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

Reprinted from

COGNITION

International Journal of Cognitive Science

Cognition 62 (1997) 169-200

A cross-linguistic study of early word meaning: universal ontology and linguistic influence

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Received 11 November 1994, final version 14 June 1996

ELSEVIER

COGNITION

International Journal of Cognitive Science

Publication information: *Cognition* (ISSN 0010-0277). For 1997 volumes 62–65 are scheduled for publication. Subscription prices are available upon request from the Publisher. Subscriptions are accepted on a prepaid basis only and are entered on a calendar year basis. Issues are sent by surface mail except to the following countries where air delivery via SAL (Surface Air Lift) mail is ensured: Argentina, Australia, Brazil, Canada, Hong Kong, India, Israel, Japan, Malaysia, Mexico, New Zealand, Pakistan, PR China, Singapore, South Africa, South Korea, Taiwan, Thailand, USA. For all other countries airmail rates are available upon request. Claims for missing issues should be made within six months of our publication (mailing) date.

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US mailing notice – Cognition (0010-0277) is published monthly by Elsevier Science B.V. (Molenwerf 1, Postbus 211, 1000 AE Amsterdam). Annual subscription price in the USA US$983.00 (US$ price valid in North, Central and South America only), including air speed delivery. Application to mail at second class postage rate is pending at Jamaica, NY 11431. **USA POSTMASTERS:** Send address changes to Cognition, Publications Expediting, Inc., 200 Meacham Avenue, Elmont, NY 11003. **AIR FREIGHT AND MAILING** in the USA by Publications Expediting Inc., 200 Meacham Avenue, Elmont, NY 11003.

⊗ The paper used in this publication meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).

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Abstract

This research concerns how children learn the distinction between substance names and object names. Quine (1969) proposed that children learn the distinction through learning the syntactic distinctions inherent in count/mass grammar. However, Soja et al. (1991) found that English-speaking 2-year-olds, who did not seem to have acquired count/mass grammar, distinguished objects from substances in a word extension task, suggesting a pre-linguistic ontological distinction.

To test whether the distinction between object names and substance names is conceptually or linguistically driven, we repeated Soja et al.'s study with English- and Japanese-speaking 2-, 2.5-, and 4-year-olds and adults. Japanese does not make a count–mass grammatical distinction: all inanimate nouns are treated alike. Thus if young Japanese children made the object–substance distinction in word meaning, this would support the early ontology position over the linguistic influence position. We used three types of standards: *substances* (e.g., sand in an S-shape), *simple objects* (e.g., a kidney-shaped piece of paraffin) and *complex objects* (e.g., a wood whisk). The subjects learned novel nouns in neutral syntax denoting each standard entity. They were then asked which of the two alternatives – one matching in shape but not material and the other matching in material but not shape – would also be named by the same label.

The results suggest the universal use of ontological knowledge in early word learning. Children in both languages showed differentiation between (complex) objects and substances as early as 2 years of age. However, there were also early cross-linguistic differences. American and Japanese children generalized the simple object instances and the substance instances differently. We speculate that children universally make a distinction between individuals and non-individuals in word learning but that the nature of the categories and the boundary between them is influenced by language.

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0010-0277/97/$17.00
PII S0010-0277(96)00784-6

1. Introduction

Children are very efficient word learners. The rapidity with which they acquire words makes it unlikely that they go through all logically possible meanings when inferring the referent of a novel word (Quine, 1960). There have been many attempts to characterize the set of constraints and learning biases that make this rapid learning possible. For example, Markman's whole object constraint states that children initially take words as applying to objects, not to parts or properties of objects (Markman, 1990; Baldwin, 1989). Gentner's natural partitions hypothesis (Gentner, 1982) states that children initially learn object names rather than names for relations of properties because object concepts are acquired prelinguistically. The principle of contrast (Clark, 1987) and the mutual exclusivity assumption (Markman and Wachtel, 1988) capture children's preference for one-to-one mapping between words and concepts. The taxonomic constraint (Markman and Hutchinson, 1984; Waxman and Kosowski, 1990) and the shape bias (Gentner, 1978; Imai et al., 1994; Landau et al., 1988; Smith et al., 1992) deal with the way children extend noun meanings to new referents given that a word has been applied to an object.

Among the proposed theories of constraints, some sort of early orientation towards object naming is most relevant to this research (e.g., Markman, 1989, 1990; cf. Gentner, 1982; Macnamara, 1982). Considerable empirical evidence has supported this early focus on object naming (e.g., Au et al., 1994; Baldwin, 1989; Baldwin and Markman, 1989; Caselli et al., 1995; Dromi, 1987; Gentner, 1982; Waxman and Markow, 1995). However, this early object-naming bias does not explain the entire range of early word learning (Bloom, 1994a,b; Carey, 1987; Nelson et al., 1993). For example, how do children learn names for non-objects such as color and material, especially given that young children interact with various kind of substances (e.g., water, juice, milk, sand) in their daily activities and know their names (cf. Au, 1994)?

The principles governing word meaning extension for substance names and color names are fundamentally different from those governing the extension for object names, reflecting the fundamental ontological difference between object kinds and substance kinds. While objects have discrete reference, substances like water have "scattered" reference and can refer cumulatively (Quine, 1960): e.g., any portion of *water* is also *water*, but the legs of a *chair* are not a *chair*). In learning new words, then, how do young children come to project meanings of words differentially for different kinds of entities in the world?

1.1. Quine's conjecture: learning through language

Quine (1960, 1969) pointed out the inscrutable nature of the referent of word meaning in the absence of a linguistic apparatus that fixes the referent. Quine (1960) argued that determining the referent of a word from the physical context alone is logically impossible and, specifically, that children encounter problems in learning the ontological difference between entities having discrete reference (i.e., objects) and those having "scattered" or "cumulative" reference (i.e., substances and attributes). He argued that learning of this semantic distinction between object reference and substance reference comes about because of the grammatical distinction between count noun and mass nouns.

1.2. A challenge to Quine: universal ontology as a guiding force in word learning

Recently, the Quinean view was challenged by a group of developmental psychologists. Soja et al. (1991) tested how 2-year-olds projected word meanings when they saw solid objects and non-solid substances in a word learning task. Children who had not yet shown evidence of awareness of the count/mass subcategorization in a production test were taught a new word in a syntactic frame. This frame was neutral as to the count/mass status of the noun (e.g., "This is my *blicket*" but *not* "This is a *blicket*" or "This is some *blicket*"). In one condition, the word was given in the presence of a novel physical object (e.g., a pyramid made of wood). The children were then shown two alternatives: one had the same size and shape as the original object but was made out of a different material (e.g., a pyramid made out of sculpting material called Super Sculpy) and the other was some pieces of the same substance as the named object (e.g., pieces of wood). They were asked to choose which of the two alternatives was the *blicket*. When they heard a novel label in the presence of a novel object, they chose another object of the same shape rather than pieces of the same substance, suggesting that they assumed the label to be an object name, not a substance name.

In the second condition, a word was given in the presence of a quantity of non-solid substance (e.g., Nivea cream) arranged into a distinctive shape. Again, they were shown two alternatives. In one alternative, a different kind of substance (e.g., hair-setting gel) was configured in the same shape as the named substance; in the other, the same substance was placed into multiple piles. Interestingly, in this condition children did not extend the new label on the basis of identical shape as they did when they saw novel objects. Rather, they tended to choose the alternative which was the same substance, not the same shape.

Soja et al. (1991) concluded that children universally know the conceptual distinction between objects and substances; they do not need to learn this distinction through language learning as Quine had claimed. They further concluded that children can use this conceptual distinction, which exists prior to language acquisition, to constrain the possible meanings of new words. Thus children will not use the whole object constraint when learning the words for non-object entities; rather, from the onset of language learning, they will project meanings of novel words onto the material component when they see non-solid substances.

1.3. Evaluation of the universal ontology view: can findings from English-speaking children alone stand as evidence?

To strengthen the claim that the children's word extensions were based on early knowledge of ontological distinctions rather than acquired from syntax, Soja et al. (1991) measured the children's productive command of count/mass syntax and found no correlation between productive control and children's performance on the task. As a further test of whether these children were influenced by English syntax, they conducted another word-extension study with children of the same age range, using an informative syntactic frame that was consistent with the ontological status of the new word's referent (i.e., using count noun syntax in the object trials and mass noun syntax in the substance trials). There was no difference in performance on the task between the children who received this informative syntax and children who received neutral syntax as described earlier.

These tests are certainly appropriate and they convincingly demonstrate that the children failed to command count/mass syntax. However, there are many levels of knowing (Jacoby and Brooks, 1984; Roediger, 1990) and it is difficult (indeed, impossible in principle) for any given test to rule out the possibility that the children possessed some tacit knowledge of count/mass syntax. In particular, a production task might not be sensitive enough to capture all that the 2-year-olds knew about count/mass noun grammar. In fact, when Soja (1992) later reversed the syntactic cues so that the count/mass syntax was incongruent with the ontological type (i.e., mass noun syntax was used in the object trials and count noun syntax was used in the substance trials), she found that performance was affected by syntax even in the 2-year-old group. Further, Gordon (1988) found some evidence for an early (around 1;11) distributional distinction in the use of count nouns and mass nouns and argues that children possess some sensitivity to the count/mass distinction before 2;0.

