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The Acquisition of the Classifier System and its Implications for the Nature of Lexical Acquisition

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Abstract

Classifiers are like nouns in that they classify entities in the world into lexical categories. However, the lexical nature of the classifier system is very different from that of nouns. We discuss how Japanese and Chinese children learn the meanings of classifiers. We focus on two specific questions: How classifier acquisition is different from noun acquisition; and what the prerequisites are for spontaneously extracting the meanings of classifiers. It is shown that children are very conservative in assigning meaning to classifiers. The pace of learning largely depends on semantic complexity, across languages and within each language. Furthermore, we suspect that learning the meanings of classifiers requires a certain cognitive ability — an ability to synthesize pieces of partial knowledge and form them into a cohesive whole. It may be only when children have developed such an ability that they are able to extract the complex semantic rules of classifiers on their own. We conclude that children take very different routes in learning nouns and classifiers: Unlike noun acquisition, classifier acquisition is guided by a slow, bottom-up process.

Key words: Lexical acquisition, Japanese and Chinese children, semantic complexity, the prerequisites for extracting the meanings of classifiers. bottom-up process.

Introduction

The research described in this paper examined how Japanese and Chinese children learn the classifier system. The acquisition of the classifier system is worthy of investigation because the nature of the classifier lexicon is very different from that of the noun lexicon, even though both nouns and classifiers deal with the classification of objects and other entities in the world. We believe that comparing the acquisition patterns of the two classes of words and identifying similarities and differences will give us important insights into the nature of lexical acquisition.

Lexical nature of numerical classifiers

Numerical classifiers are lexical items that are attached to a noun when quantity is specified. Their status is somewhat similar to quantifiers in English such as *a piece of, a portion of*. The important difference between English quantifiers and numerical classifiers is that English quantifiers are used for quantifying only mass nouns, while grammar demands that numerical classifiers be applied to *all* nouns when quantifying them. Thus, in quantifying, a classifier must be attached to individuated objects such as cars and computers, and even to humans.

Classifiers are considered to be closed-class words, rather than grammatical morphemes, and hence their lexical nature is comparable to that of English prepositions. However, relative to the learning of English count/mass grammar or prepositions, the learning of the classifier system is said to be very slow. The difficulty children face in learning classifiers seems to stem largely from the complex semantic nature of the classifier system. Although classifiers are closed-class lexical items, they are markedly different from typical closed-class words, such as English articles, in the number of lexical items belonging to this lexical category. There are approximately 70 classifiers in Japanese (Denny, 1979), compared with only two classes in the case of English count/mass grammar.

Furthermore, the semantic criteria for dividing the system according to each classifier category is complex and opaque (Denny, 1979; Downing, 1984; Matsumoto, 1987, 1993).

