

Shape, Material, and Syntax: Interacting Forces in Children's Learning in Novel Words for Objects and Substances

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In three studies, we examined the roles of ontological and syntactic information in children's learning of words for physical entities, such as objects and substances. In Experiment 1, 3-year-olds and 4- to 5-year-olds, and adults first saw either an Object or Substance Standard labelled with either a mass or a count noun. Transfer items varied in shape and/or material as compared to the Standards. The 3-year-olds attended to ontologically relevant information about the Standard (i.e. its object/substance status), whereas 4- to 5-year-olds and adults used the syntactic context that marked

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the label as a mass or count noun. However, the tendency for 4- to 5-year-olds to use the syntactic context when they heard a label (mass or count) was less pronounced when the Standards were more ambiguous (Experiment 2). In Experiment 3, 3-year-olds who were shown the Object or Substance Standard in a No-Name similarity judgement task, attended to shape for both Standard types. This contrasts with the findings from Experiment 1, and suggests that attention to information about the ontological status of a referent may only become relevant during labelling. Our results reveal a strong and changing developmental interaction for the use of ontologically relevant perceptual information, labels, and syntax. Early ontological/conceptual biases might serve as a scaffold for the later more determinate attention to syntactic information during word learning.

INTRODUCTION

Many students of language learning have noted that it is difficult to explain how young children learn the meaning of a novel word—how they map a string of sounds to the relevant conceptual category (Carey, 1978; Quine, 1960). As a novel word can be multiply interpreted, especially in a single setting, there is no guarantee that the learner's interpretation will be the same as the one intended by the speaker. This learning problem is well illustrated by considering how children learn the names of two ontological kinds: Non-animate solid objects (e.g. *table* or *cup*) and non-solid substances (e.g. *sand* or *water*).

Inanimate objects and non-solid substances are "out there" in the world, they can be named, and they are frequently talked about by parents. But such data by themselves do not suffice to guarantee that the target learning will take place. They offer multiple interpretations: Solid objects are made out of materials and therefore can be construed as an individual entity or example of a given material. While looking at a wooden table, one might choose to talk about "the table" or "the wood". Similarly, non-solid substances can be construed in more than one way: When talking about a puddle of water, one might focus on the liquid and use a mass term ("some water") or the puddle itself and use a count term ("a puddle").

In this paper, we ask how children learn labels for objects and substances. What are the different sources of information that a child learner might attend to and treat as relevant, and how might this change over development? Previous work has found that some relevant sources of information include children's non-linguistic knowledge about ontological kinds and the syntactic context of the label itself (Bloom, 1994b; Gathercole, 1985; Gordon, 1985; Imai & Gentner, 1997; Soja, Carey, & Spelke, 1991). A related issue is whether the relevance of the information changes over development. One possibility is that there are few

developmental changes—children might use precisely the same kinds of information as adults do. Children and adults might both rely heavily on syntactic information, as this is determinate (at least in English) with regard to how the referent is construed: Count nouns encode individuated entities (of which physical objects are one kind), whereas mass nouns encode non-individuated entities (of which physical substances are one kind; see Bloom, 1994b). Syntactic information could therefore direct the learner's attention to the speaker's intended construal (table or puddle: wood or water).

However, it is also possible that there are substantial developmental changes in the relevance of the different information sources. Although the properties of the physical world are not determinate with regard to our construals, there do exist important correlations between perceived properties of the world and certain ontological kinds, and these basic correlations might be important in the acquisition of words for these kinds as well as for their encoding by syntax. Beginning language learners might rely less on syntax and end up weighing such perceptual-ontological links more heavily than older children and adults, in which case their generalisation patterns would be quite different.

The respective roles of syntactic cues and perceptual-ontological links in guiding word learning have important implications for our understanding of how word learners solve the indeterminacy problem. One possibility is that either syntactic information or perceptual information might serve as the principal guide throughout development. Or both sources of information might interact uniformly or in different ways over development, suggesting increasingly complex models in this domain of learning. The issue of how such different kinds of information interact during word learning has served as a cornerstone for recent discussions of the interaction of semantics and syntax (see e.g. Gleitman & Gleitman, 1997; Pinker, 1994). Although literature on the acquisition of object and substance terms has tended to cast discussion in either/or terms (see next sections), developmental evidence in numerous other areas consistently points to the complexity and subtlety of developmental change (see Carey & Gelman, 1991; Smith & Thelen, 1993). It is possible that such a changing developmental landscape characterises even the apparently simple acquisition of terms for objects and substances.

Below, we first review evidence showing that young learners attend to key ontological distinctions when learning names for objects and substances. Then we review the possible perceptual guides to such distinctions. Next we present evidence that child learners attend to the syntactic context when learning object and substance names. Finally, we lay out the logic and hypotheses of our own studies, and the unique contribution that they offer.

Pre-linguistic Ontological Distinctions

Soja, et al. (1991) first assessed the possibility that pre-linguistic ontological distinctions might drive projections of novel object and substance terms. They suggested that there are principled differences between the quantification of objects versus substances: Objects are naturally bounded and can therefore be individuated, whereas substances are not naturally bounded, and hence their quantification requires measures words such as "a glass of" and "a bucket of". Soja et al. proposed that children approach language learning armed with knowledge about such quantificational differences, and that their assumptions of such a basic cut in the physical world lead them to make conjectures regarding the referent class of a new word. For instance, if children observe a novel object and hear a novel label, they should generalise the label to another individuated object, but not to a group of multiple objects, because they know that a single object can never be construed as multiple objects. In contrast, if they observe some portion of a material, specific numerosity should be irrelevant, and hence they should generalise its label to similar material, regardless of the number of portions.

Soja et al. (1991) showed 2-year-olds either an "Object" Standard or a "Substance" Standard and labelled it using neutral syntax (e.g. "This is my blicket"). Children then were shown two test displays, a single object of the same shape as the Standard (but of a different material) and some chunks of the same material as the Standard (but in different shapes). Children who saw the Object Standard generalised the novel name to the single object; those who saw the Substance Standard generalised the name to the single object significantly less often. Because the children did not have productive control over the mass/count distinction, and because there were no syntactic cues in the instructions, they concluded that the children's generalisation patterns were not likely to have been driven by knowledge of the mass/count distinction.

Based on these results, Soja et al. (1991) argued that children's non-linguistic knowledge—a Universal Ontology—serves as a constraint on their learning of word meanings. That is, if children know that sets of objects have numerosities, but portions of substance do not, they should generalise a label from a single object to another single object of the same shape, but not to a set of multiple objects, and should generalise a label from portions of substance to other portions of the same substance, ignoring their shape and number. This is essentially the result they obtained, showing that ontological distinctions that are ascertained through non-linguistic observations can guide generalisation of a novel word.

Soja et al.'s (1991) claim of a universal ontology has been questioned by

Imai and Gentner (1997), who note that this hypothesis would predict no cross-linguistic differences in generalisation patterns, regardless of whether or not the language encodes the mass/count distinction. Imai and Gentner replicated Soja et al.'s experiment on monolingual Japanese and English 2-, 2½- and 4-year-olds as well as adults. Similar to Soja et al., they included complex objects (possessing many parts and suggesting specific functions), simple objects (possessing a single central part), and substances (again, a central part, but composed of a non-solid substance). Furthermore, in order to separate shape and number information, which were confounded in Soja et al.'s study, they presented the material display, either as a single portion or as multiple portions/pieces of the material of the standard entity.

