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Ontological categories guide young children's inductions of word meaning: Object terms and substance terms*

NANCY N. SOJA
Northeastern University

SUSAN CAREY
Massachusetts Institute of Technology

ELIZABETH S. SPELKE
Cornell University

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Abstract

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Three experiments assessed the possibility, suggested by Quine (1960, 1969) among others, that the ontology underlying natural language is induced in the course of language learning, rather than constraining learning from the beginning. Specifically, we assessed whether the ontological distinction between objects and non-solid substances conditions projection of word meanings prior to the child's mastery of count/mass syntax. Experiments 1 and 2 contrasted unfamiliar objects with unfamiliar substances in a word-learning task. Two-year-old subjects' projection of the novel word to new objects *respected the shape and number of the original referent. In contrast, their projection of new words for non-solid* substances *ignored shape and number. There were no effects of the child's knowledge of count/mass syntax, nor of the syntactic context in which the new word was presented. Experiment 3 revealed that children's natural biases in the absence of naming do not lead to the same pattern of results. We argue that these data militate against Quine's conjecture.*

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Introduction

Young children are word-learning wizards, acquiring new vocabulary at the prodigious rate of 8 to 10 items each day (Carey, 1978; Miller, 1977). Their achievement is especially intriguing at the early stages of word learning, when word meanings are most radically underdetermined by the evidence available to the child. When a child hears a word (say "George") while attending to an object (say a man), the word could refer to the individual (i.e., George himself), the type of object (e.g., person or man), an action involving the object (e.g., eating), a part of the object (e.g., ear), a property of the object (e.g., dirty), the substance of which the object is composed (e.g., skin), an abstraction that the object embodies (e.g., virtue), among countless other options. How do young children find their way through this labyrinth of possibilities to master the meanings of words?

Word learning prior to ontological commitments: Quine's view

Quine (1960) suggested that the youngest children do not master word meanings in ways that honor the above distinctions. Rather, ontological categories such as *object* and *substance* emerge as a consequence of language learning. Such distinctions therefore are not available to guide the acquisition process during the early stages of language learning.

More specifically, Quine suggested that children learn language by detecting contingencies between words and other perceptual experiences. Generalization of a word to a new experience is determined by global perceptual similarity within a "quality space" defined by the detectability and salience of perceptual dimensions. Because the young child has made no ontological commitments, each of his words refers only to "a history of sporadic encounters, a scattered portion of what goes on". Early words function most like mass nouns in the child's conceptual system.[1] For example, "book" refers to a portion of book experience, "mama" to a portion of mama experience (Quine, 1960, 1969). Portions can be scattered – a portion of water can be distributed in drops over a table or collected in a cup. Similarly, portions of mama and book can be scattered or not. Children only begin to distinguish among different types of word meanings involving different types of quantification when they learn the syntax of quantification: determiners, plurals, and quantifiers such as "three", "some", and "another".

[1]Of course, Quine himself would not speak of concepts, mental representations, or conceptual systems; in this discussion we are "cognitivizing" Quine's claims.

Quine's proposal actually embodies two separate, partially independent, claims. The first claim (hereafter Claim 1) is that until children have learned the syntax of quantification they do not conceptualize the world in terms of objects, non-solid substances, properties, and so on. That is, these ontological distinctions play no role whatsoever in the child's mental life. The child does not see a rock and a stick as inherently more similar to each other than a rock and a pile of mud.

According to the second claim children's perceptual/cognitive system may well pick out solid objects in the world, realizing, for example, the differing consequences of grasping objects versus non-solid substances. The concern of the second claim is how the child *quantifies* over these different types of entities. Quine's deep insight was that quantification is at the heart of the distinctions among different types of conceptual entities. Suppose children say "table" every time they see a table. We would not credit them with the same concept of *table* as we have if they could not represent the conceptual distinction between one table on different occasions and two different identical tables. This quantificational distinction underlies the difference between count nouns and proper names. Similarly, we would not credit them with the same concept of *table* as we have if they conceived of tables as any portions of experience that shared a common shape, or if they conceived of any part of a table as also a table. The language quantifies over tables differently from over sand or wood; tables are directly countable whereas sand and wood must be put into portions (cups of sand, sticks of wood) in order to be counted. Quine's second claim (hereafter Claim 2) is that until children have learned the syntax of quantification they lack any concepts of individuated whole objects, like "a table", or "Mama", and of portions of substances, like "this pile of sand" or "this stick of wood".[2]

According to Quine, then, when children hear a new word, the meaning they assign to it is determined by Procedure 0:

Procedure 0 — Conclude that the word refers to aspects of the world that share salient properties of the perceptual experience when the word is used.

Psychologists have endorsed versions of Procedure 0 as well. Clark (1973), for example, conjectured that early words referred to salient perceptual properties. Landau, Smith, and Jones (1988) have added that the salient property

[2]Some languages do not have a count/mass distinction. It is possible that there are languages with no syntactic devices at all for conveying the quantificational distinction between individuated and non-individuated entities. According to Quine's position, people speaking these languages would not be able to make the ontological distinction between objects and substances.

that is weighted most strongly in this perceptual space is shape.

There is a problem with the mechanism Quine offers for how children come to share the ontological commitments of their language community. Consider, for example, the quantifiers that distinguish mass terms (e.g., "more water") from count terms (e.g., "another stick"). If a child already understood "water" to refer to portions of a kind of substance and "stick" to refer to individual whole objects, then he might discover the meanings of "more" and "another" by observing that each expression was used when an additional individual of the appropriate kind appeared ("another stick") or an additional portion of the appropriate kind appeared ("more water"). However, if the child understood "stick" to refer to a part of stick experience, it is not clear what would prevent him from concluding that "another stick" means *more stick stuff*, *more stick experience*. Although Quine (1960) hints at the ways in which children work out the syntax of quantification, no explicit or plausible account of the learning process has been given.

An alternative: Ontological commitments prior to word learning

This problem motivates an alternative to Quine's view: children may approach the task of learning language with a pre-existing set of ontological categories. That is, from the earliest stages of language acquisition, ontological commitments embodying the quantificational system of natural language syntax may guide their learning of new words. If humans approach the task of learning language with the ontological categories of object and substance, then their learning of words might proceed as follows. As in Quine's account, a child would detect a contingency between a word and a perceived state of the world. The child would represent the relevant state of the world, however, as a solid object or a non-solid substance (Step 1 of Procedures 1 and 2), provided that his perception centered on an entity of the appropriate type. Generalization of the word to new states of the world would depend on this representation, according to Procedures 1 and 2. Step 1 of each procedure embodies a denial of Claim 1; Step 2 embodies a denial of Claim 2.[3]

Procedure 1 Step 1: Test to see if the speaker could be talking about a solid object; if yes,

[3]The procedures children use include many additional components. For example, very young children are sensitive to whether they already know a word for the entity being named (Markman & Wachtel, 1988), and very young children have procedures for deciding whether the word picks out a type or an individual (Gelman & Taylor, 1984; Katz et al., 1974). Here we will focus on the object/substance distinction and the quantificational distinction between individuals and portions.

Step 2: Conclude the word refers to individual whole objects of the same type as the referent.

Procedure 2 Step 1: Test to see if the speaker could be talking about a non-solid substance; if yes,

Step 2: Conclude the word refers to portions of substance of the same type as the referent.

With respect to Quine's first claim, research with young infants suggests that prelinguistic humans conceptualize solid objects in a way that distinguishes them from non-solid substances (Spelke, 1985). For human infants, solid objects are bodies that are cohesive, bounded, spatiotemporally continuous, and solid or substantial; they move as connected wholes, independently of one another, on connected paths though unoccupied space. There is no research on infants' appreciation of non-solid substances, such as liquids, gels, and powders, in terms of the same parameters that define objects for infants. Non-solid substances are spatiotemporally continuous and substantial, but not cohesive or bounded; they do not retain either their internal connectedness or their external boundaries as they move and contact one another.

Even if infants make a principled distinction between objects and non-solid substances, it does not follow that they quantify over representations of entities of each type, nor that this distinction is relevant for word learning. Two quantificational distinctions are relevant to Procedures 1 and 2: that between individuated entities and portions of non-individuated entities and that between unique individuals and types. A given car could be conceptualized as a portion of metal and glass, as a car-shaped portion of experience, or as an individual whole object. Once it is so conceptualized, it could be thought of as a token of a type ("a hatchback", "chrome") or as a unique individual ("my own car Bessie", "my favorite pile of metal"). Notice that the quantificational distinction between individuals and portions of unindividuated entities is conceptually prior to the distinction between unique individuals and tokens of a type.

Methodological issues and problems

Despite the wealth of recent research on language acquisition, existing studies of children's word learning do not distinguish between Quine's thesis, embodied in Procedure 0, and the alternative outlined above, embodied in Procedures 1 and 2. The failure of research to distinguish these views is surprising, because many observations and experiments appear to suggest that the Quinean view is wrong.