Roughly speaking, the conceptual/semantic distinc-

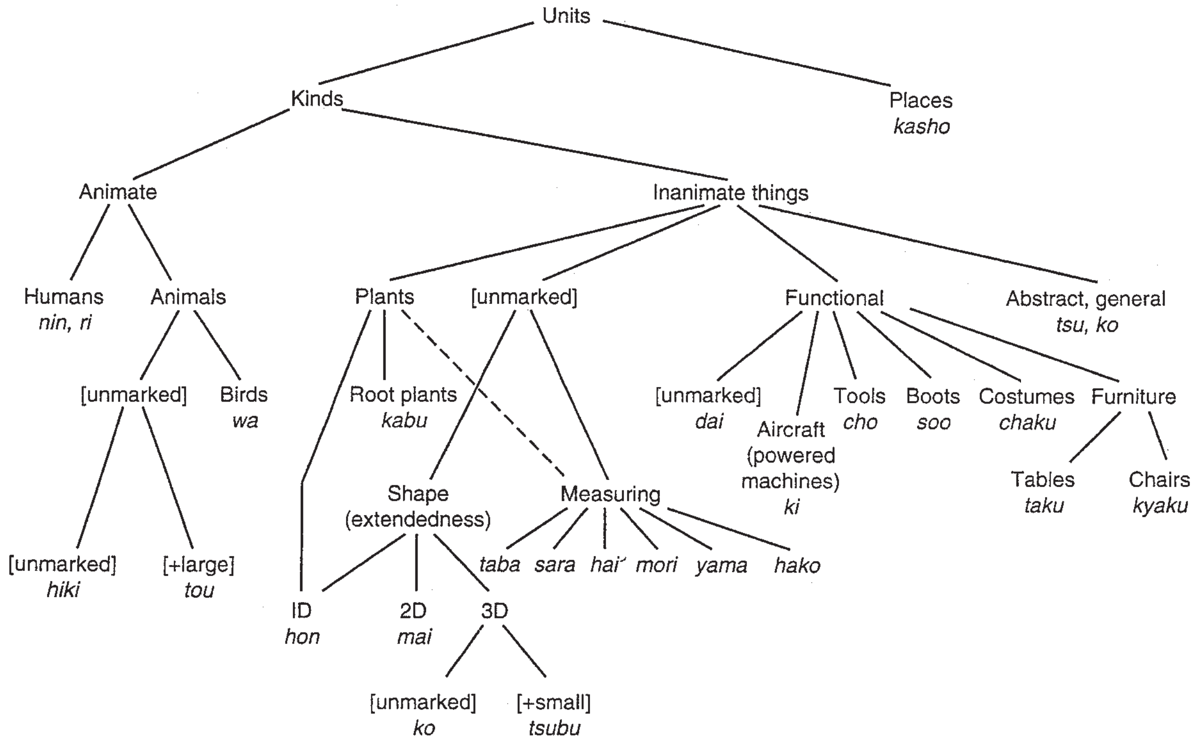

Figure 1. Outline of the Japanese numerical classifier system

tion between animals and inanimate entities is very strictly observed in the use of classifiers. That is, different classifiers are always used for animals and inanimate entities. However, further division, for example the division of each ontological class (animate vs. inanimate) into each classifier category, is made on the basis of mixed semantic criteria, including biological taxonomy, size, shape, and function. Take animate classifiers for example. Major classifiers for animate entities include *nin* (for humans), *hiki* (for small animals), *tou* (for large animals), and *wa* (for birds). Humans and birds correspond to biological categories, but all other classifiers for animate categories are assigned by size. It should also be noted that classifiers are not entirely mutually exclusive. There are a few unmarked classifiers that are used for almost anything. However, many nouns are associated with specific classifiers, and adult native speakers prefer to use specific classifiers over the general ones. Figure 1 sketches the Japanese classifier system. We constructed this schema on the basis of the data we collected from 30 Japanese adults.

Researchers have noted that there are certain universal aspects of classifiers (Adams & Conklin,1973; Allan, 1979; Croft, 1990; Denny, 1979). For example, features such as animation and shape dimensionality (one-dimensionally extended, two-dimensionally extended, and three-dimensionally extended) appear in almost all numerical classifier classes. Nonetheless, there are substantial differences across different classifier languages at a more specific level, for example, how the relevant semantic features are combined to make up classifier classes. For instance, in Mandarin, another classifier language, long, thin, curving objects, such as snakes. eels, rivers, and roads, are all associated with the classifier *tiao*. In this case, both animate objects and inanimate objects belong to a single classifier category, something that is never allowed in the Japanese system. In Korean, *mari* includes the whole of the animal world. What can be noted from the cross-linguistic pattern is that the semantic features relevant to the classification are similar across languages, but the resulting categories are quite different.

The lexical organization of classifiers is very different from that of nouns. Nouns in general have a well organized and cohesive hierarchical structure, while classifiers do not. Extension rules for nouns, particularly for basic-level object names, are transparent. For example, objects belonging to the same basic-level category greatly resemble each other in shape, and children use this to extend a novel label (e.g., Baldwin, 1992; Gentner & Imai, 1995; Golinkoff, Shuff-Bailey, Olguin, & Ruan, 1995; Imai, Gentner, & Uchida, 1994; Imai & Uchida, 1995; Landau, Smith, & Jones, 1988). In contrast, the classifier system is not organized around such transparent and cohesive semantic criteria.

Also characteristic of the classifier system is that many classifiers, especially frequently used ones, include instances that are poorly predicted by the semantic rules. For example, the Japanese classifier *hon* is typically associated with long, thin (one-dimensionally extended) objects, but instances such as home runs in baseball games and telephone conversations also belong to this category (Lakoff, 1987). Furthermore, in Japanese, rabbits are put into the *wa* class (the classifier for birds) instead of *hiki*, the classifier for small animals. Thus, if children rely on the semantic rules for typical members too rigidly, they will face great difficulty in learning such exceptions to the rules.

How does the acquisition of classifiers proceed？

The great majority of research in lexical acquisition has focused on noun acquisition. In the acquisition of this class of lexicon, the rapidity with which young children develop their vocabulary as well as the instant nature of mapping lexical labels on to their corresponding concepts (so-called "fast mapping") has been much emphasized (Carey & Bartlett, 1978; Heibeck & Markman, 1987; Markman, 1989, 1994; Markman & Hutchinson, 1984; Markman & Wachtel, 1988). Many researchers argue that noun acquisition is privileged both because concepts denoted by nouns are conceptually salient and privileged (e.g., Carey, 1982, 1997; Gentner, 1982; Keil, 1989), and because children are equipped with implicit knowledge of how words (nouns) are mapped on to concepts (e.g., Clark, 1987; Landau et al., 1988; Markman, 1989, 1994; Waxman, 1991).