Imai and Gentner (1997) found that for complex objects, both English- and Japanese-speaking subjects attended to shape; for substances, both groups gave fewer shape responses, although only the Japanese subjects showed a material bias. However, for objects with relatively simple shapes, English-speaking subjects attended to shape, whereas Japanese-speaking subjects were equivocal in their responses, attending sometimes to material, but never strongly to shape. Also, none of their participants used number information when extending the novel labels. Based on these findings, Imai and Gentner proposed a "composite model" of word learning which included both conceptual and linguistic influences. They speculate that children initially use ontological knowledge when learning names for canonical objects and substances; however, the particular language being learned influences how children learn names for entities that lie between the two canonical kinds (i.e. simple objects).

Perceptual-Ontological Links

If ontological distinctions are relevant to young children's word learning, an important question is how they identify entities that belong to the different ontological categories? One possibility draws on the strong correlation between sets of perceptual properties and global ontological categories such as the ones discussed by Soja et al. Solid objects are spatially coherent and bounded and they preserve local rigidity, with shape remaining the same over motion (Gentner, 1982; Hoffman & Richards, 1984; Leyton, 1992; Ullman, 1984). In contrast, portions of non-solid substances, such as loose gel or ground coffee, are unbounded and do not maintain their shape over motion. Physical motion tends to disrupt the spatial relationships within such an array, and the spatial result of such disruption is indeterminate. Because the size and shape of a solid object

/s
 remain constant over motion, these constitute invariants that might be used to group together objects of the same kind. In contrast, size and shape are not relevant to the categorisation of kind for nonsolid substances. Indeed, Gentner (1982) has argued that "highly cohesive collections of percept~~y~~ are universally conceptualised as objects", and tend to be labelled by nouns across languages. Based on these differences in the physical properties of object kinds versus substance kinds, children may learn very quickly that shape has good predictive validity for many object kind categories, but not for non-solid substance kinds.

There are other properties that tend to co-occur in solid artefacts as well as many natural kind objects. For example, Leyton (1992) has proposed that certain properties of shape, such as symmetry, tend to suggest a spatial organisation that could not have occurred by chance; thus symmetry may have high predictive validity for objectness, and its particular shape may be predictive of its kind. In contrast, non-solid substances such as liquids or gels tend to undergo radical spatial reorganisation under motion, so the consistent destruction of symmetry relations might have predictive validity for being a non-solid substance, with its particular material composition being predictive of its kind.

Because information about specific perceptual properties has high predictive validity for the different ontological kinds, it can be treated as relevant data for the identification of instances of these kinds. Existing evidence suggests that different properties of solid and non-solid substances may play an especially important role in pointing children towards an object versus substance reading of a stimulus array. Hall (1996) found that 4-year-olds who were shown shapes composed of solid materials (such as paper or plastic) tended to name them as object kinds (e.g. "circle", "bird"), but those who were shown the same shapes composed of non-solid materials (such as peanut butter or jam) tended to name them as substance kinds. Further, names for solid substances are especially hard to acquire, as children's default construal is that of object, not substance (Bloom, 1994b; Dickinson, 1988; Prasada, 1993). Finally, knowledge about the relationship between ontological kind and perceptual property allows inferences from kind to property as well as property to kind: Macario (1991) found that children were more likely to use colour when classifying novel items that they thought were food but were more likely use shape when they thought these same items were something to play with. These results all suggest that young learners look for and keep track of the close relationship between perceptual properties of things in the world and categories, and raise the possibility that such perceptual cues provide critical information for the young learner in assessing just what kind of ontological category a speaker has in mind—that is, object or non-solid substance, and within each, a specific kind.

Syntactic Context

There has long been evidence that linguistic input can play a modulating role in word learning (Brown, 1957; Katz, Baker, & Macnamara, 1974; Landau & Gleitman, 1985). In the original study by Brown (1957), 3- to 5-year-old children overwhelmingly generalised count nouns to objects and mass nouns to substances. Recent evidence indicates that the syntactic context may play an increasingly important role over the course of development; when a language formally marks the ontological distinction between countable and non-countable ^{formally}, learners may recruit this syntactic information while learning new terms for objects and substances (Bloom, 1994a,b; Landau et al., 1992; Soja, 1992). That is, they may use syntactic information as a mental pointer to determine what construal the speaker has in mind. /b

Names for objects and non-solid substances map on to the syntactic distinction between mass and count nouns, respectively, in English and many other languages. Generally, countable entities are encoded by count nouns whereas non-countables are encoded by mass nouns. For example, in English, countable entities are encoded by count nouns such as *chair*, *apple*, *idea*, or *belief* and must be preceded by determiners such as *a*, *another*, *the*, *this*, or *that*. These nouns also can be pluralised or modified by the numerals and quantifiers. Non-countable entities are encoded by mass nouns such as *water* or *knowledge*. They cannot be preceded by determiners that express oneness (**a water*), nor can they be pluralised or appear with numerals and quantifiers, except in specialised cases of coercion (such as "I'll have 3 coffees", Jackendoff, 1997). Mass nouns can, however, take on quantifiers and expressions that encode the nature of particular portions, including *some*, *more*, and *much*, as well as measure words, such as *piece*, *hunk*, or *pile*. The existence of the mass-count distinction—which uniquely specifies a countable versus non-countable entity—raises the question of whether young children might use syntactic context from the very earliest points of learning, to help solve the indeterminacy problem.

Experiments designed to test this hypothesis have typically presented children with stimuli that are labelled by novel count or mass nouns. The stimuli vary in how closely they represent canonical physical cases of individuated versus non-individuated entities—these are often solid objects and non-solid substances, respectively. This variation in stimulus type is often dubbed "semantic" information, presumably because it is assumed to be sufficient to induce the desired ontological reading in children through non-linguistic observation alone. Often this "semantic" information is pitted against syntactic information (mass/count context), in order to determine which kind of information most strongly guides children's generalisations.

Gordon (1985) presented 3½- to 5½-year-old children with count and mass noun contexts that were either in "accord" or in "conflict" with the Object and non-solid Substance Standards. The children performed most like adults when semantic and syntactic cues were in accord (i.e. when objects were named with count nouns, and non-solid substances with mass nouns). When the two kind of cues were in conflict, they interpreted what they observed primarily on the basis of syntactic information, although overall, responses in the "conflict condition" were weaker than in the "accord condition". Although all children showed use of syntactic information, this effect became much stronger over age, suggesting a developmental change in the weighting of syntax relative to information from the perceptual context.

In an extension of her earlier work, Soja (1992) pitted kind of syntactic frame against Standard type by introducing Object Standards with mass nouns and Substance Standards with count nouns. She found a small effect of syntactic context in children as young as 2½-years old: Although they ignored the syntactic context when the labelled entity was an object, some subjects who heard the Substance Standard introduced as "a blicket" generalised on the basis of shape rather than material. Additional evidence for the claim that attention to syntax is weaker among younger children comes from Bloom (1994b), who found that younger children make errors on mass nouns that refer to discrete objects, such as *jewellery and furniture*. The results of these studies suggest that modulating effects of the syntactic context may appear as early as 2 years of age, with increasingly strong effects over development.

The Present Studies

In order to learn a novel name for a novel object or substance, the learner must determine which of many construals the speaker has in mind—this means that at a coarse level, the learner must decide whether the speaker is referring to a countable or a non-countable entity. Given this, generalisation from a countable entity should be to other countable entities of the same kind, and generalisation from a noncountable entity should be to other noncountable entities of the same kind.