For example, observations of child language during the one-word stage (i.e., before the productive use of syntax) reveal that children quickly gain productive command of object words such as "ball", substance words such as "milk", and non-referential expressions such as "hi". Nevertheless, these observations do not reveal whether such words have the same meanings for young children as they have for adults. Each might refer to a scattered portion of what goes on, consistent with Quine's view. In fact, other observations suggest that the Quinean interpretation may be correct. Many psychologists have argued that children's earliest word meanings are sometimes complexive (Bowerman, 1978; Dromi, 1987; Vygotsky, 1962). That is, children appear to extend words to new referents on the basis of any of the salient perceptual properties of the original referent. These complexive uses often violate ontological categories, as when "paper" apparently refers to the act of cutting, to the act of drawing, to pens and pencils, and to paper (Dromi, 1987). If such uses actually reflect attempts to name, rather than other speech acts, these observations support Quine's claim. Even after the decline of complexive overgeneralizations at about 18 months (Dromi, 1987), we do not know whether words like "ball" refer to kinds of objects or perceptual properties like shape (see below).

Potentially better evidence that prelinguistic ontological commitments guide word learning comes from experimental studies of word learning. The distinction between objects and substances (or objects and parts) has been investigated in a number of experiments. Children have been taught a new word in the presence of an unnamed object and then tested on their generalization of the word to new objects. Children generalized words to new objects that adults would describe as whole individuated objects of the same type, rather than to perceptually similar entities that were not objects of the same type. For example, children generalized a word that was initially applied to one object to a new object of the same shape, in preference to a new object of a different shape but the same material, and in preference to a new object consisting only of a part of the original object (Markman & Wachtel, 1988).

Unfortunately, these findings do not permit a choice between the Quinean view and its rival, for two reasons. First, the subjects in most of these studies were over $3\frac{1}{2}$, old enough to have mastered the relevant natural language syntax. It is not clear whether their ontological commitments preceded or followed their acquisition of the corresponding syntactic forms. Second and more seriously, these studies do not reveal whether children interpreted the new word as a term for a type of individuated object or in some other way more congenial to Quine's view. For example, Landau et al. (1988) have suggested that children's first nouns refer to shapes: "book" means *book-shaped*, "clock" means *clock-shaped*, etc. Unlike adults, that is, children may think that "clock" would refer to a clock-shaped pile of ashes and not to time-keeping devices that are not round. This suggestion will be discussed, and criticized, below (see General discussion). It is consistent, however, with the Markman and Wachtel findings. Early learning of words for objects could depend exclusively on processes of contingency detection and generalization through a quality space in which shape is a highly salient dimension.[4]

A better method

These problems suggest what a better test of Quine's thesis requires. First, such a test must focus simultaneously on children's learning of words for entities in different ontological categories. If children generalize words to new situations on the basis of global perceptual similarity, then the same perceptual dimensions (such as shape) should govern generalization regardless of the ontological category of the referent. In contrast, if ontological distinctions govern word learning, then generalization to new instances should depend on the ontological category of the entity to which the child first hears the word applied. Second, to capture how the child quantifies entities of different ontological categories, the choices offered to the child for generalization must reflect different quantificational options. Specifically, if the distinction between *portion* and *individual* is at issue, the options offered should vary in the numbers of pieces or piles the entity is broken into. Third, such a test must focus on children's inductions at the very beginning of language learning, before they begin to understand and use the quantificational syntax of mass terms and count terms.

The research reported here attempts to meet these requirements. Children were presented with two word-learning tasks. In one task, they were taught a new term for a solid object. In a second task, they were taught a new term for a non-solid substance. After learning the term, they were tested for generalization to two new instances: one instance that matched the original

[4]A classic study by Katz, Baker, and Macnamara (1974; see also Gelman & Taylor, 1984) is relevant both to the quantificational distinction between types and individuals and to that between individuated entities and portions. Katz et al. showed that 17-month-old girls restricted a new proper noun "Dax" applied to an unfamiliar doll to that doll itself, while a new common noun "a dax" was generalized to other dolls of the same type. Unfortunately, this study also does not settle the argument against Quine. First, the children already knew the English syntax distinction between proper and common nouns, so it is possible, as Quine suggested, that they worked out the semantic distinction between unique individuated entities and types in the course of learning the syntax. Second, these data do not rule out the possibility that the dolls were being conceptualized as Quine said. For example, proper nouns might simply require a greater degree of similarity than common nouns on the same similarity space. To be Dax, like being Mama, means that the portions of experience so named must share more of the perceptually salient attributes than to be a dax or a woman.

instance in *shape* and *number* but not *substance*, and one instance that matched the original instance in *substance* but not *shape* or *number*.

On object trials, a word was introduced in the presence of a solid object, and then children were tested for generalization to a new object of the same shape versus three pieces of the same substance. If the ontological category of "object" governs generalization then children should generalize to the new single object; the requirement that objects be cohesive (Spelke, 1985) rules out the three spatially distinct bodies as one object. Additionally, if the subjects know that objects are quantified over individuals then they should rule out the three spatially distinct bodies as another individual object of the same type.

Nonetheless, selection of the new single object could as easily be explained by a Quinean quality space in which shape similarity or numerical similarity is more important than substance, color, or texture similarity. This possibility was tested by the substance trials. A word was introduced in the presence of a non-solid substance appearing in one (or several) piles. Children were then tested for generalization to the same substance in a different number of piles (several or one) versus a different substance in the same number and shape of piles as the original exemplar. If generalization depends on global perceptual similarity within a quality space free of ontological distinctions, then children should show the same generalization patterns for the substance trials as for the object trials. In contrast, if generalization is based on the categorization of an entity as an object or substance, and if substances are quantified over portions, then a different pattern of generalization should be seen. Children should generalize the substance word to the same substance in a new number of piles and not to the different substance in the same number of piles. The spatial distribution of parts of a portion of material are irrelevant to the identity of the material.

Our experiments were conducted with very young children, aged 2 years or 2 years, 6 months. Two-year-olds do not command count/mass syntax; $2\frac{1}{2}$-year-olds are in the process of mastering it (Gordon, 1982, 1985). Children's command of the relevant syntax was tested in two ways. First, comprehension of count/mass syntax was tested by teaching children the new words for objects and for substances under two conditions: a neutral syntax condition and an informative syntax condition. In the neutral syntax condition, the subcategorization of the word was ambiguous; in the informative syntax condition, selective count syntax was used with the term applied to the object and selective mass syntax was used with the term applied to the non-solid substance. If children comprehend the syntactic distinction, then their adherence to Procedures 1 and 2 should be greater in the informative syntax condition. Second, productive command of count/mass syntax was tested by obtaining speech production samples from each child and assessing his or her mastery of noun phrase syntax. If mastery of syntax leads to mastery of principles 1 and 2, as Quine proposed, then children who do not benefit from the informative syntax and who have not begun to produce the relevant count/mass syntax should fail to honor these principles.

Experiment 1

Method

Subjects

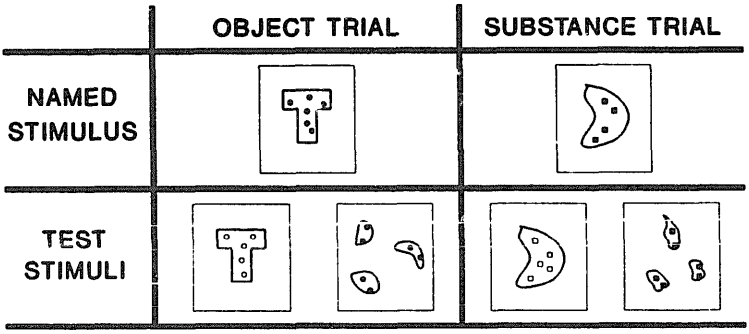
Subjects were 24 2-year-olds (mean age, 2;1), ranging from 1;10 to 2;3. They were recruited from the greater Boston area and randomly placed into two groups (neutral syntax and informative syntax) with equal numbers of boys and girls in each group. Testing was begun with three other subjects but not finished; these three had no understanding of the task and could not complete a trial. Testing was conducted at the subjects' homes. The subjects received $5.00 each for their participation.

Procedure and stimuli

Each testing session began with two familiar trials: one object trial and one substance trial. The stimuli in the familiar object trial were a blue plastic cup, a white styrofoam cup, and cup pieces. The stimuli in the familiar non-solid substance trial were peanut butter and Play-doh. These trials followed the same format as the unfamiliar trials described below. The two familiar trials were followed by eight unfamiliar trials: four object trials and four substance trials which were intermingled. The subjects were tested on each trial on two separate occasions. Eight novel words were used: "blicket", "stad", "mell", "coodle", "doff", "tannin", "fitch", and "tulver". Each word was used to refer to substances and objects across subjects.

An unfamiliar object trial in the neutral syntax condition. The child was presented with an unfamiliar object (see Figure 1). Four different sorts of objects were used: apple corers (orange plastic and aluminum); plumbing fixtures shaped like a "T" (copper and white plastic); childhood toys often called cootie catchers or fortune tellers (orange acetate and silver paper) and honey dippers (wooden and clear plastic) (see the Appendix for pictures of some of the stimuli). The objects were given names. For example, the experimenter said "This is my blicket". The experimenter then continued to talk about the object using "my", "the", and "this" for determiners. She and the subject manipulated the object. The object was placed to the side and two

Figure 1. *An example of an object trial and a substance trial in Experiment 1 (filled circles indicate metal, open circles indicate plastic, filled squares indicate Dippity-do, and open squares indicate lumpy Nivea).*



other sets of objects were presented directly in front of the subject. One set contained one object that was the same sort of object as the original but made out of a different material. For example, if the original object was a metal "T", then the second object was a plastic "T". The other set of objects contained three or four chunks made of the same material as the original object. They were small and in arbitrary shapes (see Appendix). In the present example they would have been four small pieces of metal. The experimenter said, "Point to the blicket". Both objects of each type were used as the named object across subjects.