A major goal of this paper is to characterize the acquisition of the classifier system by examining children's knowledge of classifiers across different ages and across different languages, and by discussing how the process of classifier acquisition is similar to and different from that of noun acquisition.

Possible patterns for classifier acquisition

Our main question yields further, more specific questions that are tied to specific predictions of how acquisition of the classifier system proceeds.

The speed of acquisition

The first question has to do with the speed of acquisition. Is the acquisition of classifiers as fast as noun acquisition? Or is it delayed? We discuss the two possibilities below.

Children may fast-map the meaning of classifiers. As already mentioned, it has been demonstrated that children are very quick to map novel nouns on to the corresponding concepts, guided by word-learning principles, conceptual constraints and other factors (see Imai, 1999): They make an inference about the meaning of a novel noun instantly, at their first encounter with the word, without waiting to obtain more instances (tokens) of the word. However, when semantic rules are opaque and complex, as in the case of the classifier system, what do children do? Do they try to make an inference about the meaning as soon as they hear a new classifier? Although the literature suggests that this is not likely (Carpenter, 1991; Matsumoto, 1987), this possibility should not be ruled out. It is possible that the elicited production paradigm used in the work on the acquisition of Japanese classifiers (Matsumoto, 1987) has seriously underestimated children's knowledge of classifiers. A comprehension task may reveal more sensitivity on the part of children to the semantic rules underlying the classifier system.

Acquisition of classifiers may be delayed. On the other hand, the process of classifier acquisition may indeed be delayed and quite different from that of noun acquisition: Children may be much more conservative in assigning meaning to a classifier (i.e., extracting semantic rules for each classifier category). If this is the case (which is very likely), how exactly does the learning of classifiers proceed? Several different patterns can be imagined.

One possibility is that, unlike the case with noun acquisition, children do not bother to learn the "meaning" of each classifier at all. Classifiers are grammatical particles like articles (a/the) and markers for number (-s). Hence, unlike content words such as nouns and verbs, they do not carry crucial information for the message the speaker wants to convey. In other words, even if a child drops a classifier when asking his mother for some candy, his mother can still perfectly understand what he wants. Given this secondary semantic status of classifiers, it is possible that children do not try to work out the meanings of classifiers at all, at least during the early stages of their lexical learning. Perhaps all they do is to learn the appropriate classifier for each noun by rote, from input. Before they learn the rote associations between nouns and classifiers, they may ignore the grammatical function of classifiers altogether.

The second possibility is that children become aware of the grammatical role of classifiers from a very early age, but are much more conservative in assigning meanings to each classifier (see Carpenter, 1991, for a discussion). They may know that mapping classifiers on to their respective meanings is not as obvious as mapping nouns on to their meanings. In other words, children may attach *any* classifier to a numeral, using it as a place-holder to satisfy the grammatical function but not conforming to the conventional adult usage of classifiers. At a more specific level, this possibility further yields at least three patterns:

1. Children may simply insert *any* classifier they have heard haphazardly, without paying attention to the semantic aspect at all.
2. Children may be aware that a small number of frequently used classifiers, such as *tsu*, *ko*, and *hiki*, are applied to a broad range of entities; they may thus overuse those general classifiers, making little effort to extract the meanings of other classifiers that are used more restrictively.
3. Children may be able to extract semantic rules by focusing on typical instances, applying the rules to entities similar to the typical instances. However, for atypical or exceptional members, they may learn the conventionally associated classifiers by rote from input, without forcing upon such classifiers the semantic rules they have extracted for them. A pattern similar to this has been reported by Gathercole (1985) in the acquisition of English quantifiers such as *many*, *much*, *little*, and *few*.

The influence of semantic complexity

Our second question is whether or to what extent semantic transparency/complexity influences classifier acquisition. We discuss this question on two different levels: (a) the influences of this factor on the ease of acquisition across two different languages; (b) the influence of this factor on the ease of acquisition of different classifier classes within a language.

Predictions for the relative ease of classifier acquisition across Japanese and Chinese. As we mentioned earlier, the semantic criteria for determining Mandarin classifier classes seem complex and opaque. The relation between different classifier categories also seems to be more complicated and overlapping in the Chinese classifier system than in the Japanese classifier system. As discussed earlier, in the Japanese system, the selection of classifiers is strictly separated between animals and inanimate entities. Classifier classes for animals are determined by two major semantic features, biological kind and size, while the primary semantic feature dividing the inanimate classifier classes is shape dimensionality, with functional artifact and size as secondary features. In contrast, in the Chinese system, even the feature "animate" is combined with other features such as shape dimensionality (as in the case of the classifier *tiao*). Thus, it may not be unreasonable to expect that the acquisition process in Chinese children is delayed relative to that in Japanese children.