To escape the thorny question of exactly how much children know about count/mass syntax at specific ages, an ideal test would involve children whose language lacks the count/mass linguistic apparatus for distinguishing objects and substances. This would specifically address the claim of a language-independent universal semantic ontology distinction. In many classifier languages, the criteria for this test are met. We now describe the way these languages subcategorize entities in the world and the possible implications for noun meanings, basing our analysis on Lucy's (1992) recent work on Yucatec Mayan.

1.4. Lucy's analysis of Yucatec Mayan

Lucy (1992) has presented an insightful analysis of how classifiers in Yucatec Mayan partition word meanings. In his analysis, Lucy proposes a continuum as to how likely a lexical noun for a given entity is linguistically marked as individuated (see also Allan, 1980). According to Lucy, the likelihood of individuation is highest for animate beings, then concrete objects, and finally, substances. More precisely, Lucy proposes a continuum in which [+ animate] nouns are most likely to be linguistically marked as individuated, [−animate, +discrete] nouns lie in the middle on the continuum, and [−animate, −discrete] nouns are least likely to be marked as individuated[1] (Fig. 1). In order to compare how English and Yucatec Mayan partition this continuum, Lucy considered two grammatical aspects: possibility of pluralization (i.e., whether a lexical noun can be pluralized) and necessity for unitization (i.e., whether a unit of individuation (e.g., a classifier) must be used along with the noun when counting).

As discussed earlier, the English language divides the continuum based on the *discreteness* criterion. In English, nouns marked as [+animate, +discrete] (animate entities) or as [−animate, +discrete] (concrete objects) can be (and must be when there is more than one individual) pluralized, whereas [−animate, −discrete] (substances) cannot be pluralized, (e.g., two chairs, *two waters). As shown in Fig. 1, the division made with respect to whether a noun needs a unitizer in counting agrees with the one made with respect to pluralization: only nouns that cannot be pluralized need a unitizer (e.g., *two waters, two *glasses* of water; *three clays, three *chunks* of clay). Thus on both criteria the English language divides the object/substance continuum between [−animate, +discrete] and [−animate, −discrete], that is, between animate/inanimate objects on the one side and substances on the other. This pattern, according to Lucy, suggests that the referents of [+discrete] nouns are linguistically treated as individuated whereas those of [−discrete] nouns are not (see also Laycock, 1979; McCawley, 1975).

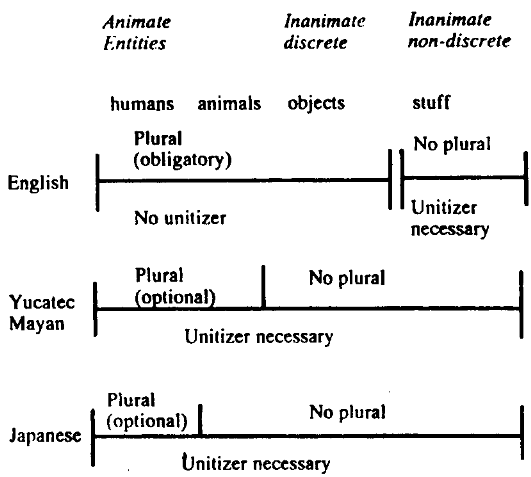

Fig. 1. Division of the pre-individuation continuum in English, Yucatec Mayan and Japanese.

[1] Lucy notes that the category [+animate] may be further subdivided. A related proposal is Croft's (Croft, 1990, pp. 112–113) Animacy Hierarchy: *Human / Nonhuman Animate / Inanimate Object / Substance*.

In contrast, Yucatec Mayan divides the continuum at the point between animate and inanimate entities. Animate nouns can be pluralized, but inanimate nouns do not generally take plurals, regardless of whether they are [+discrete] or [−discrete]. Further, all inanimate Yucatec nouns need classifiers when quantified (see Fig. 1). The role of classifiers in the noun phrase during quantification is somewhat analogous to the role of unitizing modifiers in the quantification of mass nouns in English. Just as English nouns such as *water* and *clay* cannot be directly modified by numerals and need unitizers to be quantified (e.g., four *cups* of water), so Yucatec Mayan and other numeral classifier languages need classifiers for counting purposes. (See also Quine, 1969, for a similar discussion using a Japanese example.) Thus, Lucy suggests that all inanimate nouns in Yucatec Mayan – whether their referents are objects or substances – are treated as "masses" that must be unitized for individuation.

Does this structural difference between English and Yucatec Mayan have psychological consequences? Lucy argues that the answer is yes, particularly where the contrast between the two languages is maximal: that is, for nouns referring to concrete objects, whose lexical status is [−animate, +discrete]. As Lucy states,

> certain specific regularities arise from the denotation pattern specific to a particular language and these will lead to selective attention to a different aspect of entities of this type. The unit pre-supposed by English lexical nouns of this type is usually the *form* or *shape* of an object. Yucatec nouns, lacking such a specification of unit, simply refer to the substance or material composition of an object. · · · Use of the English lexical items routinely draws attention to the shape of a referent insofar as its form is the basis for incorporating it under some lexical label. Use of the Yucatec lexical items, by contrast, routinely draws attention to the material composition of a referent insofar as its substance is the basis for incorporating it under some lexical label. Thus, in cases where *English lexical structure routinely draws attention to shape, Yucatec lexical structure routinely draws attention to material.* If these linguistic patterns translate into general sensitivity to these properties of referents, then *English speakers should attend relatively more to the shape of objects* and *Yucatec speakers should attend relatively more to the material composition of objects* in other cognitive activities – with objects of the appropriate type. (Lucy, 1992, p. 89, emphasis in original)

Lucy conducted a non-linguistic cognitive task that provided support for this conjecture. He showed Yucatec-Mayan adults and American adults a standard stimulus (e.g., a sheet of paper). He then showed two alternatives, one of which was the same shape as the standard (e.g., a sheet of plastic) and the other of which was a different kind of object made up of the same material as the standard (e.g., a book). He asked which of the two alternatives was more similar to the standard. He found that Mayan adults showed a reliable bias toward material alternatives and American adults a reliable bias towards shape alternatives. These results suggest that language may influence whether people use shape or material composition in judging the similarity of objects.

For our purposes, the most important point is that classifier languages like Yucatec Mayan provide an ideal test of the two views discussed above. According to the universal ontology view, young children should show sensitivity to ontological distinctions between object kinds and substance kinds in projecting noun meanings *universally across different languages*. It should make no difference whether their language syntactically differentiates discrete objects from non-discrete substances (as in English) or one that does not (as in classifier languages).

1.5. An empirical test

To evaluate Soja et al.'s view that universal appreciation of ontology guides early word, we extended Soja et al.'s (1991) study cross-linguistically, comparing monolingual native speakers of English and monolingual native speakers of Japanese. Like Yucatec Mayan, Japanese is a classifier language. Every noun, whether animate or inanimate, requires a unitizer (i.e., a classifier) with a numeral regardless of whether the referent is a discrete objects or a non-discrete substance; and nouns referring to inanimate entities, whether discrete or not, do not allow pluralization. Thus it appears that Lucy's analysis of Yucatec Mayan also applies to Japanese (Fig. 1). Thus Japanese provides an example of a classifier language in lacking the count/mass distinction, that can be contrasted with English in order to assess whether ontological knowledge indeed guides early lexical acquisition before learning *linguistic* categories of individuals and non-individuals. A particular advantage in using Japanese speakers for our purpose is that the Japanese and American cultures are roughly comparable in terms of non-linguistic experience, including both experience with objects in the world and educational practices. Thus, if a difference is found between native speakers of English living in the United States and native speakers of Japanese living in Japan, we can be more confident in attributing this difference to the structure of language than we can when the cultures of two language groups are markedly different, as would be the case for English versus Yucatec Mayan.

Although our primary interest is in early lexical acquisition, we also extended the study to older subjects in order to examine the possibility of differential effects of grammar across time. For example, it could be that early word learning is driven by a universal pre-linguistic ontology but that linguistic influences emerge later. In this case word learning in Japanese and English-speaking children would initially be very similar, but noun meaning projection patterns would later diverge as the speakers of the two languages became sensitive to the specific patterns of their native language.

In replicating Soja et al.'s research with Japanese children, we made a modification in the design since we wished to examine whether there is an gradient effect in projecting word meanings onto objects or substances. Gathercole (1985) has suggested that, in learning the English count/mass grammar, children may rely heavily on distributional properties (e.g., whether a given noun dominantly appears in the count or the mass noun syntactic frame); but she also suggests that children may use semantic mapping in the case of prototypical instances. (Of course, what counts as a prototypical object or substance is a non-trivial issue, but we set it aside for now.) Applying this idea here, it is possible that speakers of both languages will show sensitivity to the referent entity's ontological type in projecting noun meanings as long as the named entity is a prototypical or canonical object or substance but that speakers of the two languages may show different patterns (reflecting the different distributional patterns) when the entity's status as an object or substance is not so clear (cf. Bowerman, 1993).