An unfamiliar substance trial in the neutral syntax condition. Figure 1 shows a sample unfamiliar substance trial. The child was shown one of the unfamiliar substances and was told, for example, "This is my stad". The experimenter referred to the substance using only "my", "the", and "this" for determiners. The substance was presented in a single pile for half of the trials and in three or four small piles for the other trials. The experimenter and the subject talked about the substance and played with it. In the presentation of test substances the subject was shown two substances, the original and the new one, and told "Point to the stad". The original substance was in the alternative configuration, whereas the new substance was in the configuration used originally with the named substance. There were four pairs of substances: (1) Dippity-do (a setting gel) and lumpy Nivea (a hand cream mixed with gravel); (2) coffee (freeze-dried) and orzo (a rice-shaped pasta); (3) sawdust and leather (cut into tiny pieces); and (4) Crazy Foam and clay. Of each pair one member was named and the other was used as the alternative to the original in the test presentation. Each member served in both roles across subjects.

The syntax used in the neutral condition determined that the new word was a noun, but did not indicate whether it was a count noun or a mass noun. However, if the subjects knew both count/mass syntax and its relation to objects and substances, half of the substance trials provided syntactic evidence about the referent, namely the substance trials in which the original substance was presented in multiple piles. To see why, consider "This is my glass". If the referent is a single glass made out of glass, the syntax is neutral as to whether the object or substance is the referent. However, if the referent is many glasses, then "glass" must be being used as a mass noun because only mass nouns are used with singular verbs and singular nouns when referring to multiple items.[5]

Object and substance trials in the informative syntax condition. The informative syntax condition differed from the neutral syntax condition only in the determiners and quantifiers used when naming the original stimulus. The experimenter introduced an object trial in the informative syntax condition with "This is a blicket" and used "a blicket" and "another blicket" in subsequent discussion. Substance trials in the informative syntax condition were introduced with "This is stad" and in subsequent discussion the experimenter continued to omit determiners or use "some" or "some more". These determiners were chosen because in production they are among the earliest selective determiners used by 2-year-olds (Gordon, 1982). Also, in comprehension, 3-year-olds can determine the subcategorization of a noun based on its previous occurrence with one of these determiners (Gordon, 1985). The trials in the neutral and informative syntax conditions differed only in the introducing events; in both cases the test items were prefaced with the neutral "Which is the xxx?"

Before and after testing the experimenter played with the subject. The entire period of involvement with the subject was tape recorded, but only the productions from the play periods were used in the analyses of linguistic competence. Competence with count/mass syntax can be defined in different ways. One definition is that competence is achieved when the child's use of determiners and plural endings differs depending on the noun type. When children achieve this level of competence, they are using two different systems of individuation and quantification. It is this aspect of the count/mass distinc-

[5]Collective nouns are also used with singular verbs and refer to multiple items. For example, "family" is a count noun that is used with a singular verb to refer to multiple items in the sentence: "Everyone in the family is here". If the subjects interpret the noun as a collective noun referring to a particular arrangement of small piles, then on the test trials they should choose the other substance arranged similarly, and thus do *worse* on the non-solid substance trials in which the original stimulus is in small piles.

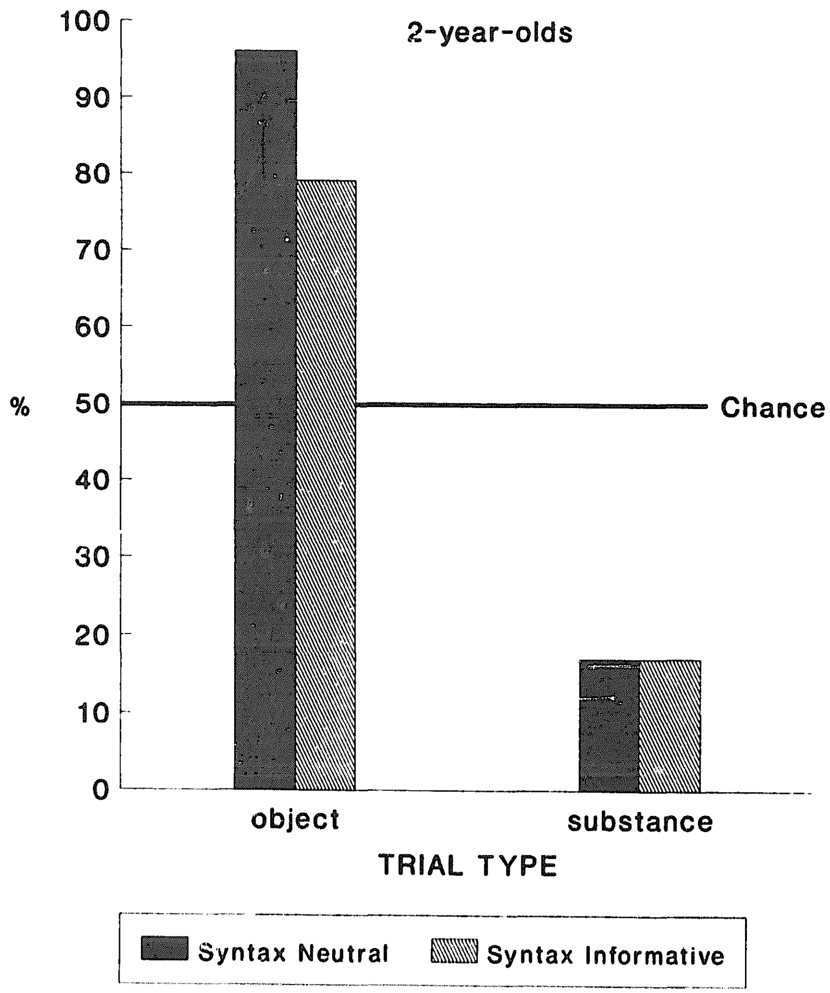
tion that reflects the object/substance distinction and that is relevant to Quine's argument. Therefore, a syntax score was found for each subject that reflected their ability to use determiners and plural endings differentially for the two kinds of nouns.

Results and discussion

Familiar word trials

The data are depicted in terms of the percentage of trials in which the child matched the shape and number of the originally named stimulus. Points above 50 indicate that the subjects chose the stimulus of the original shape

Figure 2. *Mean percentage of responses by shape and number as a function of trial type (Experiment 1, familiar word trials).*



and number, as predicted for the object trials. Points below 50 indicate that the subjects chose the stimulus of the original substance, as predicted for the substance trials. The further a point is from 50 in either direction, the further it is from chance.

Not surprisingly, subjects in both conditions did well on the familiar object trials. That is, they said that the cup was the cup, rather than the group of pieces of a previously named cup (neutral syntax condition: 96%; informative syntax condition: 79%). They also did well on the familiar substance trials. That is, for example, they said that pieces of Play-doh were Play-doh, rather than a single pile of peanut butter shaped like an earlier named pile of Play-doh (neutral syntax condition: 17%; informative syntax condition: 17%). A 4-way repeated-measure ANOVA compared the effects of session (First × Second), trial type (Object × Substance), syntax group (Neutral × Informative), and sex of subject (Female × Male). There was a significant main effect of trial type ($F(1,20) = 61.489$, $p < .001$). No other main effects or interactions were significant (all Fs < 2.7, ps $> .118$). The subjects' performance significantly differed from chance on both kinds of trials (object: $t(23) = 8.351$, $p < .001$, 2-tailed; substance: $t(23) = 5.826$, $p < .001$, 2-tailed). In sum, the subjects differentiated the object and substance trials, as predicted.

Word-learning trials

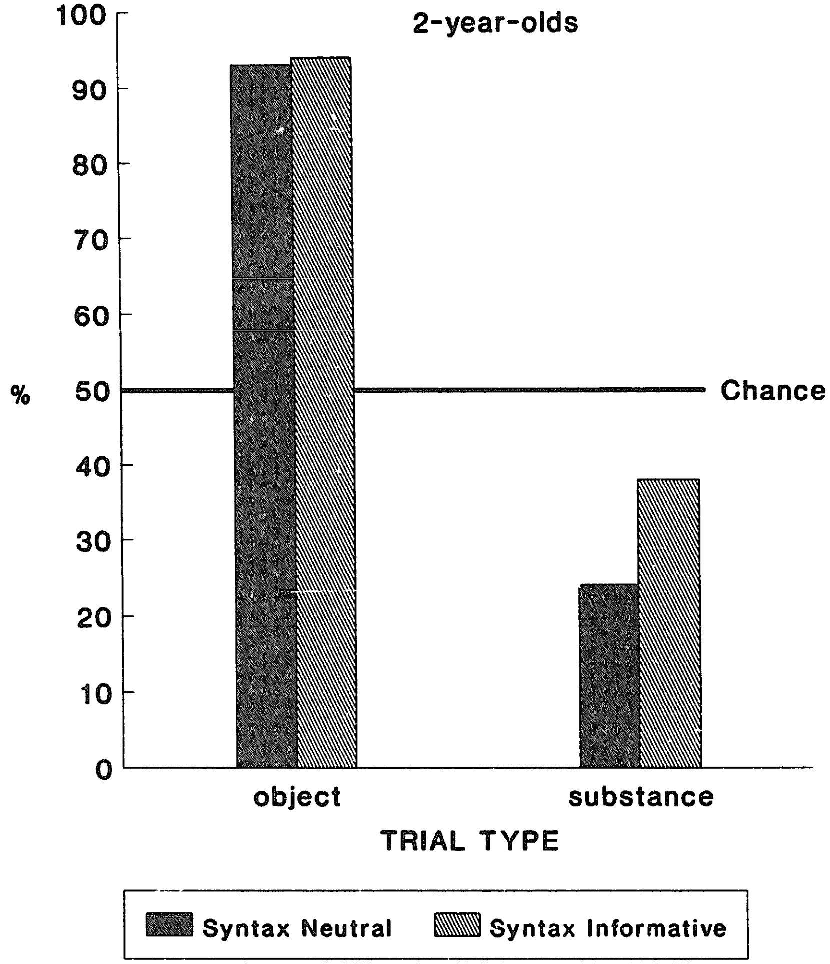
Subjects differentiated the two types of trials. Responses were consistent with shape and number on the object trials (neutral syntax: 93%; informative syntax: 94%) and were not consistent with shape and number on the substance trials (neutral syntax: 24%; informative syntax: 38%).