On the other hand, children may become sensitive to the relevant semantic features for their native language from very early on, as demonstrated in the domain of spatial language[1] (Bowerman, 1996; Choi & Bowerman, 1991). In this case, the rate of acquisition was roughly equivalent in Japanese and Chinese children.

Predictions for the relative ease acquisition within each language. If we find a cross-linguistic difference in the ease (and hence speed) of acquisition of classifiers due to the relative semantic transparency/complexity of the two languages, we can also expect this factor to affect the ease of acquisition of each classifier within each language (cf. Clark, 1973; Matsumoto, 1987). In the case of Japanese, *nin*, the classifier for humans, should be easier to use than other classes. The use of *tou*, which denotes both animals and large size, may be delayed. In the case of Chinese, *ge*, the classifier for humans and monkeys, seems to be relatively simple in meaning, while *tiao*, used for a long, thin things, including both animals and inanimate entities, seems to be complex. Following this line of reasoning, a learner can be expected to acquire the classifier *ge* with more ease than *tiao*.

Assessment of preschoolers' knowledge of classifiers: The case of Japanese and Chinese children

We attempt to propose answers to the above questions based on the studies we conducted to assess the knowledge of classifiers of Japanese children (Uchida & Imai, 1996) and of Chinese children (Uchida, 1997; Uchida & Nagai in preparation).

Method

In Uchida (1997), Uchida and Imai (1996), and Uchida and Nagai (in preparation), the knowledge of classifiers of Japanese children and Chinese children was assessed using an error-detection paradigm. We employed this method because it incorporates the assessment of both comprehension/recognition ability and a production ability. Children were asked to determine whether a puppet's use of a classifier was correct or incorrect (comprehension); when they said the puppet made a mistake, they were asked to produce the proper classifier (production). In this way, even when children failed to produce the proper classifier for a given object, we could at least know they had been paying attention to the semantic appropriateness of the target classifier.

There were 150 Japanese children, all from Tokyo, and all monolingual speakers of standard Japanese. There were 235 Chinese children, all from the Beijing area, and all native speakers of Mandarin. The Japanese children were grouped into five age groups (years: months) (4:0-4:5; 4:6-4:11; 5:0-5:5; 5:6-5:11; and 6:0-6:5), and the Chinese into six (4:0-4:5; 4:6-4:11; 5:0-5:5; 5:6-5:11; 6:0-6:5; 6:6-6:11).

The classifiers tested included the following: for the Japanese children, *nin* (human), *tou* (large animals), *wa* (birds) and *hiki* (unmarked); and for the Chinese children, *ge* (humans and human-like animals, e.g.,

Table 1. Japanese classifiers used as stimulus materials

Classifier class	Typical member	Nontypical member	Perceptually similar distractor	Inanimate distractor
hiki	dog	koala bear	tiger	stone
	cat	snake	stuffed dog	cup
tou	elephant	whale	stuffed bear	juice
	horse	little bear	racoon	dish
nin	adult	child	chimpanzee	flower
	child	Ultra Man[a]	robot	apple
wa	eagle	ostrich	bat	biscuit
	pigeon	penguin	flying lizard	spoon

a A television character.

Table 2. Table 2. Mandarin classifiers used as stimulus materials

Classifier class	Typical member	Nontypical member	Perceptually similar distractor	Inanimate distractor
ge	adult	Ultra Man[a]	chimpanzee	bicycle
	child	dwarf	rabbit puppet	cabbage
tiao	fish	snake	mouse	biscuit
	earthworm	eel	lizard	car
zhi	cat	koala bear	fairy	tree
	hen	penguin	flying fish	soap

a A television character.

monkeys), *tiao* (thin, long and curvy objects such as rivers and long, thin animals such as snakes), and *zhi* (small animals).

For each classifier class, the children were shown four different types of test object, two examples for each type: typical correct members (e.g., a cat for hiki), atypical members (e.g., a snake for *hiki*), perceptually similar nonmembers (e.g., a stuffed dog for *hiki*), and obvious nonmembers, which were always inanimate objects (e.g., a cup for *hiki*) (see Table 1). This last manipulation was included to examine to what extent typicality influences the ease of acquisition (cf. Carpenter, 1991; Gathercole, 1985).

The examples of the stimulus materials for each of the three Mandarin classifier classes, *ge*, *tiao*, and *zhi*, were organized according to the same standard as the Japanese materials (Table 2).

To elicit their knowledge of a classifier class, the children listened to a puppet count a set of target objects with either the correct classifier or an incorrect one. Incorrect classifiers always crossed the ontological boundary: For example, a classifier for inanimate entities was used in association with a target animal. We tested whether or not the child noticed the puppet's errors. To assess the children's sensitivity to the meaning of each classifier in as natural a setting as possible (to avoid them becoming aware that they were being tested on their selection of the proper classifier) the puppet sometimes made other, more obvious errors, like miscounting the number of the test objects while using a proper classifier. Each child was asked to correct any errors made by the puppet and to then justify these corrections.