Although the foregoing review suggests that both perceptual-ontological information and syntactic information may aid the learner in the fundamental task of targeting the speaker's representation, it is difficult at present to decide whether one of these has priority over the other, or whether the balance of these changes substantially over development. One principal reason for this is that different investigators have typically used quite different stimuli—with each drawing on intuition to suggest what stimulus displays should encourage an object versus substance, or

countable versus non-countable interpretation. Within each experiment, the learners have often been asked to make a forced choice, with only two alternatives and relatively few trials on these (Bloom, 1994b; Soja, 1987, 1992; Soja et al., 1991). This does not invalidate the results, but makes it difficult to evaluate general response biases relative to true generalisation tendencies. Further, experiments that have contrasted semantic/ontological information with syntactic information have typically looked at different age groups using different stimuli, making it difficult to infer a coherent developmental profile.

Thus, although the foregoing studies strongly suggest that there may be complex developmental interactions between these sources of information, a clear test of such interactions would require systematic manipulation of both kinds of information and examination of generalisation to a broad range of stimuli over a substantial developmental range. We hypothesised that when generalising novel labels, children would initially attend to ontological information about the referent; subsequently children, like adults, would attend to syntactic information. We tested this more complex developmental account by manipulating the ontological kind of stimuli as well as the syntactic context in which they were named (mass noun vs. count noun), and then characterising children's and adults' (3-, 4- to 5-year-olds and adults) naming generalisations over a wide range of stimuli (Experiments 1 and 2). Furthermore, if younger children attend primarily to ontological information, a relevant question is whether children at this age treat ontological information as highly salient in all contexts or whether they do so selectively in the context of labelling. Therefore, in Experiment 3, we compared the 3-year-old children's construal of the same stimuli in a labelling ("is this also a dax?") and a no-naming similarity context ("is this the same as this?").

We manipulated the ontological kind of the stimuli by systematically varying the shape and materials out of which they were composed. Initially, the shapes and materials were selected on *a priori* intuitive grounds and ranged from those that we thought strongly suggested a rigid solid object to those that suggested a non-rigid, non-solid substance. The Object Standard had straight edges and distinct corners and was composed of a rigid material; the Substance Standard had curved edges, was rounded overall, and was composed of a non-rigid, non-solid material. Straight versus curved edges tend to suggest rigidity and malleability, respectively (Landau, Leyton, Lynch, & Moore, 1992a; Landau & Leyton, *in press*; Leyton, 1992). The Intermediate Standard (used in Experiment 2) had curved contours with no more than three separate protrusions (which tend to correspond to object parts, Hoffman & Richards, 1984) and was composed of a semi-rigid, semi-solid material.

Next, 10 adults who did not participate in any of the principal

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experiments rated each of the stimuli in terms of how "object-like" or "substance-like" they thought it was. Results showed that, overall, the stimuli were ordered in accord with our intuitions, such that the Object Standard was rated as object-like and the Substance Standard was rated as substance-like. Interestingly, these ratings depended primarily on material compared to shape; that is, material composition appeared to determine whether a display was seen as an object (rigid, solid material), a substance (non-rigid, non-solid material), or in between (semi-rigid, semi-solid; see Appendix for details of results). One reason that shape did not predict ratings of ontological kind might be that we did not manipulate the particular properties of shape in a detailed enough manner. We return to this issue in more detail later.

EXPERIMENT 1 (Main Developmental Study)

Method

Participants. Forty 3-year-olds (3;0-4;0 years; $M = 3;7$ years), 40 4- to 5-year-olds (4;2-5;10 years; $M = 4;10$ years), and 40 adults were tested, with each group approximately balanced for gender. All children were drawn from pre-schools around Columbia University in New York City and were native speakers of English. Adults were undergraduates at the University of California, Irvine.

Design and Stimuli. There were three between-subjects factors: Standard ("Object" or "Substance"), Syntactic Context (Count or Mass noun), and Age (3-year-olds, 4- to 5-year-olds, and Adults). Within each age group, Standard and Syntax were crossed, resulting in four experimental conditions. Ten subjects were randomly assigned to each of the four conditions.

All subjects saw two sets of nine stimuli each. These stimuli were created by crossing three levels of shape and three levels of material. Of the nine stimuli in a set, three served as the Standards across the experiments: Object, Substance, and Intermediate. In the present experiment, only the Object and Substance Standards were used as models for labelling. The remaining six stimuli were test items that were different combinations of the shape and material of the Standards.  shows the Standards and test stimuli from Set 1.

The different levels of the shape and material dimensions were designated as Shape 1, Shape 2, and Shape 3, and Material 1, Material 2, and Material 3. Shape 1 and Material 1 were combined to form the Object Standard, Shape 2 and Material 2 were combined to form the Intermediate Standard, and Shape 3 and Material 3 were combined to form the Substance Standard. The remaining combinations formed the test stimuli.

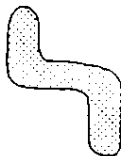
	Material 1 (Caulk)	Material 2 (Brillo)	Material 3 (Glue)
Shape 1			
Shape 2			
Shape 3			
	Object		Substance

Fig 1. Pictures of the nine displays from Set 1.

The materials for Set 1 and Set 2 included dried caulk (when dry, objects made of caulk are rigid and maintain their overall shape) and wood (each designated Material 1), Brillo and cotton (each designated Material 2), and Elmer's glue and salt (each designated Material 3). The materials for Set 1 were blue and the materials for Set 2 were white.

In pilot work, the pre-made Substance Standard appeared static and object-like. In order to minimise the probability of showing it in a "hardened" form and to emphasise instead its temporally changing nature, we created it anew on each trial. This was done by squeezing out the non-solid material (glue or salt) from a squeeze bottle on to pieces of paper, which had been lightly embossed with barely visible marks of the relevant shape on the paper background. All three displays made of the non-solid material were created by this procedure.

Procedures. Subjects in all four conditions were shown a Standard and heard it labelled. In the Object/Count noun condition, they were shown the "Object" Standard and were told: "I am going to show you a *dax*. Here is one *dax*". The Standard remained in full view of the subject. Subjects were

then told, "Now, from what I am going to show you here (pointing to an empty piece of red-coloured paper next to the Standard), I want you to look for *other daxes*. If you think what I am showing you is *a dax*, say 'yes', if you think it is not *a dax*, say 'no'".

Testing then proceeded: Subjects saw each of the nine test stimuli placed one at a time on a sheet of paper (which was placed next to the Standard) and were asked, "Is this also *a dax*?" After they responded, the test item was removed from their view, and the next test item was presented. Each stimulus was tested once, followed by a second run of the stimuli, for a total of 18 test trials. This procedure was repeated for the second test set, resulting in a total of 36 trials over both sets of items.

The same procedure was followed for the other three conditions, except for changes in the type of Standard and the syntactic context in which the novel word was introduced. In the Object/Mass noun condition, the Object Standard was shown and subjects heard, "I am going to show you *some dax*. Here is *dax*. Now, from what I am going to show you here (pointing to an empty piece of red-coloured paper next to the Standard), I want you to look for *some more dax*. If you think what I am showing you is *some dax*, say 'yes', if you think it is not *some dax*, say 'no'". For the remaining two conditions, the Substance Standard was shown and subjects heard it introduced either with a count noun or a mass noun.

Test items that were made out of the rigid and semi-rigid material (for e.g. caulk and Brillo for Set 1) were presented individually, and then removed and placed in a box. For the test items made of the non-rigid material (glue and salt), the substances were squeezed out afresh for each trial. We were concerned that seeing the non-solid material being squeezed out of a bottle might give the subjects cues about non-solid substances, and bias them toward a substance reading of these displays. To control for this possibility, we used a screen for half the subjects in each condition to prevent them from observing the non-solid material actually being squeezed out. For these subjects, the screen was used whenever a Standard or test item was placed on or removed from the coloured piece of paper. Thus, the screen was placed before presenting an item, was taken off for the subject to view the display, and was then placed back again to remove that item and present the next item. The children were told that the screen was used so that they would see a "surprise". If they tried to look over the screen, they were politely told not to peek.