A 4-way repeated-measure ANOVA analyzed the effects of session (First × Second), stimulus pairs (the 8 different stimulus pairs – 4 object and 4 substance), syntax group (Neutral × Informative), and sex of subject (Female × Male). The only significant effect was stimulus ($F(7,140) = 29.266$, $p < .001$: all other Fs < 1.992, ps $> .174$). A pre-planned contrast testing the difference between the object trials and the substance trials was significant ($F(1,140) = 202.105$, $p < .001$). In fact, 99% of the total sum of squares is attributable to this contrast. Performance on both the object trials and the substance trials was significantly different from chance (object: $t(23) = 23.3$, $p < .001$, 2-tailed; substance: $t(23) = 3.6$, $p < .002$, 2-tailed).

The subjects performed more consistently on the object trials than the substance trials. There was a significant difference between the degree to which the object scores differed from chance compared to the degree to which the substance scores differed from chance ($t(23) = 4.897$, $p < .001$, 2-tailed).

A separate ANOVA compared the substance trials in which the substance

Figure 3. *Mean percentage of responses by shape and number as a function of trial type (Experiment 1, word-learning trials).*



was named in one big pile and the trials in which it was named in three or four small piles. The two did not differ ($F(1,22) = .226$, $p = .64$).

In sum, the children chose according to object type when the stimulus was an object and according to substance type when the stimulus was a non-solid substance. However, the subjects were more consistent when the stimulus was a solid object than when it was a non-solid substance. There was no effect of the syntactic context: performance was neither facilitated nor hindered by the additional syntactic information. Performance also was not affected by the configuration of the named substance in the substance trials.

Production data

Productive competence was assessed for 22 of the 24 subjects. One subject was not yet talking and therefore had no productions to assess. Another subject had a cold – which greatly affected his desire to talk, but not his desire to do the experiment, which all children found fun.

Most nouns used were count nouns (1467 count noun tokens compared to 153 mass noun tokens). The children's count/mass syntax was not very developed. Determiners were usually omitted (55% of count noun tokens and 75% of mass noun tokens). Plural inflections were also infrequent (15% of count noun tokens and 2% of mass noun tokens).

Approximately half (52%) of the mass noun types were non-solid substance words. No solid substance words (e.g., "metal", "plastic") were used. The other mass nouns referred to abstract entities (e.g., "magic"), superordinate substances (e.g., "food", "stuff"), and entities ambiguous as to their status as solid or non-solid substances (e.g., "grass", "ground"). Although children may well first learn non-solid substance words through their experience with food, 25% of the non-solid substance types were not food words (e.g., "sand", "toothpaste").

In order to assess each child's productive command of count/mass syntax, we examined the use of selective count noun frames. Nouns that appeared in neutral syntactic frames (e.g., "the dog", "the mud", "my house", "Sandy's sand") were removed from the analysis (15% of the noun tokens). We then calculated for each subject the percentage of count nouns occurring in selective count noun contexts – "a (noun)", "one (noun)", "(noun)-s", "the (noun)-s", "some (noun)-s", and "two (or a higher number) (noun)-s". High scores should indicate good control of count syntax, except for the fact that some subjects used "a" indiscriminately with count nouns and mass nouns, which yielded a high score that was misleading. To correct for such indiscriminate use, we subtracted from that score the percentage of mass nouns used in selective count noun contexts. The resultant score could be as high as 1, indicating full command of count syntax and differentiation of count and mass nouns, or as low as 0, indicating no productive control of this syntactic distinction.[6] The scores ranged from 0 to .88 (mean .38). Thus, there was a considerable range of control of count syntax. The two groups (syntax neutral and informative syntax) did not differ (neutral: .30; informative: .47; $t(20) = 1.517$, $p > .14$, 2-tailed).

[6]Negative scores were also possible – a child using "a" indiscriminately, but not all the time, could by chance use it on a higher proportion of mass nouns than count nouns. Since this reflects no productive control of the distinction, such scores, of which there were a total of 2, were converted to zeros.

To test whether subjects who distinguish objects from substances in the word-learning task have better command of count/mass syntax, we also needed a measure for each subject that reflected the child's differentiation of the object and substance trials. We took the difference between the object and substance scores. Difference scores ranged from 0 to 100 (mean .59), with high scores reflecting good differentiation of object and substance trials. There was no correlation between the syntax scores derived from the analysis of the subjects' speech and the word-learning scores ($r = .06$, $p > .3$, 1-tailed).

The lack of correlation could reflect the fact that the variability in the word-learning score was primarily due to performance on the substance trials (because performance was essentially at ceiling on the object trials) while the syntax score reflected competence with *count* syntax. This was unavoidable; when children omit determiners and plurals, they produce a correct mass frame ("(noun)"), but many children of this age omit determiners and plurals from all nouns. Consequently, a syntax score based on the discriminating use of mass noun syntax would be essentially the same as the score we did use, since the variance would be due to count nouns used in count noun syntactic frames.[7] The score we used reflected the differentiation between count and mass nouns as well as the use of count noun syntax, and it correlated with the number of mass nouns used ($r = .54$, $p < .005$, 1-tailed). Thus, it does reflect the child's emerging command of count/mass syntax and can be used to explore Quine's conjecture.

Procedures 1 and 2 have two steps relevant to the two interpretations of Quine's claim. Step 1 requires that children represent the distinction between objects and substances, and condition their projection of word meaning upon classifying the referent as one or the other. Step 1 thus embodies the denial of Claim 1, namely that young children do not represent the ontological distinction between objects and non-solid substances. The data from Experiment 1 show that different inferences about the meaning of a newly heard word are drawn according to the ontological status of its referent. If the word refers to an object, the child's projection respects shape and number, and ignores texture, color, and substance. If the word refers to a non-solid substance, the child's projection ignores shape and number, respecting texture, color and substance.

[7]We did construct such a score. The percentage of mass nouns appearing in the frames "(noun)" and "some (noun)" was found for each child. To ensure that the score reflected command of mass noun syntax and not the general omission of determiners, it was corrected by subtracting from it the percentage of count nouns appearing in the same frames. These scores ranged from 0 to .87 (mean: .34) and were nearly identical to the syntax score based on selective command of count noun syntax ($r = .99$, $p < .001$, 1-tailed). And there was again no correlation between this score and the word-learning score ($r = -.07$, $p > .3$, 1-tailed).

The data do not support Quine's conjecture that children learn the ontological distinction between objects and substances through mastering syntactic devices for individuation and quantification. There was no effect of productive control of count/mass syntax on performance on this task, even though many of the subjects had no productive control. Perhaps children's language production underestimates their knowledge of count/mass syntax. With this in mind we assessed whether the syntactic context in which a newly heard word occurred constrained our subjects' hypotheses about its meaning. It did not; subjects in the informative syntax condition performed no better than those in the neutral syntax condition. This was even true of the substance trials, on which our subjects were not at ceiling. Further, there was no difference in performance between the substance trials in which the named substance was in one big pile and the substance trials in which the named substance was in multiple small piles. Apparently, 2-year-old children do not exploit the syntactic information derivable from the fact that mass nouns can be used with singular verbs to refer to scattered portions.

We will hold off discussion of how the child is *quantifying* over objects and substances (Step 2 of Procedures 1 and 2; Quine's second claim) until the general discussion.

Experiment 2

Another difference between the two kinds of trials in Experiment 1, besides the ontological status of the referent, might have been responsible for the pattern of results. The solid objects had complex shapes and the non-solid substances were put into simple piles. Perhaps, as indicated by Procedure 0, when children hear a new word, their first hypothesis about its meaning is the most salient perceptual property of the referent. In the stimuli of Experiment 1 the shapes of the objects were likely to be the most salient perceptual property of the referent. In contrast, since the shapes of the non-solid substances were very simple and non-distinctive, shape was not likely to be the most salient perceptual property. Rather, color or texture may have been the most salient. In Experiment 2, we reverse the ontological kind/complexity pairing: the objects had simple shapes and the non-solid substances were put into piles with complex shapes. All of the shapes in both experiments were regular. That is, none had jagged or bizarre forms.