Analyses

The children's responses were analyzed in three respects: successful recognition (comprehension), proper error correction (production), and the quality of their justifications. They were scored on the following criteria:

1. In the recognition (comprehension) measure, each child was given 1 point for every error detected. The maximum score was 32 for the Japanese group (8 questions for each classifier × 4 classifiers), and 24 for the Mandarin group (8 questions for each classif ier × 3 classifiers).
2. The subject was given 1 point for every correct correction made. The maximum score was again 32 for the Japanese and 24 for the Mandarin group.
3. In the justification measure, the subject was given varying points according to the type of justification given for a correction: 2 points for every correct reason given; 1 point for an incorrect response but correct reasoning; 1 point for the justification "Because other people say so"; 0 points for no explanation.

An overall comparison of Japanese and Chinese children in comprehension and production

As expected, the children in both language groups showed significantly higher performance in

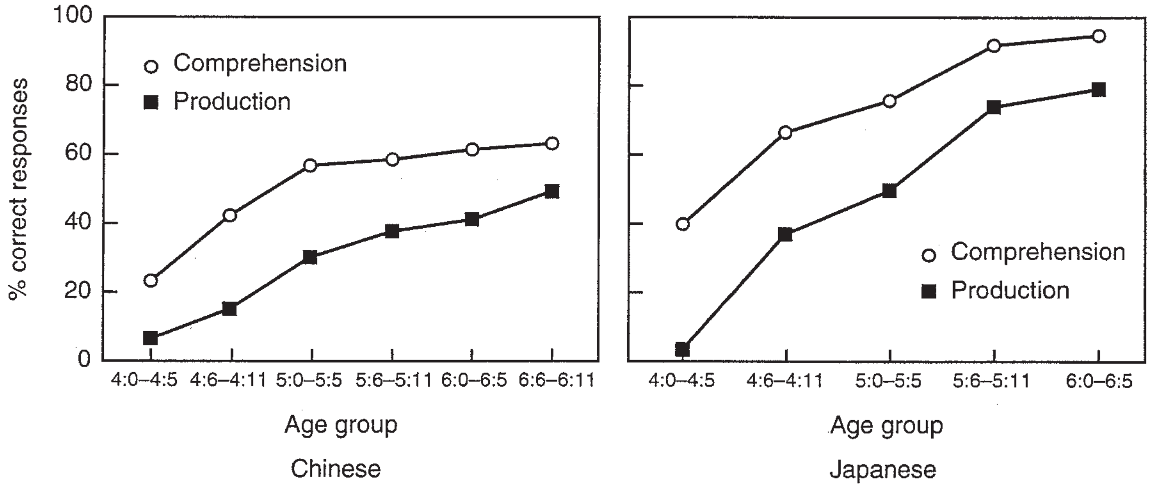

Figure 2. Overall comparison of Chinese and Japanese children in the comprehension and production of numerical classifiers.

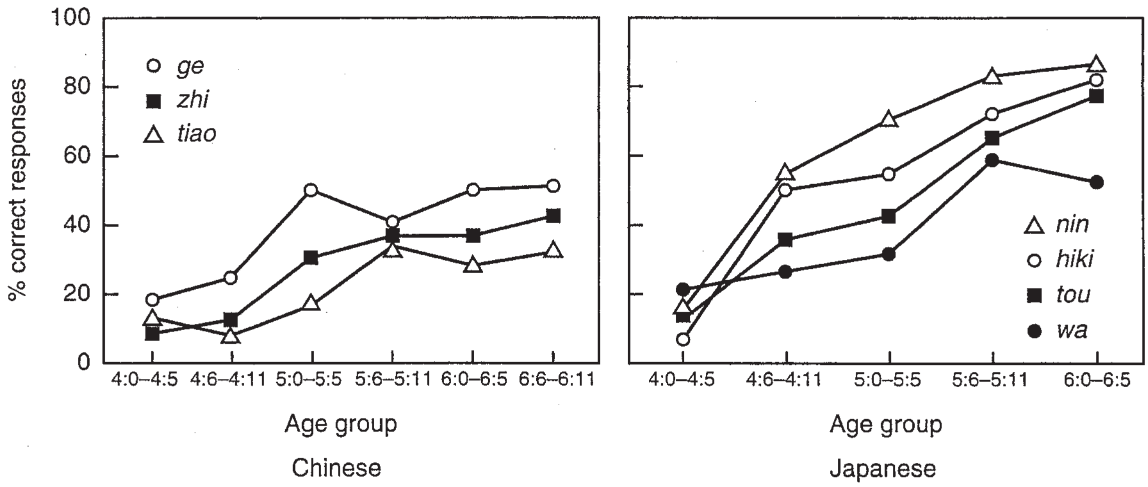

Figure 3. Percentage of correct responses for each classifier class.