Half the subjects in each condition saw Set 1 first and half saw Set 2 first. Two random orders of presentation were created for each test set, with the constraint that no shape or material could appear three times in a row. The left/right position of the Standard was varied randomly and the nonsense words *dax* and *riff* were counterbalanced across the two sets of items.

Results

We analysed the data in two different ways. First, we analysed subjects' responses to test items that were the Same-Shape versus the Same-Material as the Standard. Second, we conducted overall regression analyses on individual subjects' responses to all of the test items, in order to obtain relative weightings of shape versus material for each subject. Preliminary omnibus analyses of variance tested effects of stimulus set, nonsense-label (*dax* vs. *riff*), and the presence or absence of the screen. There were no effects nor interactions relevant to the hypotheses of interest, hence the data were collapsed across these variables for all age groups.¹

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The mean proportion of "yes" responses to the replica of the Standard (Identity), the Same-Shape items (same shape as the Standard, but different material), and the Same-Material items (same material, but different shape) are shown in [redacted]. Responses to the replica (Identity) were always at ceiling (proportions of "yes" responses ranged from 0.80 to 1.00) and were not included in any analyses. Inspection of the remaining data in the table suggests that the 3-year-olds were influenced primarily by the Standard they viewed—the "Object" or "Substance"—whereas the 4- to 5-year-olds and adults were strongly influenced by the syntactic context.

The mean proportions of "yes" responses to the Same-Shape and Same-Material items were submitted to a 2 (Standard) $\times$ 2 (Syntax) $\times$ 3 (Age) $\times$ 2 (Item: Same-Shape vs. Same-Material) mixed analysis of variance, with

¹ Omnibus analyses of variance tests were conducted on the total number of "yes" responses summed across all nine items, with Condition and Screen as between-subjects factors, and Set as a within-subjects factor. These revealed no significant main effects or interactions for the adults and 4- to 5-year-olds (all P s $> .05$). There was, however, a reliable interaction of Condition and Screen [$F(3,32) = 4.45$, $P = .01$] for the 3-year-olds. *Post-hoc* analyses of the data from this age group revealed that in the Object/Mass noun condition, subjects in the No-Screen group gave a reliably greater number of "yes" responses compared to subjects in the Screen group (Tukey's HSD = 17.4, $P < .01$). As the Object displays were pre-made and not created afresh on each trial, there appears to be no principled reason to account for this difference; furthermore, across all experiments, this was the only reliable effect of Screen. We therefore assumed that this was a random effect, and collapsed data over the Screen variable.

² Depending on which Standard was viewed, responses to different items were used to calculate each of these proportions. For example, the proportions of "yes" responses to the Same-Shape items for subjects who saw the Object Standard (Shape 1/Material 1), were calculated by summing the number of "yes" responses to the Shape 1/Material 2 and Shape 1/Material 3 items and dividing by 8 (the total number of possible responses for these two items, from 2 stimuli $\times$ 2 replications $\times$ 2 sets); for subjects who saw the Substance Standard (Shape 3/Material 3), the Same-Shape responses were computed from the responses to the Shape 3/Material 1 and Shape 3/Material 2 items.

TABLE 1
Mean Proportions (SD) of "Yes" Responses as a Function of Age, Syntax,
and Standard (Experiment 1)

Age	Syntax	Identity	Same-Shape	Same-Material
<i>Object Standard</i>				
3 years	Count	0.95 (0.11)	0.90 (0.20)	0.36 (0.40)
	Mass	0.90 (0.21)	0.86 (0.18)	0.49 (0.45)
4-5 years	Count	0.95 (0.16)	0.90 (0.16)	0.25 (0.42)
	Mass	0.80 (0.33)	0.44 (0.34)	0.68 (0.40)
Adults	Count	0.95 (0.16)	0.70 (0.42)	0.20 (0.35)
	Mass	1.00 (0.00)	0.31 (0.29)	0.88 (0.27)
<i>Substance Standard</i>				
3 years	Count	0.80 (0.20)	0.54 (0.40)	0.55 (0.42)
	Mass	0.83 (0.26)	0.56 (0.39)	0.78 (0.21)
4-5 years	Count	0.98 (0.08)	0.57 (0.43)	0.20 (0.30)
	Mass	0.93 (0.17)	0.30 (0.40)	0.70 (0.44)
Adults	Count	1.00 (0.00)	0.66 (0.36)	0.43 (0.47)
	Mass	1.00 (0.00)	0.21 (0.34)	0.85 (0.24)

Note: Here Identity refers to the item identical to the Standard, Same-Shape refers to the items composed of the same shape but different material from the Standard, and Same-Material refers to the items composed of the same material, but different shape from the Standard.

Item as the within-subjects factor. There was a main effect of Age [$F(2,108) = 3.68, P < .05$], two-way interactions between Standard and Item [$F(1,108) = 8.45, P < .01$] and Syntax and Item [$F(1,108) = 38.96, P < .01$], and a three-way interaction among Syntax, Age, and Item [$F(2,108) = 4.68, P < .01$]. Planned comparisons showed that the interaction between Standard and Item was due to the fact that subjects who saw the Object Standard accepted more Same-Shape items than Same-Material items [$t(118) = 2.66; P < .01$], whereas those who saw the Substance Standard showed no difference between the items [$t(118) = 1.46$]. Further comparisons within age showed that this effect was actually specific to the youngest age group. Three-year-olds who saw the Object Standard accepted more Same-Shape items than Same-Material items [$t(38) = 3.30, P < .01$], but those who saw the Substance Standard showed no difference between items [$t(38) = .92, n.s.$]. The 4- to 5-year-olds and adults showed no reliable effects of Standard type in their acceptance of Same-Shape versus Same-Material items [all $t(38) < 1.16, n.s.$].

A qualitatively different developmental pattern emerged, however, from the interaction of syntax, age, and item. Planned comparisons showed reliable effects of syntactic context for the 4- to 5-year-olds and adults, but

not for 3-year-olds. Specifically, the 4- to 5-year-olds and adults who heard count noun syntax accepted more Same-Shape than Same-Material items, whereas those who heard mass noun syntax accepted more Same-Material than Same-Shape items [all $t(38) > 2.45$, $P_s < .05$]. There was no effect of syntax among the 3-year-olds [$t(38) = 1.61$, n.s.]; further comparisons confirmed that the syntactic context was not effective for the Object [$t(18) = 1.22$, $P > .05$] and Substance Standards [$t(18) = 1.33$, $P > .05$].

A second analysis considered subjects' responses to all nine test stimuli. Each subject's responses to the test items were summarised by individual regression analyses to determine whether the subject had responded on the basis of shape versus material. For the regression analysis, the psychological distance of the item from the Standard (or the number of yes responses to each test item) was the dependent variable to be predicted and the predictors were shape and material parameters derived from a model of the stimulus space. Recall that the nine stimulus items were created by crossing three levels of shape with three levels of material; accordingly, the analysis treated shape and material as separate and independent dimensions.

Our model predicts that the psychological distance of a test item from the Standard is a sum of its psychological distance from the Standard on the shape and material dimensions. The psychological distance on each dimension can be decomposed into two *fixed* steps of *unequal* size³ between each pair of levels on that dimension (e.g. between Shape 1 and Shape 2, and between Shape 2 and Shape 3) and a multiplicative parameter that represents the "salience" of differences on that dimension. The size of any step within a dimension (e.g. the distance between Shape 1 and Shape 2) is assumed to be the same for all subjects. A subject is presumed to match each item to the Standard by following the city-block metric,³ that is, by mentally adding the size of the fixed psychological distances between the Standard and the test item, with each distance weighted by the salience of that dimension. For example, the distance between the Object Standard (Shape 1/Material 1) and the Shape 3/Material 3 test item is the sum of the weighted step sizes between Shape 1 and Shape 2, Shape 2 and Shape 3, Material 1 and Material 2, and Material 2 and Material 3. The combination of the fixed psychological distance weighted by the salience value yielded the shape and material parameters,

³ According to Garner (1974), research on similarity measurement suggests that integral dimensions, such as value and chroma (or brightness and saturation), combine to conform to a Euclidean metric, whereas separable dimensions such as shape and size, combine to conform to a city-block metric. Because shape and material/texture are separable dimensions, and the word learning literature shows that children selectively attend to them, we used the city-block metric in our analysis.