In Experiment 1, mass noun syntactic context did not help 2-year-olds fix the referent of a word referring to a non-solid substance. Brown (1957), in contrast, found that such evidence is used by 4- and 5-year-olds. Dickinson (1988) has shown that young 3-year-olds are at ceiling on the substance trials of the neutral syntax condition of Experiment 1; therefore, a ceiling effect would mask any effect of syntax at this age. Gordon (1982) has shown that between the ages of 2½ and 3 children gain substantial control of the quantifiers "a" and "another", numerals and plurals, and a beginning appreciation that determiners are obligatory for singular count nouns, but not mass nouns. Therefore, it is possible that an effect of informative syntax on the meaning of substance terms might be observed at age 2½. To explore this possibility, a group of children of this age was included in Experiment 2.

Method

Subjects

Subjects were 24 2-year-olds (mean age: 2;0, range: 1;10–2;3) and 24 2½-year-olds (mean age: 2;7, range: 2;5–2;9). In each age group there were 12 subjects in the neutral condition and 12 subjects in the syntax condition, half of whom were girls and half were boys. The subjects were tested at their homes and were paid $5.00 each for their participation.

The 12 adult subjects were undergraduates at Massachusetts Institute of Technology.

Stimuli and procedures

Naming task. The procedure was essentially the same as in Experiment 1. The word-learning trials were preceded by one trial with familiar objects (plastic and styrofoam cups) and by one trial with familiar non-solid substances (peanut butter and Play-doh). The novel objects were made into the following forms: pyramids (wood and Super Sculpey[8]), pancakes (yellow wax and green plastic), kidneys (orange wax and purple plaster), and half eggs (grey styrofoam and red Super Sculpey). The non-solid substances were the same as in Experiment 1, except now they were placed into more complicated, regular shapes, shown in the Appendix. Note that the coffee/orzo and sawdust/leather pairs had simple piles for the multiple shapes. Those materials do not stay in small, complex shapes.

Adult ratings. Line drawings were made of each novel stimulus. There were two drawings for each object stimulus – one of the whole object and one of the pieces. There were also two drawings each for the Crazy Foam/clay and the Nivea/Dippity-do substance pairs – one of the single large shape and one of the multiple small shapes. The coffee/orzo and the sawdust/leather

[8]Super Sculpey is a sculpting material, somewhat similar to clay.

pairs were depicted only by drawings of the large shape since the small shapes were simple piles. Each object drawing was paired with the drawing of each substance in its large shape, resulting in 16 pairings. Each of the four drawings of object pieces were paired with the two drawings of the substances in their small shapes, making another 8 pairings.[9] Each pair was presented on a separate sheet of a book; no drawing appeared on consecutive pages. The pairs were counterbalanced such that on half of the pages the object drawing was on the right side and on half it was on the left side. Subjects were tested individually; they were instructed to indicate which drawing in each pair they thought complex.

Results and discussion

Adult ratings

The substance drawing was chosen as having the more complex shape in 97% of the large shape pairs and 79% of the small shape pairs. A difference score was found for each subject by subtracting the number of pairs in which the object drawing was chosen from the number of pairs in which the substance drawing was chosen. This score could range from −24 to 24, with 0 indicating that the objects and substances were chosen equally often. A positive score reflects choice of the substance drawings more often than the object drawings. The average score was 19.8, which is significantly greater than 0 ($t(11) = 15.967$, $p < .001$, 2-tailed). No score was less than 8. A difference score was also found for each pair by subtracting the number of people who chose the object drawing from the number of people who chose the substance drawing. This score could range from −12 to 12. The mean score was 9.9, which is significantly greater than 0 ($t(23) = 11.264$, $p < .001$, 2-tailed). The scores of 22 of the 24 pairs were greater than 8. The two non-positive scores emerged from comparisons between object pieces and the small piles of substances.

Thus, on both an item analysis and a subject analysis, the substances were judged to have more complex shapes than the objects.

Word-learning task

Familiar word trials. As in Experiment 1 the data are presented as the percentage of trials in which the subjects chose the test stimulus that matched

[9] If line drawings had been made of the small shapes of the coffee/orzo and sawdust/leather substances, the small substance shapes may well have been rated as less complex than the object pieces for those substances. An item analysis of the non-solid substances will reveal whether the simplicity of those substance piles had an effect.

the named stimulus in shape and number. It was predicted that object responses would be consistent with shape and number and that substance responses would not be. The subjects chose the whole cup instead of the cup pieces (2½-year-olds: 98%; 2-year-olds: 85%) on the object trials. On the substance trials they chose the substance that was named, even though it was in a different configuration (2½-year-olds: 2%; 2-year-olds: 19%). A 5-way ANOVA examined the effects of age (2 × 2½), group (Neutral syntax × Informative syntax), trial type (Object × Non-solid substance), session (1 × 2) and sex (Female × Male). The only main effect was trial type ($F(1,40) = 230.455$, $p < .001$). There was an age by trial type interaction ($F(1,40) = 7.424$, $p = .009$). This interaction reflects the subjects' improvement with age. The 2½-year-olds were farther from chance on both kinds of trials. There were no other main effects or interactions. Thus, there was no difference between the neutral syntax and informative syntax groups (see Figure 4).

The performance of both age groups differed significantly from chance on both kinds of trials (age 2, object: $t(23) = 6.235$, $p < .001$, 2-tailed; age 2, substance: $t(23) = 4.696$, $p < .001$, 2-tailed; age 2½, object: $t(23) = 23.031$, $p < .001$, 2-tailed; age 2½, substance: $t(23) = 23.031$, $p < .001$, 2-tailed). Thus, all the subjects differentiated the familiar object trials from the familiar substance trials, but the 2½-year-olds did so more strongly than the 2-year-olds. There was no difference between the neutral and informative syntax groups.

Word-learning trials. When the referent of a newly heard word was a solid object, subjects of both ages picked the stimulus matching the original referent in shape and number, avoiding the pieces that matched in substance (see Figure 5). When the referent was a non-solid substance, subjects of both ages picked the stimulus that matched in substance, ignoring the match in number and shape (see Figure 5).

A 5-way ANOVA examined the effects of age (2 × 2½), group (Neutral syntax × Informative syntax), stimulus (the eight different stimuli sets), session (1 × 2), and sex (Female × Male). The only significant factors were stimulus ($F(7,280) = 79.005$, $p < .001$), and the Age × Stimulus interaction ($F(7,280) = 2.49$, $p = .017$). A pre-planned contrast for each age group showed that the object trials were different from the substance trials (age 2: 89% vs. 32%, $F(1,161) = 164.362$, $p < .001$; age 2½: 91% vs. 16%, $F(1,161) = 497.238$, $p < .001$). This contrast accounted for 99% of the stimulus effect for the 2-year-olds and 98% of the stimulus effect for the 2½-year-olds. The Age × Stimulus interaction reflects the fact that subjects improved with age on the substance trials but not on the object trials.

Even though the 2-year-olds did more poorly on the substance trials than

Figure 4. *Left panel: mean percentage of responses by shape and number as a function of trial type (Experiment 2, 2-year-olds, familiar word trials). Right panel: mean percentage of responses by shape and number as a function of trial type (Experiment 2, 2½-year-olds, familiar word trials).*