To address this issue, we combined Soja et al.'s (1991) Experiments 1 and 2 into a single experiment. In Experiment 1, Soja et al. used complex-shaped factory-made artifacts for the object trials (e.g., a T-shaped plumbing fixture). In Experiment 2, in contrast, the objects were simple-shaped, solid and bounded entities made out of a solid substance (e.g., orange wax formed into a kidney shape). The artifacts used in Experiment 1 tended to have an complex shape with distinct parts, and an associated function by which the shape was largely determined. In contrast, the objects used in Experiment 2 had a simple shape with no distinctive parts and no obvious function. It is possible that these differences might affect the early projection of word meanings. We therefore compared the two types of objects within subjects to investigate whether these differences matter. In the substance trials, we configured non-solid substances such as Nivea cream into complex Gestalt forms as was done in Soja et al.'s Experiment 2. In this way, as pointed out by Soja et al., we can be more sure of whether children are responding on the basis of mere perceptual saliency or on the basis of their ontological knowledge.[2]

Another modification we made in this experiment was to the number of portions presented in the *material* alternative in each set. In the object trials in Soja et al.'s two experiments, the *material* alternatives always consisted of multiple portions/pieces of the standard entity. In this case, we cannot tell whether the subject used the number difference or the shape similarity as the basis for selecting the *shape* alternative: the *shape* alternative always had the same number as the standard and the *material* alternative always appeared in a different number of portions than the standard. Since both factors, number and shape, are important for the ontological object/substance distinction, we wished to separate these two factors. We thus presented the subjects a single portion of the standard entity (configured differently from the standard) as the *material* alternative in half the sets (i.e., 6 out of 12 sets) within each entity type.

Each subject received three trial types: *complex object* trials, *simple object* trials

[2] However, because of this manipulation, the typicality of the "substance" instances were somewhat compromised, since it is rather unusual for substances to appear in a distinctive, interesting shape. To equate the prototypicality of "substances" to that of the complex objects and the simple objects, we would have had to include substances in a simple pile in addition to the substances in a complex shape. However, this would have required a prohibitive number of trials.

and *substance* trials. The subjects were given a novel label for the standard entity and then asked which of the two alternatives could be referred to with that label. Reflecting the nature of the Japanese language, there was no syntactic cue that could suggest the entity's ontological status. The subjects were monolingual English speakers and Japanese speakers of four age groups: early 2-year-olds, late 2-year-olds, 4-year-olds, and adults.

The predictions are as follows. If the distinction between objects and substances is innate or very early, as suggested by the universal ontology view, then the youngest children will look quite similar across the two language groups. They will base their word meaning extensions on the nature of the entities. Words for both complex and simple objects will be extended to other solid, bounded objects that have the same shape. Words for non-solid materials will be extended on the basis of same substance. Any cross-linguistic differences will appear later, after language has had the opportunity to add its influence to this system of initial constraints.

In contrast, if the distinction between count terms and mass terms must be *learned from* language, then there should be language-specific word meaning extensions from very early on. Thus, the Quinean linguistic influence view predicts that young children will differ sharply across the two language groups. As in Soja et al.'s results, American children will extend both complex and simple objects on the basis of like shape, and non-rigid materials on the basis of like substance (*reflecting the linguistic distinction in English*). However, Japanese children will make no distinction between objects and substances, reflecting the lack of the object/substance distinction in their language. They will either respond randomly or – if Lucy's speculation that classifier languages invite a focus on substance is correct – they will show a general material bias.

EXPERIMENT 1a: ADULT RATINGS OF SHAPE COMPLEXITY AND MEANINGFULNESS

2. Method

Twenty American adult subjects who did not participate in the main experiment (Experiment 1b) rated the complexity of the shapes of the standards using a 1 (low complexity) to 7 (high complexity) scale. For our purpose, the following two constraints needed to be met: (1) the objects used in the complex object trials had to have more complex shapes than those used in the simple object trials and (2) the shapes of the objects in the simple object trials needed to be simpler (or at least no more complex) than the shapes into which the substances were configured in the substance trials. The same subjects also rated the degree to which the shape was meaningful to the entity's function on a 1 (low) to 7 (high) scale.

Aside from replicating Soja et al.'s experiments, we wished to vary the canonicality/typicality of objects within the object trials. In the real world, the shape of an object usually is closely related to its function. (This is especially true for artifacts.) We thus thought that meaningfulness of shape to the object's function might suggest how typical/good an instance of the object kind a given entity was. Since we wished to have canonical objects in the complex object trials and less canonical ones in the simple object trials, we wanted to have the entities for the complex object trials rated higher than those in the simple object trials by the "meaningfulness of shape" criterion. Since substances by definition should not have constant shapes, the entities in the substance trials were expected to be rated lower than those in the complex object or the simple object trials on this criterion.

3. Results

The results suggested that the materials met the requirements of our design. On the *complexity-of-shape* criterion, complex objects received the highest ratings ($M = 5.41$; $SD = 0.74$), followed by substances ($M = 3.85$; $SD = 1.04$), and then simple objects ($M = 3.31$; $SD = 1.04$). The difference in means between complex objects and substances was significant, $t(20) = 4.14$, $p < 0.01$, but the difference between substances and simple objects was not, $p > 0.05$. On the *meaningfulness-of-shape-to-function* criterion, as we expected, the complex objects were rated as having the most meaningful shape ($M = 6.24$, $SD = 0.71$), followed by the simple objects ($M = 2.23$, $SD = 0.81$), with substances rated as having the least meaningful shape ($M = 1.76$; $SD = 0.81$). Both differences were significant, $t(20) = 14.48$, $p < 0.001$ for complex versus simple objects, and $t(20) = 2.02$, $p < 0.05$, one-tailed, for simple objects versus substances.

EXPERIMENT 1b: CHILDREN'S EXTENSIONS OF NOVEL WORDS

4. Method

4.1. Subjects

The subjects were monolingual Japanese-speaking and English-speaking children and adults. Children of both language groups were from middle class families. A total of 43 Japanese children, living in the greater Tokyo area, participated. There were 14 early 2-year-olds (mean age: 2;1, ranging from 1;10 to 2;5), 15 late 2-year-olds (mean age: 2;8, ranging from 2;7 to 3;2), and 14 4-year-olds (mean age: 4;2, ranging from 3;9 to 4;7). There were three other early 2-year-olds and two other late 2-year-olds who did not complete the experiment. There were 18 adult subjects who were undergraduate or graduate students at Ritsumeikan University in Kyoto.

The American children, a total of 42, were from the greater Chicago area. There were 14 early 2-year-olds (mean age: 2;1, ranging from 2;1 to 2;5), 14 late 2-year-olds (mean age: 2;8; ranging from 2;6 to 3;0), and 14 4-year-olds (mean age: 4;2, ranging from 3;10 to 4;6). There were two other early 2-year-olds and two other late 2-year-olds who did not complete the experiment. There were 18 adult subjects, all of whom were undergraduate students at Northwestern University. The gender of the subjects was approximately balanced in each age group in each language group.

All subjects (of all age groups from both language groups) were tested individually in a quiet room, either in a private home or pre-school, or in a laboratory at Northwestern University or Ritsumeikan University.

4.2. Materials

The materials are given in Table 1 (see also Fig. 2 for sample materials). There were three trial types: complex object trials, simple object trials and substance trials. The complex object trials utilized factory-made artifacts having complex shapes and specific functions (e.g., a lemon squeezer). The simple object trials utilized solid, simple-shaped entities made out of a solid substance (e.g., a kidney-shaped piece of wax). The substance trials utilized non-solid substances such as sand configured into complex forms (e.g., sand in an elongated S shape). There were four trials within each trial type: two trials in which the *material* alternative consisted of multiple portions of the standard entity; and two trials in which the *material* alternative consisted of a single portion of the standard entity configured into a different shape. The *shape* alternative always consisted of an entity that had the same shape as the standard entity but was made out of a different material than the standard.