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which were entered in the regression analyses as the predictors (see Subrahmanyam, 1993, for more details).

The resulting regression coefficients yielded one shape and one material parameter (each parameter varying from -4 to $+4$) for each of the two fixed steps. Thus, there was a total of two shape and two material parameters, and these parameters were summed to yield overall Shape and Material parameters for each subject. The difference between the Shape and Material parameters was computed to yield the Shape Salience measure, which is the overall weighting of shape relative to material when a subject matched the test items to the Standard. A positive value for the Shape Salience measure indicates that shape was more salient, whereas a negative value indicates that material was more salient. / E

Figure 1 presents the mean shape and material parameters, as well as the mean Shape Salience as a function of Standard, Syntax, and Age. Among the 3-year-olds, Shape Salience depended on which Standard was observed: Shape was the most salient property for the Object Standard, regardless of syntactic context. In contrast, among the 4- to 5-year-olds and adults, the observed Shape Salience values varied depending on the syntactic context, with shape being stronger for the count noun context.

The Shape Salience values were submitted to a 2 (Standard) $\times$ 2 (Syntax) $\times$ 3 (Age) analysis of variance, with Standard, Syntax, and Age as between-subjects factors. There were main effects of Standard [$F(1,104) = 6.155$, $P = .01$], Syntax [$F(1,104) = 32.38$, $P < .01$], and Age [$F(2,104) = 3.19$, $P < .05$] and an interaction between Syntax and Age [$F(2,104) = 5.53$, $P = .01$]. Figure 2 presents the mean values of Shape Salience as a function of Standard, Syntax, and Age.

Planned comparisons revealed that the main effect of Standard was due to a preference for shape among subjects who saw the Object Standard (M Shape Salience = 0.89 , collapsing over syntactic context), compared to those who saw the Substance Standard (M Shape Salience = -0.23 , collapsing over syntactic context), [$t(114) = 2.34$, $P < .05$]. The interaction of Age and Syntax reflects a reliable effect of the syntactic context for the 4- to 5-year-olds and adults [$t(38) = 4.27$ and 5.19 , respectively, P s $< .01$], but not for the 3-year-olds [$t(38) = 0.70$, $P > .05$]. When the 4- to 5-year-olds and adults heard the novel word in the Count noun context, they weighted shape more strongly than material, regardless of the Standard they saw (collapsing across Standard, M shape Salience = 2.22 and 1.59 for the 4- to 5-year-olds and adults), whereas those who heard the word in a Mass noun context weighted material more strongly than shape, regardless of the Standard they saw (collapsing across Standard, M Shape Salience = -1.13 and -2.48 for the 4- to 5-year-olds and adults). In contrast, the 3-year-olds tended to generalise on the basis of shape in both syntactic contexts, as long as they observed the Object Standard.

TABLE 2
Mean Values (SD) of the Shape (Sh) and Material (Mat)
Parameters and the Shape Salience Measure as a
Function of Age, Standard, and Syntax (Experiment 1)

	Shape	Material	Shape Salience (Sh-Mat)
Count Noun			
<i>3 years</i>			
Object	2.42 (1.55)	0.20 (0.31)	2.22 (1.66)
Substance	1.18 (1.92)	1.07 (1.55)	0.11 (3.12)
<i>4-5 years</i>			
Object	3.03 (1.43)	0.33 (0.65)	2.70 (1.82)
Substance	2.54 (1.32)	0.80 (1.38)	1.74 (2.61)
<i>Adults</i>			
Object	2.86 (1.30)	0.85 (1.10)	2.01 (2.17)
Substance	2.50 (1.64)	1.33 (1.83)	1.17 (3.42)
Mass Noun			
<i>3 years</i>			
Object	2.04 (1.85)	0.21 (0.25)	1.83 (1.83)
Substance	0.48 (1.13)	0.89 (1.97)	-0.41 (2.02)
<i>4-5 years</i>			
Object	0.57 (1.33)	1.27 (2.59)	-0.70 (3.00)
Substance	0.87 (1.55)	2.43 (1.47)	-1.57 (2.91)
<i>Adults</i>			
Object	0.57 (0.96)	3.13 (0.93)	-2.57 (1.66)
Substance	0.70 (1.16)	3.10 (1.46)	-2.40 (2.60)

Summary

Both Standard type and syntactic context had powerful effects on the way that novel items were construed, and hence on the way the novel word was generalised. However, the effects were developmentally quite different. Ontological kind governed the 3-year-olds' generalisations, whereas syntactic context governed the 4- to 5-year-olds' and adults' generalisations.

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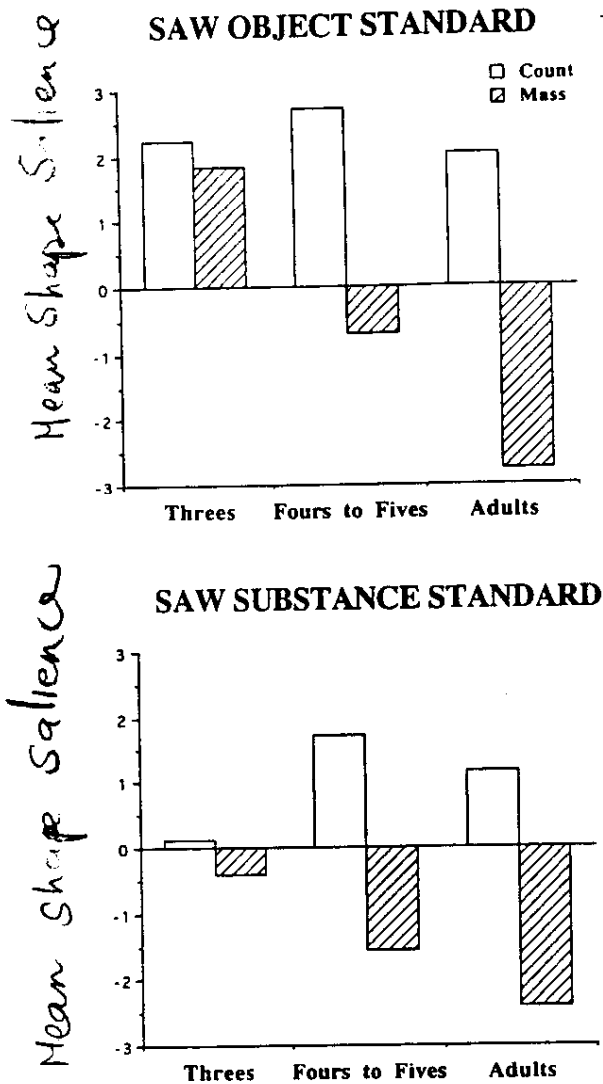


FIG. 2. Mean values of the Shape Salience measure as a function of Age, Standard, and Syntactic context (Experiment 1).

An important concern when interpreting the results of the youngest children is our finding that when rating the ontological status of our stimuli, adults attended to material, and not shape; one reason for this might be that we did not manipulate shape in a detailed enough manner when creating the stimuli. Despite the apparent lack of variability in the

balanced for gender. All subjects were drawn from the same pools as in Experiment 1.