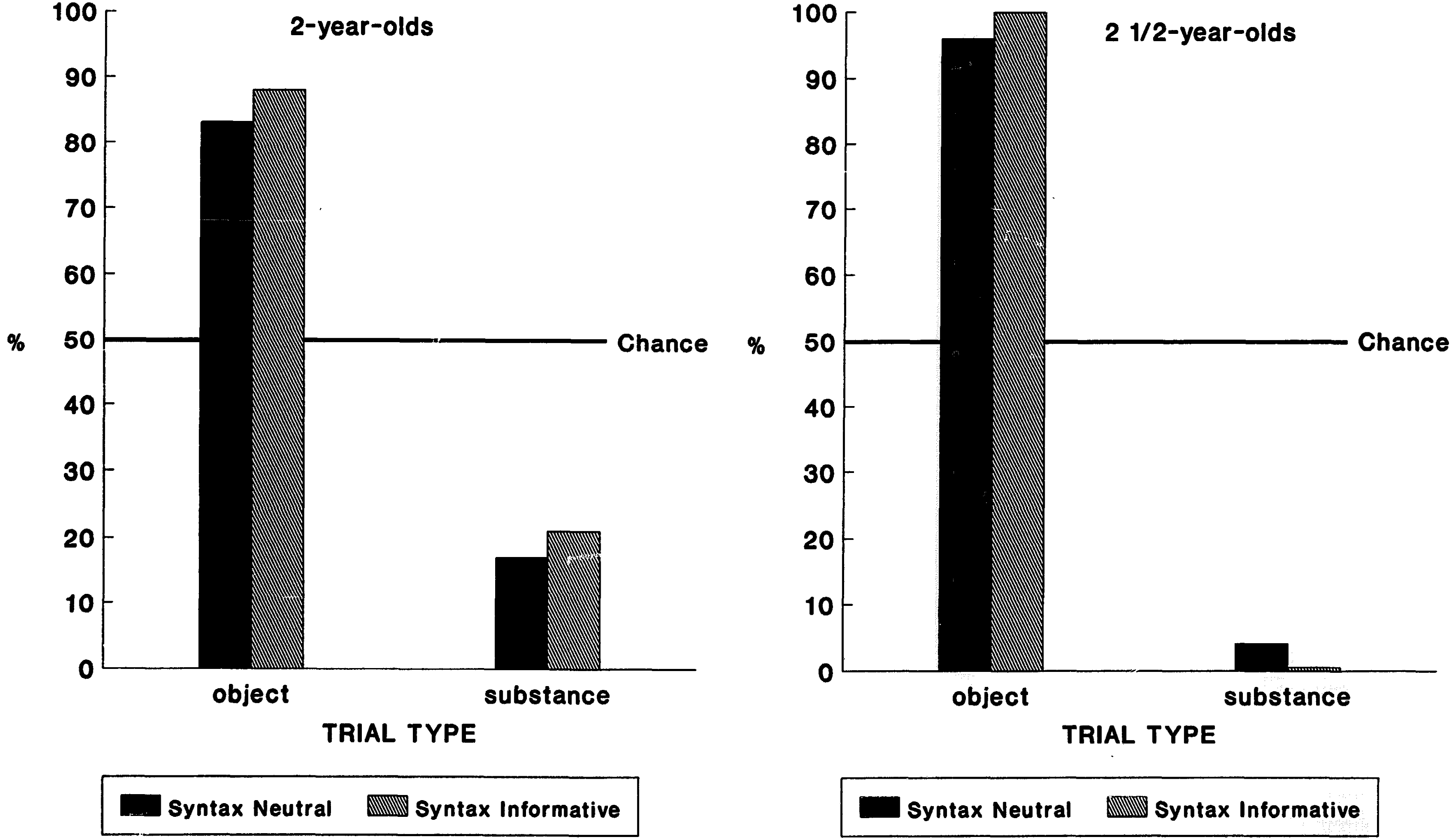
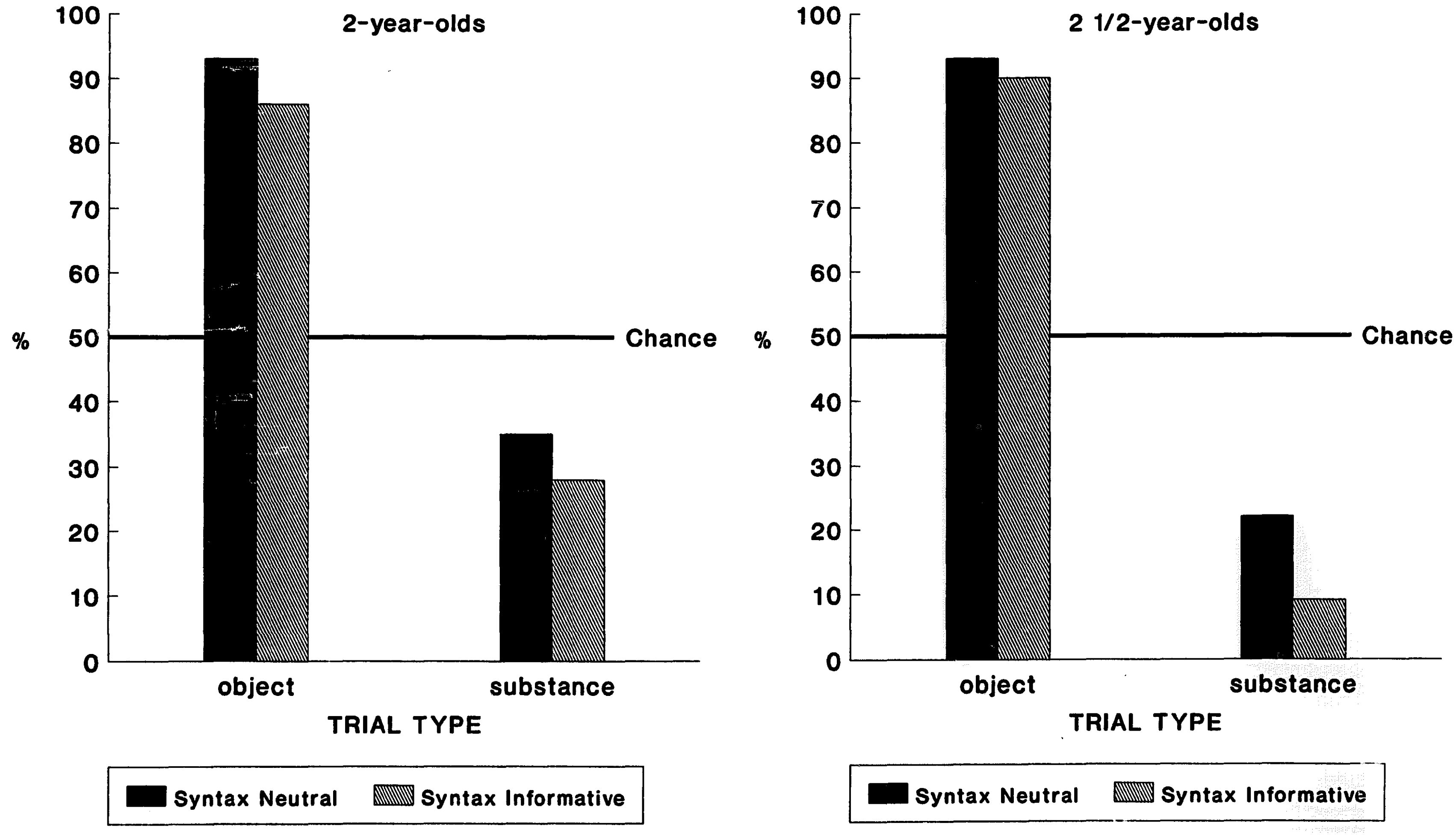


Figure 5. *Left panel: mean percentage of responses by shape and number as a function of trial type (Experiment 2, 2-year-olds, word-learning trials). Right panel: mean percentage of responses by shape and number as a function of trial type (Experiment 2, 2½-year-olds, word-learning trials).*



the $2\frac{1}{2}$-year-olds, they still were different from chance on both the object and the substance trials (object: $t(23) = 11.59, p < .001$, 2-tailed; substance: $t(23) = 3.24, p < .005$, 2-tailed). The $2\frac{1}{2}$-year-olds were, of course, also different from chance on both kinds of trials (object: $t(23) = 15.46, p < .001$, 2-tailed; substance: $t(23) = 9.11, p < .001$, 2-tailed). As in Experiment 1, the 2-year-olds performed more consistently on the object trials than the substance trials, as tested by a comparison of the degree to which the trials differed from chance ($t(23) = 3.76, p = .001$, 2-tailed). The $2\frac{1}{2}$-year-olds were equally consistent on both kinds of trials ($t(23) = 1.323, p = .199$, 2-tailed).

The effect of substance configuration was analyzed separately. A 3-way ANOVA examined the effects of substance configuration during the introducing event (One big pile × Multiple small piles), group (Neutral syntax × Informative syntax), and age ($2 \times 2\frac{1}{2}$). This analysis revealed only the age main effect shown in the previous analysis.

When the substances were in multiple small piles only two of the four substances could support complex shapes. A look at the means of the substances that had the small piles in simple shapes (mean: 24%) and the substances with small piles in complex shapes (mean: 23%) shows that the complexity of the shapes of the small piles made no difference.

To analyze the effects of the new stimuli in this experiment the 2-year-olds were compared to the subjects in Experiment 1. A 3-way ANOVA examined the effects of experiment (1×2), trial type (Object × Substance), and group (Neutral syntax × Informative syntax). As can be seen by a comparison of Figure 3 and the 2-year-olds' data in Figure 5, there was no effect of experiment. The only significant effect was the trial type main effect demonstrated in the contrasts of both studies.

The data from Experiments 1 and 2 are superimposable. This is a sobering result for any who believe that projection of word meanings is determined by perceptual properties such as shape, color and texture. Consider the range of shapes used in the two studies (pictures of some of the stimuli from each experiment are shown in the Appendix). The substances in Experiment 1 were totally non-distinctive, non-salient blobs, whereas the objects of Experiment 1 had complex, salient shapes that reflected their functions. Experiment 2 reversed the shape saliency difference between objects and substances, but remained within the extremes of Experiment 1. There is no evidence that shape, per se, was affecting the pattern of results.

Production data

2-year-olds. Data were analyzed from 22 children; 2 were lost due to recording difficulties. As in Experiment 1, most of the nouns used were count nouns (2463 count noun tokens compared to 397 mass noun tokens). Again, determiners were mostly absent (68% of count noun tokens and 83% of mass noun tokens). And also, as in Experiment 1, most of the mass noun types (66%) were non-solid substance words; 29% of these were not food words. The rest of the mass noun types were superordinates, abstract, or ambiguous as to whether they are solid or not. None was a solid substance word such as "metal" or "plastic".

For each child we calculated the score used to reflect control of count noun syntax used in Experiment 1. Scores ranged from .05 to .79 (mean .30). The performance of the neutral syntax group (.25) and the informative syntax group (.34) did not differ ($t(20) = 1.006$, $p > .32$, 2-tailed). For each subject the word-learning score, reflecting how well the object trials were differentiated from the substance trials, was also found, as in Experiment 1. These ranged from 8 to 100 (mean 55). There was no relation between the scores reflecting command of count/mass syntax and the word-learning scores ($r = .04$, $p > .4$, 1-tailed). Thus, exactly the same pattern of results emerged from the 2-year-olds in Experiment 2 as from Experiment 1.