Table 1
Materials used for the studies

	Standard	*Shape* alternative	*Material* alternative
Complex object			
1	clear plastic clip	metal clip	a clear plastic piece
2	ivory plastic T	copper T	an ivory plastic piece
3	porcelain lemon juicer	wood lemon juicer	porcelain pieces
4	wood whisk	black plastic whisk	wood pieces
Simple object			
1	cork pyramid	white plastic pyramid	a chunk of cork
2	dylite UFO	wood UFO	a dylite piece
3	red Super Sculpy half egg pieces	gray Styrofoam half egg	red Super Sculpy pieces
4	orange wax kidney	purple plaster kidney	orange wax pieces
Substance			
1	lumpy Nivea (reverse C)	Dippity-Do (Reverse C)	a Nivea pile
2	Crazy Foam (Gamma)	clay (Gamma)	a pile of Crazy Foam
3	sawdust (Omega)	leather(tiny pieces, Omega)	two piles of sawdust
4	decoration sand (S-shape)	glass pieces (S-shape)	three piles of sand

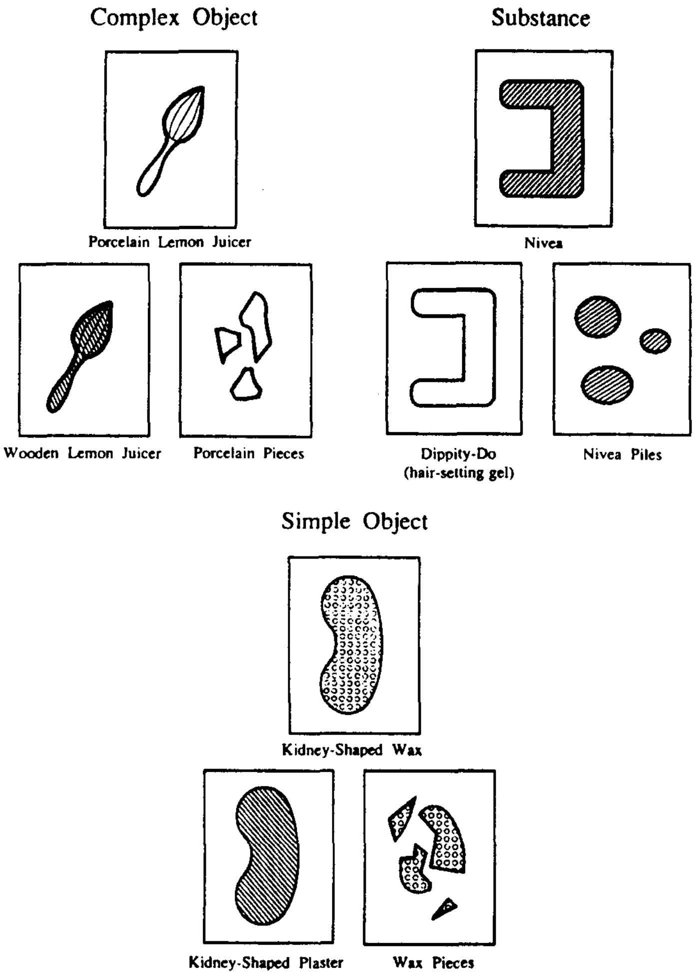

Fig. 2. Sample material sets.

4.3. Procedure

There were four item sets for each trial type. Thus each child received a total of 12 trials (see Table 1).[3] In each trial, the subject was presented with a triad of a standard and two alternatives – a *shape* alternative and a *material* alternative – and was asked to choose the one that best matched the standard. A nonsense label (e.g., *blicket*) was given to the standard. The instructions were given to the Japanese subjects by a native speaker of Japanese and to the American subjects by two native speakers of English. In the instructions for the American subjects, words were given in a neutral syntactic frame using "the" or "this"; for example, "Look at this *dax*." They were then asked to "point to the tray that also has the *dax* on it." The phrase used for the Japanese subjects reflected the inherently ambiguous nature of their language in terms of the object/substance distinction[4] (see footnote for the actual text). The adult subjects (both Japanese and American) were told to assume that the novel words were words in a language they did not know, since they were likely to know the names for the materials. The order of presentation of the 12 trials was counterbalanced across subjects.

Prior to testing, each child received two warm-up trials to make sure that he/she could select one of the alternatives. In one of the trials, the experimenter showed the child two familiar objects (a spoon and a cup) and said "Can you point to the spoon?" In the other trial, two familiar substances (strawberry jam and Play-doh) were used in the same way.

5. Results

The two language groups both showed ontologically-differentiated word meaning projections across different types of entities from the 2-year-olds through

[3] To be able to compare our data with Soja et al.'s (1991), we tried to replicate the materials used in their two experiments as much as possible. However, for some stimulus sets, we had to replace their original materials with other materials, so that all the materials were unfamiliar to both American and Japanese children. For example, in the Substance trial, the Orzo/Coffee pair (rice-shaped pasta) used by Soja et al. was replaced with decorative sand used for Bonsai trees and tiny glass beads (also for Bonsai decoration) because we thought Japanese children might think Orzo was rice, a substance which is highly familiar to them.

[4] *The text of the instruction in Japanese:*

" Kono osara-o mite. Kore-wa *dax* to iimasu*.
this tray-Acc look. This-Top is named

Dewa, kondowa kochirano osara-o mite.
Now, this time on this side tray-Acc look

Dochirano osara ni *dax* ga notte- imasuka?"
which tray LOC Nom is-placed-on

* This is a common, natural way to introduce a new word in Japanese. The noun is neutral in terms of the count/mass status.

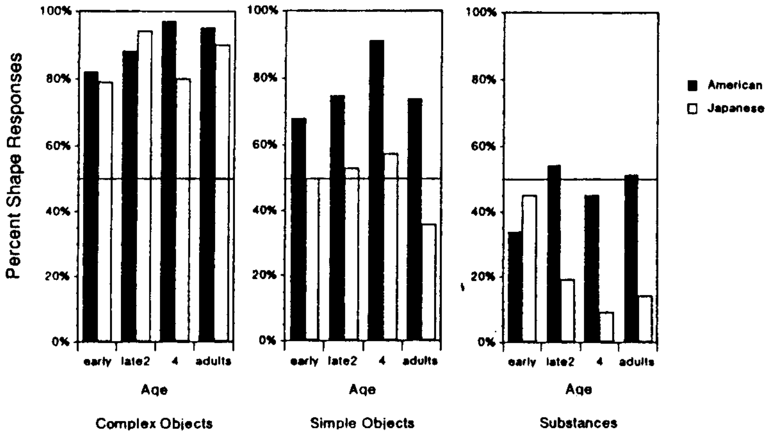

Fig. 3. Proportion of shape responses on (a) complex object trials, (b) simple object trials, and (c) substance trials.

adults. However, *how* speakers of each language differentiated the three entity types was not the same across the two languages. Fig. 3 shows the proportion of *shape* responses in each age group within each language population for the complex object, the simple object, and the substance trials, respectively.[5] Children in both language groups, from the earliest age tested, made a strong distinction between complex objects and substances. Subjects of all ages uniformly treated complex objects as objects, extending them on the basis of common shape. The two language groups were also similar in that both made many fewer shape-based projections in the substance trials than in the complex object trials.

However, at the same time, the word meaning projection patterns were largely different across the two language groups in the simple object trials and the substance trials, and this cross-linguistic difference was observed from the youngest age groups on. Overall, American subjects made a higher proportion of shape responses than Japanese subjects in both the simple object and substance trials. In the simple object trials, from the youngest age on, American subjects treated simple objects like complex objects, extending their names on the basis of shape. In contrast, Japanese children showed no clear preference on the simple object trials. Their extension patterns were random, as though they found simple objects intermediate between the object-reference case (complex objects) and the substance-reference case (substances). In the substance trials, while Japanese subjects (except for the youngest group) consistently projected novel words based

[5] Since there were only two alternatives (*shape* and *material*), the proportion of *material* responding is simply 1 minus the proportion of *shape* responding.

on material identity, American subjects (except for the youngest group) failed to show such distinct preference for material-based extension.

With this overview in mind, we now turn to the analyses that support these findings. To examine the overall pattern, a 2 (Language) × 4 (Age) × 2 (Gender) × 3 (Entity Type) mixed ANOVA (with entity type as a within-subjects factor and all other factors between subjects) was conducted using the frequency of *shape* responses as the dependent variable. Since there were no main effects or interactions involving gender, this factor was dropped from further analyses. We also conducted a separate 2 (Language) × 4 (Age) × 3 (Entity Type) × 2 (Number of Portions) mixed ANOVA to see whether subjects' performance was affected by the number of portions in the *material* alternative (i.e., whether the *material* alternative contained the same number or a different number from the standard entity).[6] Because there was no main effect nor any interactions involving the number-of-portions variable, it was dropped from further analysis as well. This lack of a number-of-portions effect is inconsistent with Soja et al.'s (1991) and Carey's (1994) claim. They argued that what children use in assigning a given instance's to the class of individuals or non-individuals is an abstract concept of number and not mere perceptual attributes such as shape. Although the number-of-portions effect was not a central focus of this research, we will come back to it in the Discussion. At any rate, we thus report the results from a 2 (Language) × 4 (Age) × 3 (Entity Type) mixed ANOVA model below.

There was a significant main effect of language, indicating that American subjects made more *shape* responses than Japanese subjects, $F(1, 115) = 33.04$, $p < .001$. There was no main effect of age, $F(3, 115) = 0.43$. However, there was a significant Language × Age interaction, $F(3, 115) = 2.92$, $p < .05$. We will return to this finding below.