Design, Stimuli, and Procedures. These were identical to those of Experiment 1, with the exception that all subjects were shown the "Intermediate" Standard (Shape 2/Material 2; see Fig. 1). As before, half of the subjects heard the novel word as a count noun (Intermediate/Count noun) and half heard it as a mass noun (Intermediate/Mass noun).

Results

Preliminary analyses revealed no main effects or interactions with Set, Nonsense label (*dax* vs. *riff*), and Screen. Hence, data were collapsed over these variables. [redacted] shows the mean proportions of "yes" responses to the Identity items as well as to the Same-Shape and Same-Material items.

The mean proportion of "yes" responses to the Same-Shape and Same-Material items were submitted to a mixed analysis of variance, with Item (Same-Shape vs. Same-Material) as a within-subjects factor and Syntax (Count vs. Mass) as a between-subjects factor. No reliable main effects or interactions were obtained (all P s > .05).

Assessing subjects' overall responses to all test items as before, the Shape Salience measure was derived and analysed using a one-way analysis of variance, with Syntax (Count vs. Mass) as the between-subjects factor. Although the signs of the mean Shape Salience measure [redacted] suggest that subjects who heard count syntax weighted shape more heavily than material ($M = 2.00$), and that those who heard mass syntax weighted material more strongly than Shape ($M = -1.50$), this was not a reliable difference [$F(1,18) = 3.72, P > .05$].

In sum, although there was no reliable effect of syntax among the participants who observed the Intermediate Standard, the general direction of the results were consistent with those of Experiment 1;

TABLE 3
Mean Proportion (SD) of "Yes" Responses for the 4- to 5-
year-olds (Experiment 2)

<i>Syntax</i>	<i>Identity</i>	<i>Same-Shape</i>	<i>Same-Material</i>
Count	0.88 (0.21)	0.73 (0.30)	0.48 (0.20)
Mass	0.98 (0.08)	0.53 (0.44)	0.71 (0.40)

Note: Here, Identity refers to the item identical to the Standard; Same-Shape refers to the items composed of the same shape but different material from the Standard; and Same-Material refers to the items composed of the same material, but a different shape from the Standard.

Same 4

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TABLE 4
Mean Values of the Shape (Sh) and Material (Mat)
Parameters and the Shape Saliency Measure as a Function
of Syntax for the 4- to 5-year-olds (Experiment 2)

Standard	Shape	Material	Shape-Saliency (Sh-Mat)
Intermediate			
Count Syntax	2.10 (2.36)	3.60 (3.33)	-1.50 (5.40)
Mass Syntax	2.33 (1.69)	0.33 (1.50)	2.00 (1.94)

children who heard count syntax showed a trend toward weighting shape more strongly than material and those who heard mass syntax showed a trend toward weighing material more strongly than shape. Recall that the motivation for Experiment 2 was to assess whether effects of the syntactic context might be stronger when perceptual information in the setting was more ambiguous. Contrary to our expectations however, observing an "ambiguous" Standard did not lead to enhanced effects of the syntactic context; even more surprisingly, attention to the syntactic context was lessened when the Standards were more ambiguous. Clearly, more work is needed to clarify the conditions under which learners attend to syntax when inferring the meaning of novel nouns.

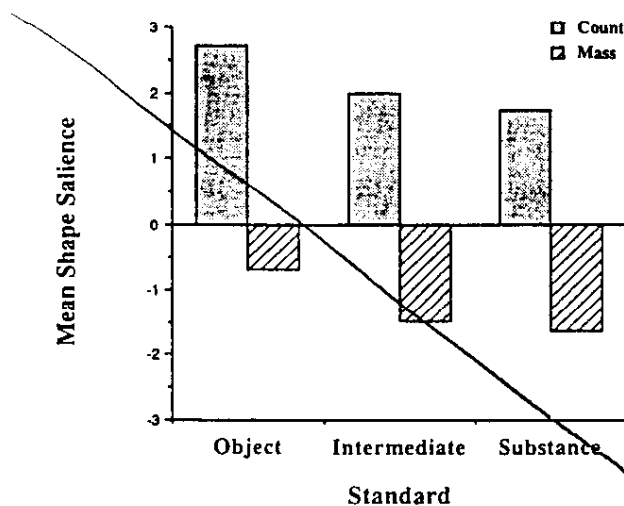


FIG. 3. Mean values of the Shape Saliency measure as a function of Standard and Syntax for the 5-year-olds (Experiments 1 and 2).

In Experiment 3, we explore further the salience of ontological kind among younger children. Recall that the 3-year-olds in Experiment 1 attended to shape for the object and material for the substance suggesting that they attended to the ontological status of the named stimulus and ignored the syntactic class of the novel noun. It is not clear whether this attention to ontological kind information was a default strategy used in the context of physical entities or whether it was triggered by the presence of a label. In Experiment 3, we investigate this question using a No-Name similarity task ("is this the same as this?") with the identical stimulus sets used in Experiment 1. Data from this experiment were then compared with those from the 3-year-olds in Experiment 1.

EXPERIMENT 3 (No-Name Study)

Method

Subjects. Twenty-four 3-year-olds (3;0–4;1 years; $M = 3;6$ years) participated, half in each of two conditions, roughly balanced for gender. All children were drawn from preschools in Los Angeles and were native English speakers.

Design, Stimuli, and Procedures. The stimuli and procedures were identical to those in Experiment 1, except for the instructions. Subjects were shown either the Object or Substance Standard and were told, "See this?" (pointing to the Standard). Then each test item was placed next to the Standard and subjects were asked, "Is this (the test item) the same as this (the Standard)?" The results of using this context, in which the Standard was not named, were compared to those from Experiment 1, in which the Standard was named with a Count or Mass noun.

Results

Preliminary analyses revealed no main effects or interactions with screen or set; hence the data were collapsed and analysed as in the previous experiments. The mean proportion of "yes" responses to the Same-Shape and the Same-Material items show that subjects attended to shape regardless of whether they saw the Object or Substance Standard (see  No-Name condition). These data were submitted to a mixed analysis of variance with Standard as the between-subjects factor and Item (Same-Shape vs. Same-Material) as the within-subjects factor, resulting in a reliable effect of Item [$F(1,22) = 10.08, P < .01$], with Same-Shape items accepted more often than Same-Material items.

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TABLE 5
Mean Proportion (SD) of "Yes" Responses for the 3-year-olds (Experiments 1 and 3)

<i>Standard</i>	<i>Identity</i>	<i>Same-Shape</i>	<i>Shape-Material</i>
<i>No-Name (Exp. 3)</i>			
Object	0.98 (0.07)	0.74 (0.39)	0.49 (0.47)
Substance	0.90 (0.20)	0.72 (0.29)	0.33 (0.40)
<i>Name (Exp. 1)</i>			
Object	0.93 (0.16)	0.88 (0.19)	0.43 (0.42)
Substance	0.81 (0.23)	0.55 (0.39)	0.66 (0.34)

Note: Here, Identity refers to the item identical to the Standard; Same-Shape refers to the items composed of the same shape but different material from the Standard; and Same-Material refers to the items composed of the same material, but a different shape from the Standard.

As in Experiment 1, regression analyses were performed to derive the shape and material parameters and the Shape Salience measure for each condition (see Table 6, No-Name condition). Shape Salience was analysed using a one-way analysis of variance, with Standard and between-subjects factor. There was no reliable effect of Standard [$F(1,17) = 0.49, P > .05$]. Unlike the results of Experiment 1, Shape Salience in the No-Name condition did not differ as a function of Standard type: Subjects weighted shape strongly whether they observed the Object or Substance Standard.