2½-year-olds. Data from production were available from all 24 2½-year-olds. As with the younger subjects, most of their nouns were count nouns (2977 count noun tokens compared to 745 mass noun tokens) and use of nouns with no determiners was still common (47% of count noun tokens and 80% of mass noun tokens). Also, as with the 2-year-olds, the mass noun types were mainly (67%) non-solid substance words, and 61% of these were food words. There was one solid substance word, "wood", used by one subject three times and by three other subjects one time each. The rest of the mass nouns were superordinates, abstract nouns, or ambiguous with respect to their status as solid or non-solid substance words.

These subjects were more advanced than the younger subjects in their differentiation of count and mass syntax, which is seen predominantly in their increased use of "a" with singular count nouns. This is illustrated best by the syntax scores of these subjects (mean: .54; range: 0–.90). Again, there was no difference in syntax scores between the two groups (neutral syntax, .57, and informative syntax, .52; $t(22) = .52$, $p > .6$, 2-tailed). However, there was a small, positive correlation between the syntax scores and the word-meaning scores that measured the differentiation of objects and substance trials (word-meaning scores: 13–100, mean: .76; $r = .34$, $p = .054$, 1-tailed).

The main purpose of Experiment 2 was to decide whether perceptual salience of the shapes in Experiment 1, as opposed to ontological status of the referent, was responsible for the pattern of results observed. The results of Experiment 2 support Procedures 1 and 2. In Experiment 2 the substances had more complicated and salient shapes than did the objects, and yet the data from the two experiments were practically superimposable.

There was a small correlation between the 2½-year-olds' command of count/mass syntax and the degree of their differentiation of object trials and non-solid substance trials. Since this pattern was not found for the 2-year-olds, and since these younger children already distinguished objects from non-solid substances, this correlation cannot be interpreted as support for Quine's position. Soja (1990) has supporting evidence that 2-year-olds use Procedures 1 and 2 before acquiring the count/mass distinction. A condition was run in which the objects were labeled with *mass* nouns and the substances were labeled with *count* nouns. There was no effect on responses to the object trials. Responses to the substance trials were affected, but only for the subjects who produced count/mass syntax.

As in Experiment 1, Experiment 2 revealed no effects of whether children heard informative syntax, "a blicket" and "some stad", or neutral syntax, "my blicket" and "my stad". Two-year-old children do not exploit syntactic context in determining whether a newly heard noun refers to a solid object or a non-solid substance, at least when the syntactic context supports Procedures 1 and 2.

The absence of any effect of syntactic context in constraining 2-year-olds' hypotheses concerning word meanings contrasts with other cases where such effects have been found. Katz, Baker, and Macnamara (1974) showed that 17-month-old girls use the presence or absence of a determiner to determine whether a newly heard noun is proper or common (see also Gelman & Taylor, 1984). Similarly Naigles (1990) has shown that young 2-year-olds use syntactic context to constrain hypotheses about verb meanings. The first effects of syntax in the present case are observed in our 2½-year-old group (a small positive correlation between productive control of the count–mass distinction and degree of differentiation of object and substance trials and a 12% difference between the neutral and informative syntax groups on the substance trials which, while non-significant, was in the expected direction). Apparently the quantificational importance of determiners is being worked out at the same time as the syntactic count/mass distinction in the second half of the third year (Gordon, 1985).

The present studies do not assess the significance that the newly taught word is a noun. Procedures 1 and 2 are stated in terms of newly heard "words". It is likely that there are constraints on *noun* meanings, but this is an empirical matter to be addressed in future research.

Experiment 3

In all conditions, and at both ages, children were near ceiling on object trials. The child's task was to choose either a whole object of the same shape as the original or pieces of the same material as the original. Perhaps young children find whole objects more attractive than pieces, and so choose them out of a simple preference. A whole item bias cannot account for the subjects' better than chance performance on the substance trials – in half of these trials the correct answer was the whole pile and in the other half the three or four small piles. Furthermore, in neither Experiment 1 nor 2 was there an effect of stimulus configuration on the non-solid substance trials; that is, the subjects did equally well in each of these two cases. Thus, while a whole item bias could have contributed, perhaps even determined, responses on the object trials, such a bias played no role in the child's responses on the non-solid substance trials.

Experiment 3 tests for a whole item preference, and assesses whether this preference alone could account for the ceiling performance on object trials. Subjects were given the test pairs from Experiment 2 without having seen the original stimulus or having had any stimuli named for them. They were asked simply to choose one of the stimuli in the pair to play with. If they are subject to a whole item bias, they should choose the whole object and the non-solid substance in the single pile.

Method

Subjects

There were 12 subjects with a mean age of 2;2 (range: 2;1–2;2). Half were boys and half were girls. They were tested at their homes and were paid $5.00 each for their participation.

Stimuli and procedure

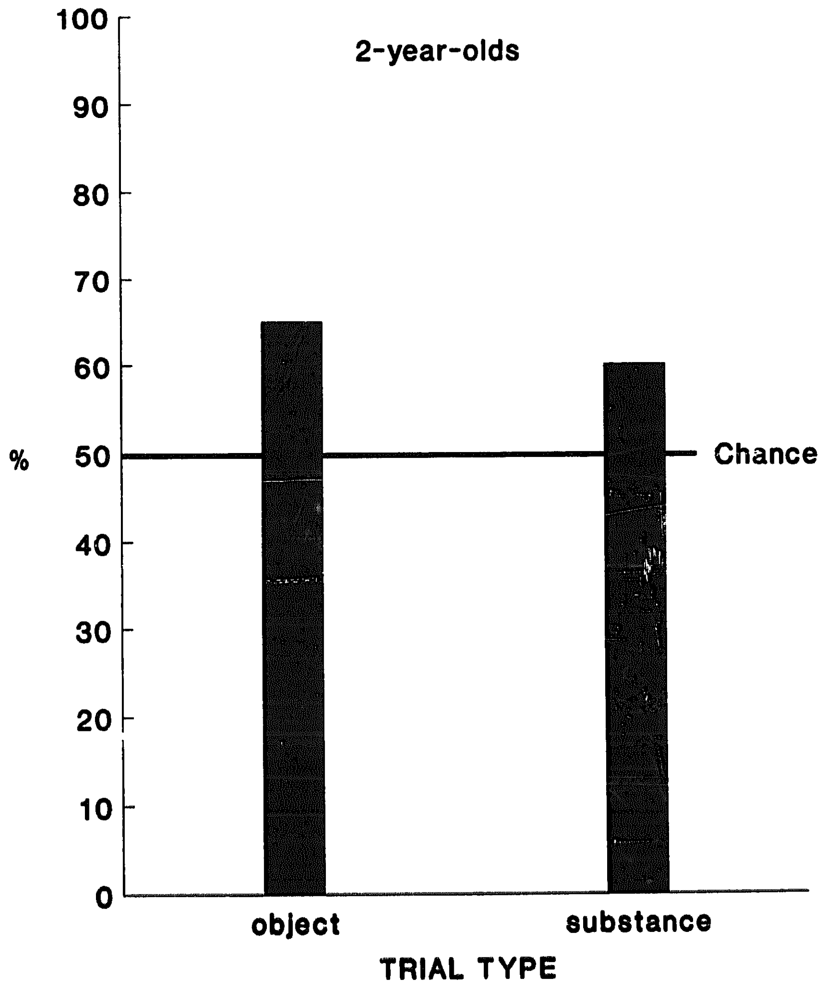
The stimuli were the same as in the word-learning task of Experiment 2, presented in the same orders and same left/right positions as in the test trials for that study. Each child participated in just one session, making a total of 8 choices. Subjects were shown the test pairs and asked "Which of these would you like to play with?" There was no naming event; subjects simply picked the item or chunks they preferred. There were no trials with familiar objects or substances.

Results and discussion

A whole object score, the percentage of object trials in which the subject chose the single object, and a whole pile score, the percentage of substance trials in which the subject chose the substance in the single pile, were determined for each subject. There was a bias to select the whole item (62.5%; $t(23) = 2.63$, $p < .02$, 2-tailed). The average whole item score for objects (65%) did not differ from that for the non-solid substances (60%; $t(11) = .51$, $p = .62$, 2-tailed) (see Figure 6).

To see if the whole item bias could account for the results on the object trials of Experiment 2, we compared the object scores of the 2-year-olds in Experiment 2 with the whole item scores on the object trials of Experiment

Figure 6. *Mean percentage of responses by whole item as a function of trial type (Experiment 3).*



3. Performance on the object trials of Experiment 3 (65%) is significantly different from the 2-year-olds' performance on the object trials of Experiment 2 (89%; $t(34) = 4.11$, $p < .001$, 2-tailed). Thus, while 2-year-olds show a preference for the whole item when given the choices of the test trials in the word-learning experiment, this preference cannot account for the children's response pattern in Experiment 2. We conclude that whether the initial referent of a newly heard word is a solid object or a non-solid substance determines the pattern of projection as specified in Procedures 1 and 2.

The preference for whole items, coinciding as it does with the correct choice on object trials in Experiments 1 and 2, may be one reason for the 2-year-olds' superior performance on the object trials compared to the substance trials of those experiments.