The key predictions concern whether children showed differential projection patterns for different entity types and how language and age influenced these patterns. First, there was a significant main effect of entity type, indicating that the proportion of *shape* responses differed across different types of entity, $F(2, 230) = 141.26$, $p < .001$. More importantly, there was also a significant Entity Type × Language interaction, $F(2, 230) = 7.71$, $p = .001$, indicating that the way people projected noun meanings in the presence of the three types of entities differed across the two language populations. There was also a significant Entity Type × Age interaction, indicating a developmental change in projection patterns $F(6, 230) = 2.65$, $p < 0.02$. The three-way Entity Type × Language × Age interaction did not quite reach significance, $F(6, 230) = 1.91$, $p = .08$.

We now wish to look at the Entity Type × Language interaction more closely to ascertain how the three entity types differed across language. We decomposed the effect of entity type into two single-degree-of-freedom planned contrasts, one

[6] We did not include this last factor in the previous analysis because including too many variables in one model will produce unreliable higher-order interactions due to the small number of cases in each cell.

contrasting complex objects versus simple objects, the other contrasting simple objects versus substances. Looking at the first contrast, (complex objects vs. simple objects), there was a main effect, $F(1, 115) = 76.46$, $p < .01$. This means that across the two language groups, the proportion of shape responses was higher in the complex object trials than in the simple object trials. More importantly, however, there was a significant interaction between this contrast and language, $F(1, 115) = 16.93$, $p < .01$, confirming that the difference in the proportion of shape responses was greater among Japanese subjects (86.5% vs. 48.5%, averaged across the four age groups) than among American subjects (90.5% vs. 76.8%). To examine whether this complexity differential holds, within each language, the same contrast analysis was performed separately for English and Japanese subjects. These analyses revealed a significant difference between the two entity types not only among Japanese subjects but also among American subjects, $F(1, 56) = 13.75$, $p < .01$, and $F(1, 59) = 69.06$, $p < .01$. Thus, the likelihood with which people construe bounded solids as pre-individuated objects was graded with respect to complexity of shape, but this graded effect was larger in Japanese speakers than in English speakers.

The planned contrast between simple objects and substances showed only a main effect for the contrast, $F(1, 115) = 71.27$, $p < .01$; the interaction with language was not significant, $p > .1$; that is, that both language groups made more shape responses in the simple object trials than in the substance trials even though American subjects were more shape-oriented overall (76.8% simple objects vs. 46.2% substance across the four age groups) than Japanese subjects (48.5% vs. 21.0%).

The next question is whether the children's response patterns change with age, and whether language influences this development. To unfold the Entity Type × Age interaction, we carried out three different univariate ANOVAs, one for each entity type.

5.1. Complex object trials

A 2 (Language) × 4 (Age) ANOVA showed no main effects of either language or age, $F(1, 115) = 1.35$, and $F(3, 115) = 1.36$, respectively, $p > .1$ in both cases. The Language × Age interaction was also non-significant, $F(3, 115) = 1.51$, $p > .2$. This unequivocal orientation towards shape given complex object trials is evidence for a universal tendency to take complex bounded solids as pre-individuated entities.

5.2. Simple object trials

There was a marked cross-linguistic difference on the simple object trials. A 2 (Language) × 4 (Age) ANOVA revealed a significant main effect of language, reflecting the fact that American subjects gave more *shape* responses than Japanese subjects, $F(1, 115) = 27.73$, $p < .001$. Neither the effect of age nor the

Language × Age interaction was significant, $F(3, 115) = 2.47$, $p > .05$ and $F(3, 115) = .80$, respectively.

5.3. Substance trials

As noted above, both language groups gave significantly fewer *shape* responses on the substance trials than on the object trials. However, the results also showed marked cross-linguistic differences. A 2 (Language) × 4 (Age) ANOVA for the substance trials showed a significant main effect for language, reflecting the fact that the Japanese subjects made fewer *shape* responses overall than did the American subjects, $F(1, 115) = 18.30$, $p < .01$. There was no main effect of age, $F(3, 155) = .84$. However, there was a Language × Age interaction, $F(3, 115) = 4.04$, $p < .01$. Two univariate ANOVAs were conducted separately for each language group to unfold this interaction. These analyses revealed a significant effect of age for the Japanese subjects, $F(3, 59) = 17.34$, $p < .01$, but no significant effect for the American subjects, $F < 1$. That is, the material preference for substance trials increased with age in Japanese subjects.

5.4. Tests against chance level

We also examined whether the proportion of shape-based projection for each entity type in each age and language group is different from chance level. These tests provide us with a different way to look at the data, that is, whether the response pattern for a given group for a given entity type should be characterized as a shape preference, a material preference, or no preference. All tests against chance probability were done by t-tests.

In the complex object trials, *shape* responses were made at significantly above-chance levels, $p < .01$ for all ages in both language groups. The proportion of shape-based projections for this entity type ranged from 79% to 97%. That is, all subjects regardless of age and language treated complex objects as pre-individuated entities.

In the simple object trials, American and Japanese subjects showed largely different response patterns. From the youngest age on, American subjects showed a *shape* preference for simple objects (ranging from 68% to 91% *shape* responses, all above chance). In sharp contrast, Japanese children between 2 and 4 years of age performed at chance (ranging from 50% to 57% *shape* responses), and Japanese adults showed a significant *material* preference (36% *shape* responses, $t(13) = 2.22$, $p < .05$). These results suggest very early effects of language. From the age of 2 onwards, American subjects construed both simple and complex bounded solids as pre-individuated entities; in contrast, Japanese children were neutral as to the ontological class of simple objects. Further, a possible entrainment effect is suggested by the fact that the Japanese material preference for simple objects increased with age.

The substance trials also showed marked language differences. Although

American subjects made fewer *shape* responses on the substance trials (ranging from 34% to 54%) than they did on the object trials, they did not show a reliable material preference on the substance trials. They performed at chance. The only exception was that American 2-year-olds showed a significant material preference; their level of *shape* responding on substance trials (34%) was significantly below chance, $t(13) = -2.22$, $p < .05$. (However, there was no age main effect in the substance ANOVA for American subjects. Without a reliable difference between the American 2-year-olds and the older groups, it is not clear whether we should take the significant material bias in the youngest American children as unequivocal evidence that they construed the entities as non-individuated substances.) In contrast, all Japanese groups except the youngest group showed an above-chance material preference on substance trials. (The range was 19% to 9% *shape* responses, or 81% to 91% *material* responses.) Only Japanese 2-year-olds showed no consistent preference between *shape* and *material* selections (55% material responses). Tukey HSD tests revealed that the Japanese 2-year-olds made a significantly higher proportion of shape responses than any of the older groups, all $ps < .02$.

The above patterns suggest that Japanese subjects except for the youngest group construed the substance standards (i.e., non-solid substances configured into complex shapes) as non-individuated substances. Further, this construal strengthened over time. In contrast, American subjects, except for the youngest group, were neutral in their assignment of these configured substances into the two categories.

5.5. Subject analysis

To examine whether these group averages are consistent with individual subjects' patterns, a subject analysis was conducted. We classified each subject's response preference in each trial type as *shape preference*, *material preference*, or *no preference*. The subject 's pattern was scored as *shape preference* (or *material preference)* when he/she made a shape (or material) choice three or four times out of the four trials for the trial type. The pattern was scored as *no preference* when the child made two shape and two material choices. Table 2 shows the proportion of the number of subjects in each preference type for the three trial types within each age and language group. Binomial tests were conducted to see whether the number of subjects in each cell differed from the probability expected by chance. The chance probabilities for *shape preference* and *material preference* were both .31 (5/16), and that for *no preference* was .36 (6/16).[7]

[7] We computed the chance level for each class by first calculating the probability for each of the possible response patterns, and then adding the probabilities of the responses that fall into each of the three classes. For example, for a subject to be classified as having shape preference for a given entity type, he/she needs to make shape selections three times (probability = 4/16) or four times (probability = 1/16) out of four trials. Thus the probability of a given subject falling into the *shape preference* class is 5/16. The same probability holds for the *material-preference* class. The probability of a no-preference pattern – that is, of selecting the shape alternative twice and the material alternative twice – is 6/16.

