15-month-old infants. *Cognitive Development,* **6,** 355–375.

Rosch, E. H. (1978). Principles of categorization. In E. H. Rosch & B. B. Lloyd (Eds.), *Cognition and categorization.* Hillsdale, NJ: Erlbaum.

Rosch, E. H., Mervis, C. B., Gray, W., Johnson, D., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology,* **3,** 382–439.

Saffran, J. R., Aslin, R. N., & Newport, E. L. (1996). Statistical learning by 8-month-old infants. *Science,* **274,** 1926–1928.

Savage, S. L., & Au, T. K. (1996). What word learners do when input contradicts the Mutual Exclusivity assumption. *Child Development,* **67,** 3120–3134.

Schieffelin, B. B., & Ochs, E. (1986). (Eds.). *Language socialization across cultures.* Cambridge: Cambridge Univ. Press.

Schwartz, R., & Leonard, L. (1982). Do children pick and choose? An examination of phonological selection and avoidance in early acquisition. *Journal of Child Language,* **9,** 319–336.

Scaife, M., & Bruner, J. S. (1975). The capacity for joint visual attention in the infant. *Nature,* **253,** 265–266.

Shettleworth S. J. (1972). Constraints on learning. In D. S. Lehrman, R. A. Hinde, & E. Shaw. (Eds.), *Advances in the study of behavior,* Vol. 4. New York: Academic Press.

Siegler, R. S. (1996). *Emerging minds.* New York: Oxford Univ. Press.

Sigman, M., & Kasari, C. (1995). Joint attention across contexts in normal and autistic children. In C. Moore & P. J. Dunham (Eds.), *Joint attention: Its origins and role in development.* Hillsdale, NJ: Erlbaum.

Smiley, S. S., & Brown, A. L. (1979). Conceptual preference for thematic or taxonomic relations: A nonmonotonic age trend from preschool to old age. *Journal of Experimental Child Psychology,* **28,** 249–257.

Smith, L. B. (1979). Perceptual development and category generalization. *Child Development,* **50,** 705–715.

Smith, L. B. (1989). A model of perceptual classification in children and adults. *Psychological Review,* **96,** 125–144.

Smith, L. B. (1999). Children's noun learning: How general learning processes make specialized learning mechanisms. In B. MacWhinney (Ed.), *28th Carnegie Symposium on Cognition.* Mahwah, NJ: Erlbaum.

Smith, L. B., Jones, S. S., & Landau, B. (1992). Count nouns, adjectives, and perceptual properties in children's novel word interpretations. *Developmental Psychology,* **28,** 273–289.

Smith, L. B., Jones, S. S., & Landau, B. (1996). Naming in young children: A dumb attentional mechanism? *Cognition,* **60,** 143–171.

Soja, N., Carey, S., & Spelke, E. (1991). Ontological categories guide young children's inductions of word meaning: Object terms and substance term. *Cognition,* **38,** 179–211.

Spelke, E. S., Breinlinger, K., Macomber, J., & Jacobson, K. (1992). Origins of knowledge. *Psychological Review,* **99,** 605–632.

Spelke, E. S., Phillips, A., & Woodward, A. L. (1995). Infants' knowledge of object motion and human action. In D. Sperber, D. Premack, & A. Premack (Eds.), *Causal cognition: A multidisciplinary debate.* Oxford: Clarendon.

Sternberg, R. J. (1989). Domain-generality versus domain-specificity: The life and impending death of a false dichotomy. *Merrill-Palmer Quarterly,* **35,** 115–130.

Tager-Flusberg, H. (1985). The conceptual basis for referential word meaning in children with autism. *Child Development,* **56,** 1167–1178.

Tager-Flusberg, H. (1994). Dissociations in form and function in the acquisition of language by autistic children. In Tager-Flusberg, H. (Ed.), *Constraints on language acquisition: Studies of atypical children.* Hillsdale, NJ: Erlbaum

Tardif, T., Shatz, M., & Naigles, L. (1997). Caregiver speech and children's use of nouns versus verbs: A comparison of English, Italian, and Mandarin. *Journal of Child Language,* **24,** 535–565.

Terrace, H. S., Pettito, L. A., Sanders, R. J., & Bever, T. G. (1979). Can an ape create a sentence? *Science,* **206,** 891–900.

Thompson, J., & Chapman, R. (1977). Who is ''Daddy'' revisited: The status of two-year-olds' overextended words in use and comprehension. *Journal of Child Language,* **4,** 359–376.

Tinbergen, N. (1951). *The study of instinct.* Oxford: Oxford Univ. Press.

Tomasello, M. (1995). Language is not an instinct. *Cognitive Development,* **10,** 131–156.

Tomasello, M., & Barton, M. (1994). Learning words in non-ostensive context. *Developmental Psychology,* **30,** 639–650.

Tomasello, M., & Farrar, M. J. (1986). Joint attention and early language. *Child Development,* **57,** 1454–1463.

Tomasello, M., & Mervis, C. B. (1994). The instrument is great, but measuring comprehension is still a problem. Commentary on Fenson et al. *Monographs of the Society for Research in Child Development,* **59**(5) 174–197. [serial No. 242]

Tomasello, M., & Todd, J. (1983). Joint attention and lexical acquisition style. *First Language,* **4,** 197–212.

Velleman, S. (1988). The role of linguistic perception in later phonological development. *Applied Psycholinguistics,* **9,** 221–236.

Waddington, C. H. (1957). *The strategy of the genes.* London: Allen & Unwin.

Wales, R., Colman, M., & Pattison, P. (1983). How a thing is called: A study of mothers' and children's' naming. *Journal of Experimental Child Psychology,* **36,** 1–17.

Waxman, S. R., & Kosowski, T. D. (1990). Nouns mark category relations: Toddlers' and preschoolers' word learning biases. *Child Development,* **61,** 1461–1473.

Waxman, S. R., & Markow (1995). Words as invitations to form categories: Evidence from 12- to 13-month-old infants. *Cognitive Psychology,* **29,** 257–302.

Waxman, S. R., & Namy, L. L. (1997). Challenging the notion of a thematic preference in young children. *Developmental Psychology,* **33,** 555567.

Werner, H., & Kaplan, E. (1952). The acquisition of word meanings: A developmental study. *Monographs of the Society for Research in Child Development,* **15.** [serial No. 51]

White, T. G. (1982). Naming practices, typicality, and underextension in child language. *Journal of Experimental Child Psychology,* **33,** 324–346.

Woodward, A. L., & Hoyne, K. L. (1999). Infants' learning about words and sounds in relation to objects. *Child Development,* **70,** 65–77.

Woodward, A. L., & Markman, E. M. (1991). Constraints on learning as default assumptions: Comments on Merriman and Bowman's ''The Mutual Exclusivity bias in children's word learning.'' *Developmental Review,* **11,** 137–163.

Woodward, A. L., & Markman, E. M. (1997). Early word learning. In D. Kuhn & R. Siegler (Eds.), *The handbook of child psychology: Vol. 2, Cognition, perception, and language.* New York: Wiley.

Wynn, K. (1992). Addition and subtraction by human infants. *Nature,* **358,** 749–750.

Yoder, P. J., Warren, S. F., & Biggar, H. A. (1997). Stability of maternal reports of lexical comprehension in very young children with developmental delays. *American Journal of Speech-Language Pathology,* **6,** 59–64.

Zelazo, P. D., Frye, D., & Rapus, T. (1996). An age-related dissociation between knowing rules and using them. *Cognitive Development,* **11,** 37–63.

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