General discussion

Claim 1: Step 1 of Procedures 1 and 2

We can reject Procedure 0 as the basis of young toddlers' fixation of word meanings. The present results show that presyntactic infants[10] do see the world as composed of objects and non-solid substances (among other ontological types, presumably), and do condition the projection of word meanings in terms of this distinction. The salient perceptual features – shape, texture, number of entities – were the same for object trials and non-solid substance trials. Indeed, in Experiment 2 we made the shapes of the non-solid substances more complex and salient than those of the objects. Yet the subjects did not project word meaning according to the same perceptual features across the two sets of trials. A single similarity space based on perceptual salience cannot explain the pattern of results. A more complex perceptual similarity space, in which salience of perceptual features is context dependent (e.g., if the referent is solid, then shape is salient) will be addressed in the discussion of Procedures 3 and 4 below.

On ontology and noun meaning

Landau et al. (1988) claim that adults, as well as children, ignore ontological categories in their inductive projection of noun meanings. Rather, they argue, shared shape is the basis of noun meanings. They support this claim with evidence that the extension of a single noun can include referents of

[10] The subjects were "presyntactic" with respect to the count/mass distinction; obviously they mastered a good deal of syntax.

different ontological types, in Sommers' (1963) sense. For example, "bear" can refer to the wild animal or to a stuffed toy. Moreover, they present evidence that young children generalize words applied to a single, solid inanimate object to new objects of the same shape.

Even if we grant Landau et al.'s examples[11] and evidence, it does not follow that nouns refer to shape. As the present studies show, 2-year-old children ignore shape when the referent of a newly heard noun is a non-solid substance, as do 3- to 5-year-old children and adults (Dickinson, 1988). Further, many nouns in the speech of young children refer to abstract entities for which shape is irrelevant. Perhaps Landau et al. meant that when the referent is a solid object, shape is the basis for determining the relevant kind. Even this is not so. Data from Keil (1989) show that adults, and even early elementary-aged children, are robustly sensitive to how an animal came to get its shape in deciding what that animal is. For example, adults and 10-year-olds are certain that if an antelope were to get a long neck by plastic surgery, it would not become a giraffe, even if the surgeon made it physically indistinguishable from a giraffe.

Suppose, however, that Landau et al. were correct that shape provides the taxonomic basis for noun meanings, *when the referents are solid objects*. Far from showing ontology is irrelevant to word meanings, this generalization has an ontological condition. While Keil's studies show that adults do not determine noun categories of objects, at least for natural kinds, on the basis of shape, Landau et al.'s work suggests a serious alternative to Procedures 1 and 2 as the basis for the projection of word meanings by very young children. Perhaps Procedures 3 and 4 underlie the projection of word meanings of the toddlers in Experiments 1 and 2.

Procedure 3 Step 1: Test to see if the speaker could be talking about a solid object; if yes,

Step 2: Conclude the word refers to shape.

Procedure 4 Step 1: Test to see if the speaker could be talking about a non-solid substance; if yes,

Step 2: Conclude the word refers to texture.

Are the data from the present studies consistent with Procedures 3 and 4? While these data do show that the young child's projections of word meanings are conditioned by the ontological status of the referent, they may not show

[11]Actually, we do not agree that a toy bear is a bear; when we call a stuffed animal a "bear", the context allows us to drop the qualifier "stuffed" or "toy".

anything about how the child is quantifying over the referent. The question we now turn to, then, is whether these data bear on Quine's Claim 2.

Claim 2: Step 2 of Procedures 1 and 2

Consideration of the crucial role of *number* in the present studies supports the conclusion that the children in our study are taking nouns to refer to objects quantified as individuals and to refer to non-solid substances quantified as portions. On each object trial, the choice that the child rejects (the distractor) consists of three or four chunks of the original material. If the child is following Procedure 3, then the child should perform equally well if the distractor consisted of a single intact object of the same material but a different shape from the target. This, however, is not the case. Two studies have found that 2-year-old children are much less likely to project noun meanings on the basis of shape under these circumstances (chance performance in Landau et al., 1988, 73% success in Soja, 1987). In the present studies, therefore, shape alone did not account for the ceiling performance on the object trials. Instead, children evidently performed at ceiling because the distractor was something that could not be an object at all. The 2-year-old child appears to know that "blicket" must refer to individual whole objects of the same kind as the ostensively defined referent, but does not yet have very good ways of determining what properties are likely to determine "same kind".

Consider now the substance trials. Unlike the situation of the object trials, in which one of the choices is ruled out if the child is following Procedure 1, following Procedure 2 does not allow the child to rule out either choice. Portions of substance can be scattered – three piles of stad is as good an example of a portion of stad as is one big pile. Thus, the object trials and the substance trials are not entirely symmetrical. If children followed Procedures 1 and 2, then their performance should be perfect on object trials but not on non-solid substance trials. That is, of course, the consistent finding of Experiments 1 and 2.

A detailed comparison of the $2\frac{1}{2}$-year-olds in Soja (1987) and those of Experiment 2 supports this analysis. Soja used neutral syntax; the stimuli had complex shapes (as in Experiment 1 of the present study).[12] Subjects in Soja's experiment picked the object of the same shape as the target 73% of the time (as opposed to 93% performance in Experiment 2; $p < .002$, 2-tailed). Indeed

[12]There were three conditions in Soja (1987). We are referring to the double-object condition. All three conditions involved objects; non-solid substances were not tested in that experiment.

the performance of the $2\frac{1}{2}$-year-olds on the substance trials of Experiment 2 (79%) did not differ from the performance of the subjects in Soja (1987) ($p > .5$, 2-tailed). We take this pattern of results to show that 2-year-olds are projecting word meanings from solid objects to individual whole objects of the same kind and from non-solid substances to portions of substance of the same kind, *without yet having very good methods of determining kinds of objects and substances*. In sum, the role number plays in the trials of Experiments 1 and 2 supports our conclusion that toddlers are following Procedures 1 and 2 and militates against the conclusion that they are following Procedures 3 and 4.

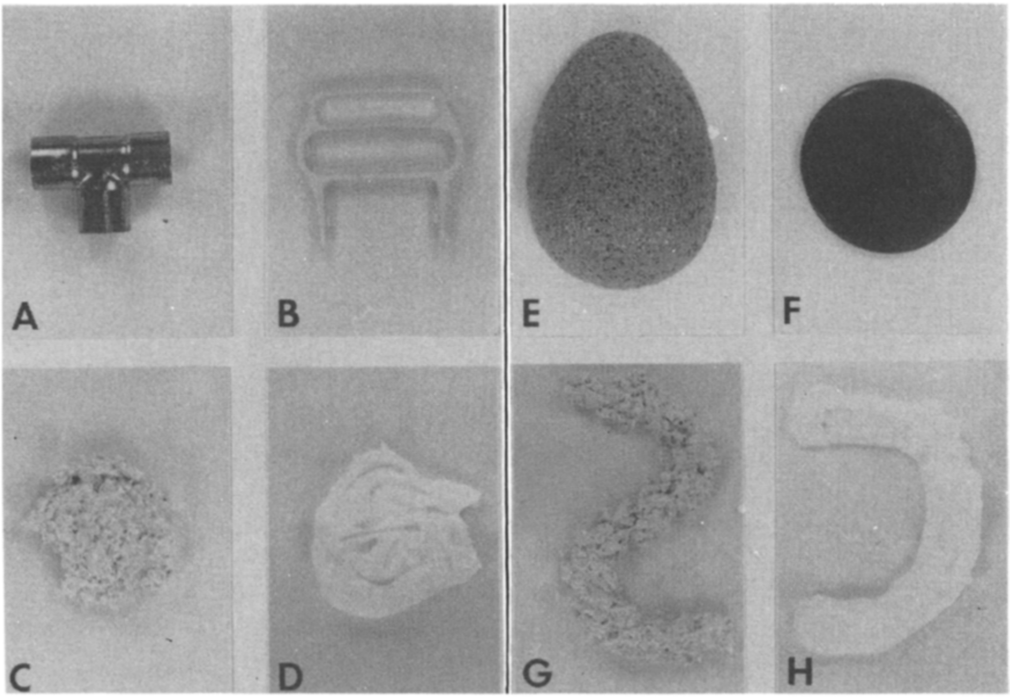
The relation between Procedures 1 and 2 and other work on word-learning constraints

Our focus here differs from most related work on the early constraints on word meanings. We have not here been concerned with contrast (Clark, 1987) or mutual exclusivity (Markman & Wachtel, 1988) although we ensured that the objects and materials we used were unfamiliar to the child, so that contrast or mutual exclusivity would not influence the child's choices. Nor was the taxonomy constraint (Markman, 1989; Markman & Hutchinson, 1984) our focus. We assumed, following Markman, that the child was projecting noun meanings according to taxonomic categories. A taxonomy requires an ontology; our concern here was explicitly the ontology underlying the kinds children think nouns name.

We have argued that the quantificational distinction between objects and non-solid substances guides word learning from at least age 2, and is not induced from learning the explicit quantificational syntax of English. These studies leave open whether the conceptual distinction between objects and substances influences all of the child's inductive projections, just projections of word meanings, or just projections of noun meanings. Future research will establish the scope of the constraint.

Appendix

Pictures A–D show stimuli from Experiment 1. Pictures E–H show stimuli from Experiment 2. The stimuli represented in the top row are objects and the stimuli represented in the bottom row are non-solid substances.



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