comprehension than in production. As shown in Figure 2, there was a large developmental increase in both languages. Because the maximum possible scores were different for Japanese children (32) and Chinese children (24), the raw scores were converted to be proportionate to each other. The younger children (early 4-year-olds) performed very poorly in both language groups. Overall, the Japanese children showed significantly higher performance relative to the Chinese children across all age groups. By late 5-year-olds, the Japanese children marked near perfect scores in the comprehension test, while the Chinese age counterpart still hovered around 45%. Even the oldest group (late 6-year-olds) of Chinese children made a substantial number of errors (71.1% correct). In fact, the performance of Chinese 6-year-olds was on the same level as that of Japanese 4-year-olds.

These results are in accord with the previous findings in Japanese children (Matsumoto, 1987) and in Thai children (Carpenter, 1991), demonstrating that the acquisition process of numerical classifiers is much slower than that of nouns, in which even 2-year-olds fast-map the meanings. The results also suggest that the complexity of semantic organization of a particular classifier system (i.e., by what criteria classifier categories are divided in a language) affects the ease of acquisition.

Performance on each classifier class

The delay in the acquisition of Chinese classifiers leads us to the expectation that semantic complexity/-transparency affects the ease of learning within a language. Figure 3, which shows the proportion of successful error corrections for each classifier tested for

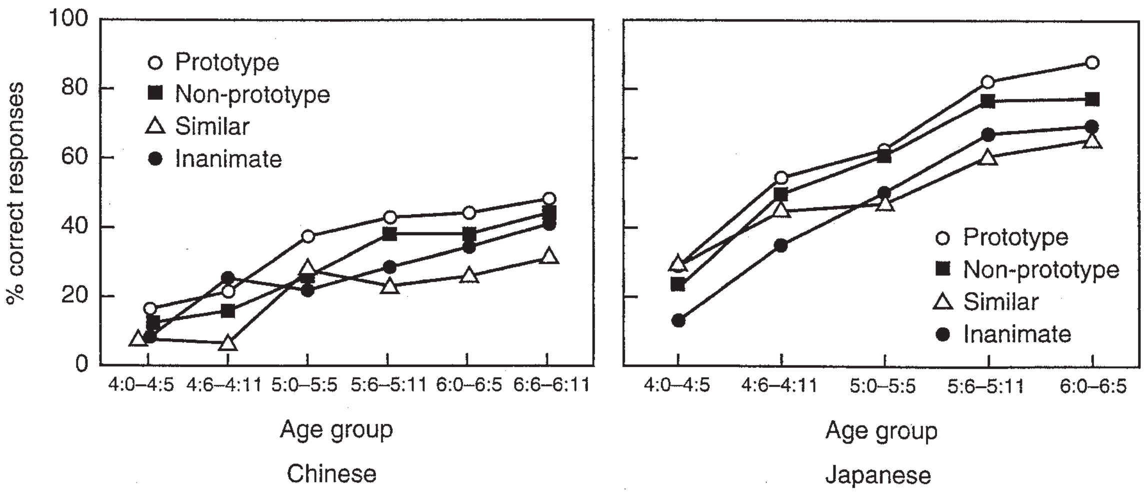

Figure 4. Percentage of correct responses for each typicality type.

the two language groups[2], suggests that this is in fact the case. It also suggests that the magnitude of this effect was larger in the Japanese children than in the Chinese children. In the Japanese children, *nin* (for humans) yielded the highest performance. *Hiki* (the unmarked animal classifier) was the second easiest to be learned, followed by *tou* (for large animals). The children were not able to distinguish the *tou* class from the *hiki* class until they were late 5-year-olds[3]. *Wa*, the classifier for birds (and, as an exceptional class member, rabbits), yielded the lowest performance.

As expected, among the Chinese children, *ge* (for humans and human-like animals) was the most easily acquired, and *tiao* was the most difficult. Furthermore, even the late 6-year-olds had not learned the distinction between these two classifiers.

Typicality types of counted objects

The children performed better in tests on typical instances than on atypical instances for each of the tested classifier classes. Figure 4 shows the Japanese and Chinese children's rate of successful corrections for the errors made by the puppet separately for each of the four types of typicality: *prototypical* (e.g., a cat for testing *hiki*, mistakenly counted using *ko*, an inanimate classifier for three-dimensionally extended entities), *nonprototypical* (a snake, a nontypical member of the *hiki* class because of its shape, mistakenly counted using *hon*, an inanimate classifier for long, thin entities), *perceptually similar nonmember* (e.g., a stuffed toy animal which should belong to the *ko* class, but erroneously counted using *hiki* by the puppet), and *an obvious nonmember* (e.g., a rock counted mistakenly with *hiki*). The data were collapsed across different classifier classes. Because the maximum score was different for the Japanese (8) and Chinese (6) groups, the scores were converted to the proportion relative to the maximum.