Table 2
Proportion and number of subjects (in parentheses) classifiered as shape preference, material preference, or no-preference for each entity type within each age and language group

		Complex objects		Simple objects		Substances	
		American	Japanese	American	Japanese	American	Japanese
2-year-olds							
A: $n = 14$	S[a]	0.79 (11)*	0.79(11)*	0.57 (8)*	0.29 (4)	0.14 (2)	0.21 (3)
J: $n = 14$	M[b]	0.21 (3)	0.07(1)[#]	0.29 (4)	0.36 (5)	0.57 (8)	0.36 (5)
	N[c]	0.00 (0)[#]	0.14(2)	0.14 (2)	0.36 (5)	0.29 (4)	0.43 (6)
21/2-year-olds	S	0.93 (13)*	0.93 (14)*	0.64 (9)*	0.27 (4)	0.43 (6)	0.07 (1)[#]
A: $n = 14$	M	0.07 (1)[#]	0.07 (1)[#]	0.07 (1)[#]	0.33 (5)	0.21 (3)	0.67 (10)*
J: $n = 15$	N	0.00 (0)[#]	0.00 (0)[#]	0.29 (4)	0.40 (6)	0.36 (5)	0.27 (4)
4-year-olds	S	1.00 (14)*	0.86 (12)*	0.93 (13)*	0.43 (6)	0.29 (4)	0.00 (0)[#]
A: $n = 14$	M	0.00 (0)[#]	0.07 (1)[#]	0.07 (1)[#]	0.43 (6)	0.36 (5)	1.00 (14)*
J: $n = 14$	N	0.00 (0)[#]	0.07 (1)[#]	0.00 (0)[#]	0.14 (2)	0.36 (5)	0.00 (0)[#]
Adults	S	0.94 (17)*	0.89 (16)*	0.61 (11)*	0.17 (3)	0.44 (8)	0.06 (1)[#]
A: $n = 18$	M	0.00 (0)[#]	0.00 (0)[#]	0.11 (2)	0.61 (11)*	0.44 (8)	0.89 (16)*
J: $n = 18$	N	0.06 (1)[#]	0.11 (2)[#]	0.28 (5)	0.22 (4)	0.11 (2)	0.06 (1)[#]

[a]Shape preference subjects – selected shape choice 3 or 4 times.
[b]Material preference subjects – selected shape choice 0 or 1 time.
[c]No-preference – selected shape (and thus material) 2 times.
*Significantly higher than the base probability at $p < .05$ (two-tailed).
[#]Significantly lower than the base probability at $p < .05$ (two-tailed).

The results of the subjects analysis converged with the results of the prior analyses. Again there was uniformity on the complex object trials: the number of subjects who showed a shape preference highly exceeded the number expected by chance ($p < .05$, two-tailed) in all age groups in both languages (91.7% of all American subjects, and 86.9% of all Japanese subjects, averaged across all ages). And again, the two language groups differed on the simple object trials and on the substance trials. In the simple object trials, the number of American subjects showing a shape preference exceeded the chance level in all age groups (68%, averaged across all ages); in contrast, Japanese children were evenly distributed across the three preference classes (32.6% *shape-preference*, 30.2% *no-preference*, and 37.2% *material-preference*, averaged across 2- to 4-year-olds); among Japanese adults, a majority fell into the *material-preference* class (61%, above chance).

In the substance trials, all Japanese groups except for the 2-year-olds showed a significantly above-chance number of *material preference* subjects (35.7% for the 2-year-olds; 85% for the rest, averaged across the three ages). Among Americans, only the 2-year-olds showed above-chance *material preference* (57%); none of other age groups fell into any of the three classes at the above-chance level (39.1% in the *shape-preference* class, 34.8% in the *material-preference* class, and 26.1% in the *no-preference* class, averaged across the three ages). This last result again underscores the greater material bias found in Japanese.

6. Discussion

Our results demonstrate a striking pattern of cross-linguistic similarities and differences. First, there is evidence for the universal use of ontological knowledge in individuation independent of language. That pre-linguistic ontological distinctions influenced patterns of individuation in word extension can be seen in the fact that children in both languages extended complex objects according to shape and distinguished between complex objects and substances in their projections. Both the American and the Japanese children gave many fewer shape extensions for non-solid substances than for complex objects. That the Japanese 2-year-olds showed this pattern is particularly strong evidence for Soja et al.'s early ontology argument, and against the strong form of Quine's conjecture, since Japanese has no linguistic apparatus for marking the two ontological categories.

However, our results also indicate strong early effects of language. Despite the cross-linguistic similarity with regard to complex objects and substances, a marked cross-linguistic difference was observed for simple objects. English speakers from 2 years onward projected nouns according to common shape for simple objects as well as complex objects. They used an object-naming rule for any solid, bounded entity, conforming in effect to the whole-object constraint. In contrast, Japanese children – whose language provides no guidance as to whether simple objects should be seen as objects or as substances – responded at chance levels.

Our finding of early influence of linguistic categories on children's projection of word meanings accords with other reports of very early effects of language (e.g., Choi and Bowerman, 1991; Slobin, 1987). For example, Choi and Bowerman found that English-speaking and Korean-speaking children, whose languages partition the domain of physical attachment and separation events differently, begin to acquire their very different semantic patterns by 2 or 3 years of age. Our results indicate that even something as basic as the scope of early object-naming is influenced by the language learned.

The American subjects' stronger orientation toward shape was also shown in the substance trials. Although, like Soja et al.'s 2-year-olds, the youngest American subjects showed a reliable material bias in these trials, this material bias was not nearly as strong as the shape bias for the complex and simple objects. In fact, within the American group, there was no main effect of age on this trial. From the late 2-year-old period onward, older groups showed a random response pattern between the two alternatives. This pattern was somewhat different from that found in Soja et al.'s study. Soja et al. found that the older (American) 2-year-olds showed a stronger material bias than the younger 2-year-olds. We do not have a clear explanation for the discrepancy between their results and ours. Perhaps the shapes of the substances in our study were more salient and interesting than those in their study, and thus were more suggestive for individuation.

The lack of a strong material bias among English-speaking subjects when non-solid substances were presented in a distinct shape was also found by Subrahmanyam et al. (under review). Subrahmanyam et al. presented English-speaking American 3- and 5-year-olds with either of the two types of standard entity. One type, the "object" standard, had an angular shape and was made out of a solid material (e.g., caulk). The other one, the "substance" standard, had a curvy U-shape and was made out of non-solid material (e.g., glue). Depending on the condition, the children heard a novel label associated with the standard stimulus either as a count noun or a mass noun. They were then shown a series of alternatives that varied systematically from the standard in shape and/or material and asked whether each of the alternative stimuli could be labeled with the same name as the standard. When 3-year-old American children saw the "object" standard, they extended the label to the entities of the same shape regardless of the syntactic context. When they saw the "substance" standard, in contrast, they did not show a distinct bias for material (or shape) even when the label was given in mass-noun syntax.

However, in sharp contrast to American subjects (both in our and Subrahmanyam et al.'s studies), Japanese subjects in our study across all ages but the youngest group consistently showed a strong material bias on these trials. Unlike American subjects, Japanese subjects were not affected by the fact that non-solid substances were presented in a distinct shape.

In sum, our evidence suggests that children may universally possess an ontological distinction between individuated objects and non-individuated substances,[8] and that this distinction informs their word learning. However, the structure of their language influences where and how this division is made. We will consider implications of this position below. First, however, we wish to consider some possible alternate accounts of the findings.

6.1. Can the English shape preference be explained as a lexical effect?

American subjects gave more shape responses than did Japanese for both the simple objects and the substances. The combination of solidity plus even a simple shape was enough to lead English speakers, but not Japanese speakers, to construe the entity as an individuable object and extend its name on the basis of shape. Even for the non-solid substances in complex shapes (which the Japanese speakers unequivocally construed as substances) English speakers were split between extending by shape (the object construal) and extending by material (the substance construal), again suggesting a greater focus on shape. Such a cross-linguistic difference is consistent with the possibility that languages require their speakers to pay attention to different dimensions. English and Japanese may lead their speakers to take on slightly different construals for pre-individuated entities versus non-individuals, or to differ in where they place the boundary between the two

[8] These results could also suggest that complex objects may be pre-linguistically conceptually privileged, so that words for them are interpreted as object-reference terms and learned very early across languages (Gentner, 1982; Gentner and Boroditsky, in press). However, with our data, we cannot exclude the possibility that substance names (for typical substances) are as easily learned as object names because our substance instances are not comparable with the complex object instances with respect to typicality, as we mentioned earlier (see footnote 2).

classes. For example, English count/mass syntax requires speakers to make a dichotomous decision as to whether something should be coded by a count noun or a mass noun. Thus, it could be argued that the structure of English leads to its speakers' paying "habitual attention to shape".

However, there is another possible explanation. It is also possible that when English speakers saw a substance in a discrete shape, they interpreted the novel noun as a count noun describing a particular unit/form of substances, something like *puddle* or *pile*.[9] Such an interpretation is very unlikely in Japanese, where words like *puddle* and *pile* that provide units for quantification are classifiers, not nouns. (Thus a noun phrase like "kono *dakkusu* (this *dax*)" would not be taken to mean a counting unit like *pile*, *puddle*, or *chunk*.) If English subjects on the simple object and substance trials were taking the name to mean something like "puddle", this could explain their frequent failure to choose on the basis of material (after all, "puddle" could involve common shape as well as common material).

Fortunately, our results provide an indirect check of this account. On the "puddle" lexical account, we should see strong effects of numerosity. The child should be more likely to extend *blicket* (or "puddle") to the material alternative when it is a single piece of the original substance than when it is three pieces of the original substance. Soja et al. (Soja et al., 1991, 1992; also Carey, 1994) suggested that such a numerosity effect may have occurred in their studies: children showed higher performance on the object trials in Soja et al.'s (1991) task, in which such numerosity cues were present, than in Soja's (Soja, 1987) study in which the material alternatives were always single objects. However, we did not replicate this finding. To examine this issue directly (although this was not our central interest), we designed the stimulus materials so that within each entity class, the material alternative consisted of a single portion of the standard entity in half of the trials and multiple portions for the other half of the trials. We found no evidence that subjects (either children or adults, Japanese or American) made use of the number of portions in the material alternative as a basis for noun meaning projections. Of course, caution is warranted in drawing conclusions from these null results, and more work on numerosity in individuation is clearly called for.[10] However, as it stands, our results are most consistent with the possibility that the structure of English leads its speakers to attend to shape, as well as other cues, in individuating referents.