The data from subjects in the No-Name Study were compared directly to those of the 3-year-olds in Experiment 1, who heard the Standard labelled with either a Count or Mass noun. As there was no effect of the syntactic context among the 3-year-olds in that experiment, their data were collapsed across syntactic condition into a "Name" condition (see Table 5, Name condition).

The proportions of "yes" responses to the Same-Shape and Same-Material items were analysed by a 2 (Standard) $\times$ 2 (Name/No-Name) $\times$ 2 (Item) mixed analysis of variance, with Item as the within-subjects factor. This analysis yielded a main effect of Item [$F(1,60) = 12.78, P < .01$] and an interaction among Standard, Name/No-Name, and Item [$F(1,60) = 8.23, P < .01$]. The three-way interaction was analysed by 2 complex comparisons, one for each Standard, in which we compared the difference between the Name and No-Name groups on their preference

TABLE 6
Mean Values of the Shape (Sh) and Material (Mat)
Parameters and the Shape Salience Measure as a
Function of the Standard for the 3-year-olds (Experi-
ments 1 and 3)

<i>Standard</i>	<i>Shape</i>	<i>Material</i>	<i>Shape-Salience (Sh-Mat)</i>
<i>No-Name (Exp. 3)</i>			
Object	2.00 (1.39)	0.67 (0.89)	1.33 (1.89)
Substance	2.21 (1.18)	0.51 (1.19)	1.70 (2.10)
<i>Name (Exp. 1)</i>			
Object	2.23 (1.65)	0.20 (0.28)	2.30 (1.70)
Substance	0.83 (1.57)	0.98 (1.72)	-0.15 (2.56)

for Same-Shape versus Same-Material items. Subjects who saw the Object Standard showed no reliable difference between the Name and No-Name conditions; subjects in both conditions preferred Same-Shape to Same-Material [$t(31) = 1.24, P > .05$]. However, among subjects who saw the Substance Standard, there was a preference for Same-Shape over Same-Material in the No-Name condition, whereas there was no such preference in the Name condition [$t(31) = 2.88, P < .01$]. A complex comparison showed that, in the No-Name condition, subjects preferred Same-Shape regardless of the Standard they observed, whereas in the Name condition, this was true only for subjects who saw the Object Standard [$t(63) = 2.93, P < .01$].

The comparison of Name and No-Name conditions showed a similar overall pattern for the Shape Salience measure (see Table 6). A 2 (Standard) $\times$ 2 (Name/No-Name) between-subjects analysis of variance yielded a reliable interaction of Standard with Name/No-Name [$F(1,51) = 4.47, P < .05$]. Planned comparisons showed that for subjects in the No-Name condition, there was no difference in Shape Salience between those who saw the Object Standard ($M = 1.33$) versus those who saw the Substance Standard ($M = 1.70$), [$t(22) = 0.40, n.s.$], whereas in the Name condition there was a reliable difference in Shape Salience between subjects who saw the Object Standard ($M = 2.03$) versus those who saw the Substance Standard ($M = -0.15$), [$t(38) = 3.08, P < .01$]. Finally, a complex comparison of this difference between the No-Name and Name condition was reliable [$t(63) = 2.36, P < .05$], showing that the name condition pulled children towards shape for the Object Standard and away from Shape for the Substance Standard.

Summary

The results of the No-Name study build on our earlier findings among 3-year-olds. In a similarity judgement task with no label, children at this age chose the Same-Shape items regardless of whether they saw the Object or Substance Standard. However, the presence of a label appeared to focus their attention on the ontological category of the Standard: They attended to shape for the Object Standard, and moved away from shape and towards material for the Substance Standard. Apparently, the presence of a label alone, regardless of its specific syntactic form, can influence 3-year-olds' interpretations of object and substance displays.

GENERAL DISCUSSION

Our goal was to examine the relative roles of ontology, perception, and syntactic context and their interactions over development as they guide children's learning and generalisation of novel names for objects and substances. Our studies reveal a rather complex developmental trajectory in which conceptually relevant perceptual information may serve as a scaffold for the later use of syntactic constraints on word meaning.

Among 3-year-olds, the use of a label (whether mass or count) encouraged an interpretation consistent with ontological category. When 3-year-olds heard the Object Standard labelled, they generalised the name on the basis of shape; when they heard the Substance Standard labelled, they tended to generalise on the basis of material. Altering the syntactic context did not change this pattern.

Interestingly, when the Object or Substance Standards were not labelled for 3-year-olds, these young children used shape to generalise for both Standard kinds. Their construals of the Object and Substance Standards as an object or a mass of stuff, respectively, apparently were not a necessary consequence of perception, but rather, were linked to the categorisation of these Standards by words. These results are consistent with previous findings by Soja et al. (1991) that children generalised labels on the basis of ontological category (object, substance) when they were introduced in a neutral syntactic context (i.e. "This is my dax"). Converging evidence about the effect of labels comes from Markman and Hutchinson (1984), who report a link between words and taxonomic categories; this effect appears in infants as young as 12- to 13-months of age (Waxman & Markov, 1995). Together, they suggest that the relevance of ontological information during the early stages of word learning must follow from the general context of a label and not from specific information about the count/mass categorisation of the label.

By the age of 5 years, the developmental picture changes substantially.

Children are guided strongly by syntactic context; when shown the Object and Substance Standards, 4- to 5-year-olds and adults generalised novel count nouns on the basis of shape, and novel mass nouns on the basis of material. A similar, although not reliable effect of syntax was obtained when the 4- to 5-year-olds were shown the "ambiguous" Intermediate Standard (i.e. those judged to be moderately Object-like and moderately Substance-like).

Given these findings, we revisit the issues which motivated our study: How links between ontological kinds and perceptual properties, as well as language, interact developmentally to guide children's learning of novel words for object or substance.

Perception and Ontology

We hypothesised that in the early stages of word learning children's generalisation of a referent's label would depend on their interpretation of the referent as an object versus a substance. Furthermore, we conjectured that certain properties of ~~references~~ ^{referents} such as their shape and material would guide them to an "object" interpretation, whereas others might guide them toward a "substance" interpretation. Consequently, our Object Standards were relatively angular, symmetrical, and rigid, whereas our Substance Standards were less angular and symmetrical, and were composed of non-rigid materials.

Although adult ratings confirmed that the Object Standard was perceived as object-like and that the Substance Standard was perceived as substance like, adults' interpretation of the stimulus as an object or a substance appeared to have been dominated by material (see Adult Rating Studies, Appendix). Whether an item's material was rigid or non-rigid was more important in adults' judgements of object or substance than were specific properties of shape, such as symmetry and angularity. The shapes we used for the Object Standard were more angular and symmetrical than those of the Substance Standard. However, the differences in shapes might not have been as systematic or as varied as the difference in the materials of our displays. Still, our results are consistent with the proposal that an item's rigidity and consequently its construal as an object versus a substance might be critically linked to its material (see Landau & Leyton, in press; Landau, Leyton, Lynch, & Moore, 1996).

Ontology, Naming, and Relevance

As predicted, the youngest children generalised novel nouns on the basis of ontological kind. Of special note is the finding that their attention to

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ontological kind was strongly affected by the presence of a *name*. In the No-Name context, 3-year-olds were likely to match both the Object and Substance Standards to other stimuli on the basis of their shape, suggesting that shape was very salient to them, and readily available as the basis for generalisation. In the Name context, however, children generalised on the basis of shape when they saw the Object Standard, but not when they saw the Substance Standard. The presence of the name changed children's assumptions about what, in the perceived array, was relevant. (See also Gelman, 1972, and Massey, 1988, for related evidence that what the child makes of a task influences what in the stimulus array they attend to.)