In both language groups, the children corrected the puppet's error with more success on the prototypical objects for each class than the atypical objects. Furthermore, they both showed the poorest performance on perceptually similar nonmembers. This pattern suggests that children try to determine what the proper classifier for a given item is on the basis of meanings but require more input in order to select a proper classifier for an object whose class membership is not obvious. In other words, although children are semantically driven (as opposed to learning from input by rote) in learning classifiers, extracting semantic rules is not enough for them to learn full use of classifiers, since most classifiers, especially frequently used ones, include members whose class membership may not always be transparent from the semantic rules.

Children thus have to continue to pay close attention to the input in order to learn the proper classifiers for entities whose class membership cannot be so obviously detected from the rules they have extracted. This picture is similar to the acquisition patterns of quantifiers such as *many* and *much* in English-speaking children reported by Gathercole (1985) and the acquisition of Thai classifiers reported by Carpenter (1991).

Nature of children's error responses

We further examined the nature of children's error responses and how such responses change with development. More specifically, we classified each error response into one of three error types: (a) failure to supply any classifier; (b) error across the ontological boundaries (e.g., the child failed to detect the error when an animal was counted with a classifier for inanimate entities, or counted an animal with an inanimate

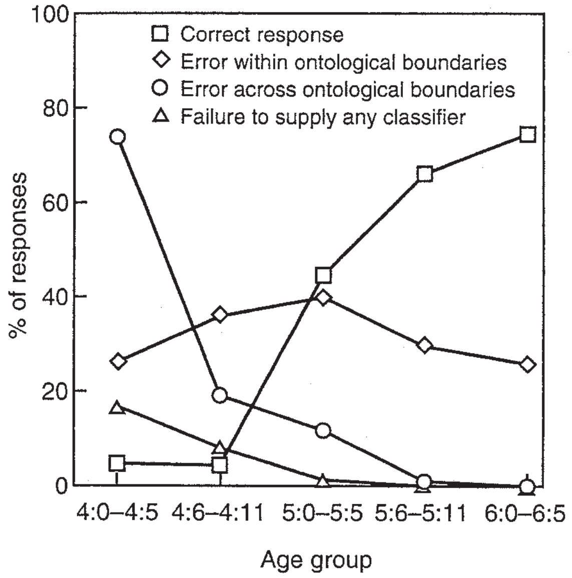

Figure 5. Japanese children's response patterns.

classifier in correcting the puppet's error); (c) error within ontological boundaries (e.g., the child failed to detect the error when the puppet counted an animal with a wrong animal classifier, or the child counted an animal with a wrong animal classifier when correcting the puppet's error).

We have so far analyzed only the Japanese data, and the analyses of the Chinese data are currently in progress, so we will report the developmental change of error types using only the Japanese data (see Figure 5). The Japanese children rarely failed to add a classifier when the puppet dropped it in counting, indicating that Japanese children knew the grammatical function of classifiers at least by 4 years of age. However, interestingly, younger and older children made different types of errors.

Failure to add any classifier after a numeral was rare within the youngest group. Even the youngest children knew that a numerical classifier is required after a noun. The youngest group (early 4-year-olds) made numerous errors that crossed the ontological boundary between animals and inanimate entities, but the proportion of this error type dropped sharply between early 4-year-olds and late 4-year-olds. Late 4-year-olds and the older children made errors mostly within the ontological boundary, regardless of whether targets were animate or inanimate, for example, counting birds, which should be counted with *wa*, with *hiki*, or counting long, thin objects, which should be counted with *hon*, with *ko* (for inanimate three-dimensionally extended entities).

Justifications

We also analyzed the children's justifications for their error corrections to examine to what extent they were able to verbalize the meanings they had assigned to classifiers.

Figure 6 shows that the younger children gave few justifications for their responses. They showed a tendency to accept the puppet's mistakes. In the Japanese children, appropriate justifications for corrections given increased with age and there was a large improvement between the early 5-year-old group and late 5-year-old group. On the other hand, the Chinese children's achievement was much lower than the Japanese children's. Overall, the Chinese children showed a strong "Yes" bias, saying the puppet was correct even when it made mistakes.

Summary of the findings and discussion

Before moving on to the next section, we will give a brief summary of the findings.