Turning to the Japanese speakers, we found many more material selections than among English speakers in the simple object and substance trials, consistent with

[9] Imai (1995) in fact found that, for both 4-year-olds and adults, English-speakers' pattern of novel noun extension given a *neutral* syntactic frame (e.g., *this dax*) was almost identical to the pattern given a *count noun* syntactic frame (e.g., *a dax*). This suggests that, when the count/mass syntactic status is ambiguous or neutral, English speakers may be biased to interpret a novel noun as a count noun (provided this interpretation is plausible for the referent).

[10] Also, in our study the contrast between single and multiple portions was confounded with particular stimuli rather than counterbalanced across sets (e.g., the material alternative in the cork-pyramid set was always presented with a single piece of cork).

Lucy's prediction that the structure of classifier languages should lead speakers to pay habitual attention to the material component of entities. Further, Japanese subjects showed a shift towards an increasing focus on material across development (at least on the substance trials), as would be predicted under a linguistic entrainment account.[11]

6.2. Can Japanese subjects' performance be explained by classifier distribution?

Japanese children made a distinction between complex objects and substances despite having no count/mass distinction in their grammar. We have suggested that this is evidence for a universal early conceptual distinction between object kinds and substance kinds. However, there is another possibility. Although Japanese speakers are unlikely to experience lexical effects of the "puddle" kind, as discussed above, there is another possible explanation:[12] the performance of the Japanese subjects may have simply reflected a distributional tendency for certain classifiers to be associated with objects and others to be associated with substances. If this were the case, Japanese subjects could have responded differentially to complex objects versus simple objects and substances simply because different types of classifiers are associated with these classes.

There is some reason to doubt that a classifier distribution explains our Japanese subjects' behavior. In modern Japanese, the ontological cut between object and substance is only vaguely distinguished at the lexical level. There exist some classifiers that are typically associated with objects, but even these "object classifiers" can sometimes be used for substances and vice versa. For example, typical shape classifiers such as *hon* (one-dimensional extension), *mai* (two-dimensional extension) and *ko* (three-dimensional extension) are usually associated with objects, but are often used for solid or semi-solid substances such as butter and clay. Likewise, classifiers providing a measuring unit such as *hai* (a bowl of) and *yama* (a heap of; literally, 'mountain') are often used for collections of individuated objects such as apples, potatoes, oranges,[13] etc. This lack of a clear object/substance distinction in the distribution of classifiers in Japanese contrasts with a strict division in classifiers for other important ontological cuts, namely, sentient/animate/inanimate. For example, the classifier for humans, *nin*, cannot be used for any other animals or for inanimate entities. Classifiers for animals such as

[11] However, here too caution is warranted. We cannot know whether Japanese speakers are being led to pay more attention to material, or whether they are simply *not* being entrained to attend to shape (since Japanese does not force speakers to habitually determine entities' status as to pre-individuation). On this account, their developmental increase in attention to material on the substance trials would simply reflect increasing perceptual/conceptual experience.

[12] We thank Terry Au for pointing out this possibility.

[13] Note that, in English, when we unitize oranges and potatoes with boxes or baskets, the individuality of the objects is still marked by the use of a plural marker (e.g., *a basketful of oranges* rather than **a basketful of orange*). In Japanese, however, the individuality of oranges cannot be detected in *mikan hito-yama* (literally, orange one heap).

hiki (for small animals), *tou* (for big animals), and *wa* (for birds and rabbits) are never used for inanimates; likewise, classifiers for inanimates are never used for animals, except for dead bodies of animals.

6.3. Experiment 1c: A check for differential classifier distribution?

To test this claim that the object–substance distinction is not sharply marked by distinct classifiers in Japanese, we conducted a production test with Japanese adults.

Twelve Japanese college students who had not participated in the rating study (Experiment 1a) or the main study (Experiment 1b) served as subjects. We showed them all 12 standards – four complex objects, four simple objects, and four substances – and the 12 material alternatives (single or multiple pieces/piles of the standard entities) one at a time and asked them which classifier or classifiers they would use in counting the given entity. This test was done individually and the presentation order was counterbalanced across subjects.

If the Japanese subjects' response patterns are to be explained in terms of distributional correlations between classifiers and entity types, then Japanese native speakers should use different types of classifiers for the three entity types. However, this was not what we observed in the adults' production pattern. Most notable was that *ko* and *hon* were used not only for the complex object standards but also for the simple object standards. For the complex objects, all 12 subjects used *ko* for the clip and the T-joint, and *hon* and/or *ko* for the lemon juicer and the whisk. Likewise, 10 out of 12 subjects used *ko* for all the simple object standards. For the material alternatives (the chunks/broken pieces of the complex and simple object standards), subjects tended to give both *kake* or *hen* (both mean "piece") and *ko*. This argues against the possibility that Japanese subjects responded differently to the complex objects than to the substances (or the simple objects) because of a distinctive distribution of classifier types.

Further evidence against a distributional explanation is that the Japanese adults often used *ko* and *hon* for the substance standards, although not as often as for the complex and simple object standards (the range was from 5/12 to 8/12 subjects across the four items).[14] Subjects also used *mai*, the classifier for two dimensional objects, for these items. Overall, these findings argue against a purely distributional explanation for the semantic distinctions made by Japanese subjects. This is especially true for the distinction between complex objects and simple objects, for which the distributional cues are weak or non-existent. Thus the distributional account does not appear sufficient. The evidence suggests that the Japanese children's distinction between complex and simple objects is acquired independent of language.

[14] Subjects sometimes had difficulty producing an appropriate classifier for the substance standards, because most unitizers for non-solid stuff are containers, such as a glass, cup, bottle, or tube; there are no conventional classifiers dedicated to shapes of non-solid substances.

6.4. Early object naming

Some theorists have proposed a privileged role for object-naming in early acquisition (Gentner, 1982; Gentner and Boroditsky, in press; Golinkoff et al., 1995; Macnamara, 1982; Markman, 1989; Waxman, 1991; see also Au et al., 1994; Woodward, 1992). Our results provide partial support for this position: both Japanese and American children of all ages uniformly projected complex objects according to shape, despite their linguistic differences. However, the fact that this shape-responding was graded according to complexity of object (strikingly so among Japanese subjects) requires a further specification of the early object advantage. Gentner's (1982) natural-partitions hypothesis asserts that object names are learned earlier than relational terms because objects are highly perceptually cohesive and stable over time, and thus more easily individuated and parsed out from the perceptual context than other kinds of referents.[15] Our results suggest adding the assumption of graded individuability: for example, that complex objects are more readily individuated (and thus mapped onto language) than simple objects.

6.5. Early object concepts

We might ask how our results fit with research on infants' attainment of the object concept, and in particular with the evidence that pre-linguistic infants possess fundamental knowledge of objects (e.g., Baillargeon and DeVos, 1991; Mehler and Fox, 1985; Spelke, 1985, 1990) as well as an appreciation of a fairly abstract notion of individuation (e.g., Carey, 1994; Huntley-Fenner, 1995; Spelke, 1990; Wynn, 1990). In particular, infants have been found to track the identity of objects and are apparently able to individuate and keep track of even simple objects such as spheres (e.g., Huntley-Fenner, 1995; Spelke, 1990; Wynn, 1990). Even the most pessimistic accounts (e.g., Xu and Carey, 1996) would grant a notion of individuation to infants past 12 month of age.

One may think that our finding that the Japanese children failed to show a clear object interpretation for the simple objects is in conflict with these results. However, it is not necessarily so. Our study focused on slightly different aspects of ontological knowledge than the above-mentioned studies. Specifically, the studies done by Spelke, Baillargeon, and other researchers have primarily focused on infants' understanding of the essential properties and behaviors of objects, while our research dealt with children's classification behavior. We asked, given a series of perceptual stimuli, which perceptual dimension(s) children varying in language

[15] An important corollary contributor to the early object advantage is that relational terms (e.g., adjectives, verbs and prepositions) are more cross-linguistically variable in meanings than object-reference terms because they are relatively underdetermined by perceptual experience. Because relational meanings are linguistically shaped, learning their meanings requires some entrée into the language. In contrast, the infant can learn some object reference terms by simply attaching words to pre-existing object concepts. This assumption, too, may be more correct for complex, perceptually coherent objects than for simple objects.

and age use as a basis for assignment to the two ontological classes. It has been pointed out that determining the extension of a category may not be equivalent to understanding properties that comprise its intension (Armstrong et al., 1983; Gelman et al., 1986; Imai, 1996). In our case, the Japanese children may well have understood that important properties of "objects" (e.g., that objects maintain their boundaries as they move, and that one object cannot pass through the space occupied by another) can be applied to a solid lump of wax or clay. Yet they may have had difficulty determining whether these "object properties" should be weighed more heavily than "substance properties" (e.g., being made out of homogeneous material; being divisible into pieces without change in functionality). Likewise, American children may well have understood that a complex-shaped portion of sand would not move coherently. Yet they may have had difficulty determining whether this entity should belong to the class of individuals or that of non-individuals, because complex shape points to the "individual" interpretation.