The striking difference in generalisation patterns between the two tasks suggests that the inductive processes involved in world learning might be separate from those involved in other types of similarity tasks (e.g. our No-Name question, "Is this the same as this?"). The apparent preference for shape in the No-Name context would be obtained if the children were strictly concerned with questions of perceptual similarity, ignoring information relevant to category membership. Because sameness of shape is important for many intuitions about object similarity, children could judge on the basis of shape similarity, even if not considering sameness of kind. For instance, a child might judge a round lampshade to be similar to the moon on the basis of overall shape, without considering whether they are both of the same kind (either the category of objects or that of natural kinds).⁴

Ontological kind information is apparently not relevant to children in all contexts, but becomes so selectively, as in the context of word learning. Despite a general preference for shape in the No-Name similarity task, children reliably attended to different properties of the Standards in the Name task. This result suggests that labels guide learners' attention to properties that are relevant to categorising the referent as an object or substance. This highlights the problem faced by the child when learning words for objects and substances: Children's unbiased observations are not so determinate so as to force one reading of an input rather than another. Words push their interpretations in certain systematic directions, with increased shape-based responding for the Object Standards, and increased material-based responding for the Substance Standards. What the words alone could not do, however, was to push the younger children's interpretations just one step further, to bypass the preferred interpretation of each Standard, and focus on the material of the Object Standard or the shape of the Substance Standard. This required syntax.

⁴ We thank Paul Bloom and an anonymous reviewer for suggesting this to us.

Naming and Syntax

Our findings indicate that by the age of 5 years, the syntactic context of naming becomes so salient that when one is viewing a table, learning the label "wood" is as likely as learning "a table"; similarly, when viewing a pool of water on the road, learning "a puddle" is as likely as learning "some water". Whereas the nature of the Standard guided younger children's attention to either shape or material in the Name task, older children's and adults' attention was modulated primarily by syntactic cues in a similar situation.

Despite the strong reliance on the syntactic context among our 5-year-olds, we still found some remnants of a preference for object shape. Anecdotal evidence suggests that these children were uncomfortable construing a rigid object in terms of its material (at least, in this context): When we labelled the Object Standard with a mass noun, many were visibly confused and hesitated before responding. In a similar vein, Soja (1992) reported that 2½-year-old children used syntactic information to modulate their construals of non-solid Substance displays, but did not use syntactic information to modulate their construals of Object displays. This suggests that syntactic information may be first and most useable in contexts where it correlates with preferred perceptual and conceptual biases to produce a robust interpretation.

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The overall pattern of our results that there is a shift in attention from ontological information to syntactic information is consistent with a growing literature, which suggests that the syntactic and morphological context become increasingly salient over development. In a number of experiments, investigators have found that initial perceptual or conceptual preferences are later modulated to yield the flexible interpretations characteristic of natural languages. For example, 3-year-olds tend to generalise novel object count nouns on the basis of object shape, even when surface texture is highly salient (Smith, Jones, & Landau, 1992). This attention to shape holds even when the novel word is introduced as an adjective (Landau, Smith, & Jones, 1992b; Smith et al., 1992; see also Au & Markman, 1987). However, 5-year-olds and adults who hear a novel adjective generalise on the basis of surface texture, indicating that their attention is guided by syntactic and morphological cues. Syntactic context can also play an important role in guiding young children's attention to different levels of taxonomic hierarchies (Waxman, 1990; Waxman & Hall, 1993), and in pointing to a categorical versus individual reading of a noun (Gelman & Taylor, 1984; Katz et al., 1974).

Studies on the acquisition of verbs also indicate an increasingly salient role for syntactic cues over development. Fisher, Hall, Rakowitz, and Gleitman (1994) presented 3- and 4-year-olds and adults with action

scenes, which were described using novel verbs in varying linguistic contexts. In one context, no syntactic information was provided: Subjects heard "Ziffing!" while observing a scene, for example, of one toy animal pushing another, which fell to the ground. Two other contexts included syntactic information: one represented the agent as subject (e.g. "The bunny is ziffing (pushing) the monkey!") and the other represented the patient as subject (e.g. "The monkey is ziffing (falling)!"). In the neutral context, subjects of all ages interpreted the novel verbs as agentive, when for example reporting that "ziffing" meant "pushing". This "agency-bias" was modulated by syntactic context for all age groups; however, the effects were categorical for adults, whereas they were only probabilistic for children. For example, when adults heard "The monkey is ziffing", they categorically guessed that the verb meant "falling", thus running against the agency bias. When children heard this context, only about half of them guessed "falling", while a substantial proportion guessed "pushing", the verb consistent with the agency-bias but inconsistent with the syntactic context. These findings are consistent with our own in suggesting an increased attention to the syntactic context in overriding non-linguistic perceptual or conceptual preferences.

One issue that remains is the age at which children begin to attend to the syntactic context when generalising labels. Our finding that 3-year-olds attended to the overall presence of a label, but not its specific syntactic category is in contrast to those of Soja (1992), who found a weak effect of syntax among 2½-year olds and Bloom (1994b), who found an effect of the syntactic context among 3- and 4-year-olds for non-material entities (e.g. sound). Some of the difference between our finding and that of Soja's and Bloom's may be due to difference in method. Our method of requiring yes/no judgements for a single test object is more demanding than the forced-choice method used by them, in which children "have" to choose one of two options. The difficulty of our method is reflected in our observation that some of the 3-year-olds in our study slipped into a pattern of responding "yes" to all the test items. Another possibility is that the count and mass cues might have played a weak, but undetected role in guiding the generalisation patterns of the 3-year-olds in our study. This is an empirical question, and can be tested by comparing generalisation in a mass/count context with a context in which the Standard receives a label in neutral syntax with no clues about the mass/count status of the noun (*the dax*). Regardless, the differences in our results, possibly due to differences in method, suggest that attention to syntax might not be robust at younger ages, and consequently might be more susceptible to demands of the task context. Clearly, more research is necessary to identify accurately when children start attending to syntax and also to identify the factors that influence attention to syntax among younger children.

Universal Ontology and Naming

The strong and changing developmental interactions among perception, word, and syntax shed some light on the role of ontology in early word learning, at least among English speakers. Based on their results, Soja et al. (1991) proposed that a universal ontology drives children's early interpretations of novel words. Our own findings confirm that ontological information is especially salient in young children's generalisations of novel nouns.

Soja et al.'s interpretation of a universal ontology emphasised the role played by numerosity in the structure of the test pairs. They argued that children conceptualise some entities as individuated and others as non-individuated, and that this knowledge leads to the use of number information on object trials but not on substance trials. As a further consequence, they suggested that number, not perceptual information such as shape and material, is critical to constraining children's projection of word meanings (see also Carey, 1994). However, both Imai and Gentner's (1997) study, in which children saw either single or multiple portions, and our work, in which children were shown a single test object after the Standard, call into question the idea that the object-substance distinction is yoked to considerations of numerosity.

Instead, the child's use of basic ontological categories (object, substance) appeared to depend on whether or not examples were paired with labels. Children in our experiment attended to shape for both Standards when they were asked to judge whether test items were "the same" as the target Standard. They generalised differently for the two Standards when each was labelled. This suggests that the word served as a mental pointer to a kind—in this case, an object kind or a substance kind. This implies that children use context to decide what kind of data are relevant for a given task. Put differently, children alter their ideas of what inputs are relevant for a given learning task as a function of their interpretation of the goal of the task and the setting (see also Gelman, 1972, 1990). Once again, it is clear that an explanation of the miracle of word learning must include an account of the young learner's ideas of what are and what are not relevant aspects of information in the environment (Landau & Gleitman, 1985).

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