6.6. Does universal ontology go beyond physical entities?

Our cross-linguistic results are consistent with the claim of a universal ontological distinction between individuals and non-individuals. Our next question is whether this distinction should be seen as a concrete division between objects and substances, or whether it involves an abstract division between individuated and non-individuated classes. It has been demonstrated that English speakers impose the individual/non-individual distinction beyond physical entities (Bloom, 1994a,b; Bloom and Kelemen, 1995: Wisniewski et al., 1996). As pointed out by Bloom (1994a, 1994b), English requires its speakers to be explicit about individuality not only in labeling physical entities but also in labeling abstract concepts, events, superordinate categories and so forth (see also Wisniewski et al., 1996). Perhaps it is an abstract distinction between individuals and non-individuals that is universal.

For example, Bloom (1994a) reported that English speakers projected the individual/non-individual distinction when asked to describe sounds. People preferred a plural count noun to label a sound described as occurring over discrete intervals, consistent with their construing the sound as number of distinct, temporally bounded and separable individuals. In contrast, people preferred a mass noun to label a sound described as occurring over a long, continuous period of time, consistent with a construal of the sound as a temporally unbounded, unindividuated entity. Bloom (1994a, 1994b) took this as evidence for the idea that a non-physical, abstract notion of individuality is present in universal ontology. This is an interesting claim, but it should be tested by asking whether speakers of a language that does not mark individuality indeed impose this conceptual distinction on abstract concepts. For example, *idea* is a count noun and *thought* is a mass noun in English. Accordingly, English speakers may construe an *idea* as an individual but *thought* as indivisible mass. These two words are both translated to the noun "*kangae*" in Japanese. Now, do Japanese speakers (consciously or unconsciously) think of the meaning of this word in terms of individuality? Or do Japanese people divide superordinate concepts into two types according to whether the category is divisible into individual members or indivisible and draw different kinds of inference as English speakers do (Wisniewski et al., 1996)? We see this is an extremely important question that yet needs to be empirically tested.

6.7. *Language and thought*

We turn now to the perennially fascinating (and perennially undecidable) Whorfian question of whether linguistic categories affect our thought. Our results run against the extreme version of the Whorfian hypothesis, as well as of Quine's conjecture. With or without linguistic apparatus to mark the object/substance distinction, even 2-year-old children distinguish between two ontological classes – the class of pre-individuated entities and that of non-individuated matter – and use this knowledge for word learning. Even where we did find large cross-linguistic differences, it could be argued that they are irrelevant to the Whorfian hypothesis, since they merely show that grammar influences word meaning, not that it also determines non-linguistic categories.

Recently, however, the issue of whether language learning singles out some aspects of the non-linguistic world as more important than others has returned to the research foreground (e.g., Bowerman, 1985, 1993; Byrnes and Gelman, 1991; Choi and Bowerman, 1991; Gentner and Rattermann, 1991; Slobin, 1987). More specifically, recent theorizing has explored subtler versions of the linguistic influence hypothesis (as did Whorf, 1956, himself). For example, Slobin (1987) suggests that language may influence categorization during "thinking for speaking". Hunt and Agnoli (1991) reviewed evidence that different languages impose different cognitive burdens on their speakers. They argue that language may influence thought by making certain habitual aspects extremely fluent (either at the structural level or at the lexical level). They argue that linguistic influences may obtain even when the speakers of two different languages can eventually arrive at the same meaning for a given text: "linguistic reasoning often occurs concurrently with non-linguistic reasoning and ... the complexity of linguistic analysis will affect concurrent non-linguistic thought" (Hunt and Agnoli, 1991, p. 384; see Lakoff, 1987, for a similar view).

In this light, the cross-linguistic difference we found in the simple objects and substance trials can be seen as support for this moderate version of the Whorfian hypothesis. Japanese speakers and English speakers appeared to use different criteria in determining the class membership for a given instance, suggesting that they have a different representation for, or at least a different boundary between, individuals and non-individuals. This is not to suggest that the notion of individual is incommensurably different across the speakers of the two languages. We assume that it largely (perhaps mostly) overlaps, and that speakers of both languages know that solid, bounded entities move cohesively in space, do not pass through one another, and so on. However, we suggest that the results of our word-extension task are relevant to the issue of what the speakers of the language consider "another entity of like kind". Indeed, the word-extension task may well be the most reliable task for eliciting the young child's sense of categorial relatedness (Markman, 1989; Waxman and Kosowski, 1990). Pre-school children, whose spontaneous groupings often reflect thematic relations, nonetheless show categorical classification when asked to extend a novel noun meaning[16] (e.g., Baldwin, 1992; Imai et al., 1994; Imai, 1995; Markman and Hutchinson, 1984; Waxman and Kosowski, 1990). Thus, our finding that English-speaking subjects attended relatively more to shape and the Japanese speakers to material in the word-extension task is consistent with the claim that linguistic structure affects the weighting of dimensions and the way in which speakers classify entities into different categories.

However, a more direct test for Whorfian effects – and in particular of Lucy's specific predictions – would be a non-linguistic similarity triads task like Lucy's. Lucy tested his claim that classifier languages entrain their speakers into thinking about materials by giving English and Mayan speakers a triads similarity task, as discussed above. He found, as predicted, that English speakers were more likely to choose the shape alternative, and Mayans the material alternative. Imai (1995) carried out such a test, using the same triads as in the present study. She asked Japanese and English children and adults which of the alternatives the standard was most similar to (without invoking any novel word meanings). The results were intriguing. Adults in both language groups showed the same response patterns in the similarity classification task as in the word-extension task, with American subjects weighting shape and Japanese weighting material. However, children in the similarity task showed patterns quite different from the adult response patterns. In particular, American 4-year-olds failed to show any appreciation of ontological classes; their responses were random for all three types of entities (see Subrahmanyam et al., under review, for a similar finding). Children were more similar to adults in the novel word-extension task than in the no-word triads task, as would be expected if non-linguistic classification follows developmentally after classification for word learning. (See Smith and Sera, 1992, for a consistent result with dimensional adjectives in English.)

These results suggest the following speculation as to the development of language-specific biases. Children begin learning word meanings building on their pre-linguistic ontological knowledge about individuation. Language learning leads children to pay attention to those aspects of the world that are habitually used in their own language, and this influence begins very early. Finally, children's

[16] Note, however, that the actual categories formed by young children are not always equivalent to the adult's taxonomic categories. When category membership is separated from perceptual similarity, young children often rely on shape similarity as a basis for novel noun extension and thus the output category sometimes contains members that are shape-similar but are not actual members of the target taxonomic category (Baldwin, 1992; Imai et al., 1994; Golinkoff et al., 1995). Perhaps this is because children use shape as an indicator for detecting "like kind" when they have only scanty content knowledge about the target category. In any case, where perceptual similarity does not conflict with taxonomic/ontological category membership, children have been reported to show more taxonomically sensitive performance.

sensitivity to linguistically-relevant aspects of the world may come to extend beyond the context of language use.

7. Summary

We conclude that the projection of word meanings is determined by an interplay of cognitive and language-specific factors. Children universally distinguish two important ontological classes in the realm of physical entities – the classes of objects and substances – and apply this knowledge in word learning, in line with Soja et al.'s arguments; but the linguistic structure of their native language may influence how particular perceptual dimensions are weighed in determining the class membership for instances that are located in the middle ground of the individuation continuum (such as our simple object and substance instances). Our evidence is consistent both with Slobin's (Slobin, 1985) claim of a set of core meanings that figures cross-linguistically in early language and with Bowerman's (1985) claim that there are specific linguistic influences on children's semantic categories from the outset. The challenge as we see it is now to discover which kinds of categories are likely to be most influenced by language, and how this influence manifests itself developmentally.

Acknowledgments

This research was supported by Ministry of Education grant-in-aid for Scientific Research, by NSF grant BNS-87-20301, and by Keio University and Northwestern University. We are indebted to Tomoko Fujitani, Tatsuya Ishibashi, Yuwako Kikuchi, Kazuko Takagi, and especially to Aiko Imai for help in data collection in Japan. We thank Elvira Kaszuba and Cindy Harpenau for assistance in data collection in the United States. We thank the teachers, children and parents at Central Evanston Child Care and School for Little Children for their participation. Finally, we are grateful to Richard Beckwith, John Lucy, Ed Wisniewski, Phillip Wolff and Nobuko Uchida for discussions of the research ideas and to Terry Au and two anonymous reviewers for thoughtful suggestions on an earlier draft of the paper. Parts of this research have been presented at the 29th meeting of the Chicago Linguistic Society, April, 1993 (see Imai and Gentner, 1993) and at the 26th annual Stanford Child Language Research Forum, April, 1994.

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