The overall acquisition pattern suggests that children first become aware of the grammatical role of classifiers and then gradually extract the semantic rules. Overall,

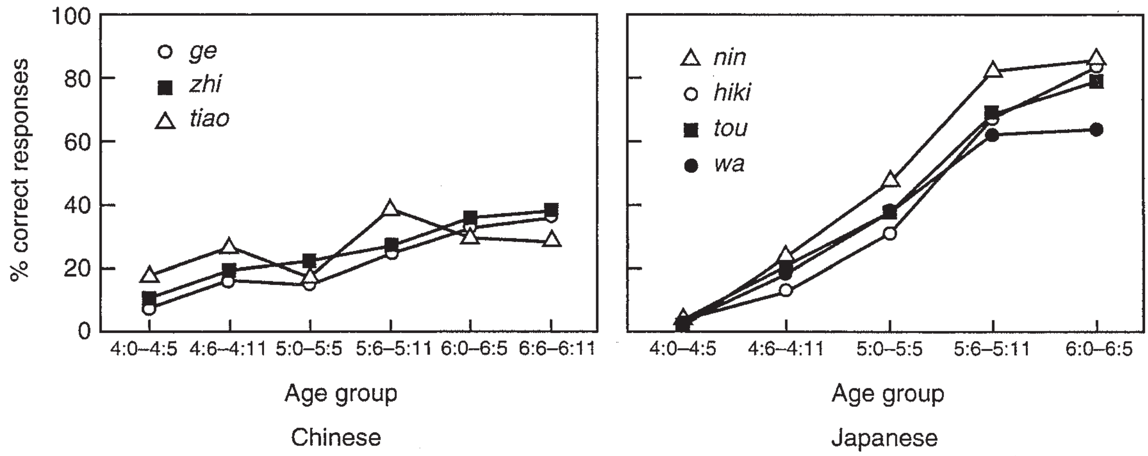

Figure 6. Percentage of correct justifications.

the learning process of correct semantic criteria for the classifiers is difficult. The Japanese children had not yet fully learned the criteria by $5^{1/2}$ years, and Chinese children by the age of 7. Semantic complexity greatly affects the speed of classifier acquisition. In Mandarin, whose classifier system has more complex categories than the Japanese system, the children acquired the rules of their classifiers at a slower pace than the Japanese children did theirs.

From these results, we can at least conclude that the acquisition of classifiers is a much slower process than the acquisition of nouns. Before the age of 4 years, it is not even clear to what extent children are aware of the grammatical role of classifiers, since neither Japanese nor Chinese 3-year-olds were able to add any (either semantically proper or incorrect) classifier after a numeral in the error-detection paradigm.

One may wonder whether there is a discrepancy between these results and reports in the literature of the early emergence of classifiers in spontaneous production. Children do produce classifiers in everyday settings (Naka, 1999; see also Iwabuchi & Muraishi, 1976). However, the types of classifier produced by children before 4 years are limited to *tsu/ko* (unmarked generic classifiers for inanimate entities: *tsu* is attached to Sino-Japanese numerals while *ko* is attached to Arabic numerals; see Downing (1984) for more detailed description), *ri/nin* (classifiers for humans), and *kai* (classifiers for counting events). It is possible that very young children (before 3 years of age) use a whole phrase of numeral plus classifier as an unanalyzed whole, rote memorized from input, without being aware that *-ko, -tsu. -ri, -nin, -kai* are independent lexical items.

Support for this view is provided by Naka's corpus (see Naka, 1999), which was constructed from a longitudinal study of everyday conversations at mealtimes between her twin daughters and herself, when the girls were 24 to 35 months of age. Naka reports utterances such as "otsuyu [soup] mou ik-kai [one more time]," requesting another sip of soup. As previously mentioned, *kai* is a classifier used for counting the repetition of a same event (like once, twice, three times ...). In this case, however, the phrase "ik-kai [1-kai]" was obviously produced by the child to mean "(give me) more."

By the age of 4 years, children have learned the grammatical function of classifiers: 4-year-olds and older children rarely fail to supply a classifier after a numeral. Yet they still have a long way to go to sort out the semantic complexity of the classifier system. The degree of difficulty of full mastery is magnified when the system in a child's native language is curved upward in such a way that basic ontological distinctions, such as the animate-inanimate boundary, are crossed within classifier classes.

Prerequisites for extracting the meaning of each classifier class

The acquisition of classifiers is slow. Nonetheless, in Japanese children, a large developmental improvement in knowledge of classifiers seems to take place between 4 and 5 years of age. What happens during this period? What is the prerequisite for their ability to extract basic semantic rules for applying classifiers? In this section, we will explore this issue based on the results of Uchida and Imai's (1996) Study 2, with Japanese 4- and 5-year-old children who had not yet demonstrated evidence of awareness of the semantic rules for the classifiers *hiki* and *tou*.

Method of the training study

A training paradigm was used. A pretest was conducted on a pool of Japanese children to select those who had not yet learned the correct meanings of *hiki* and *tou*. In the pretest, the children were asked to count typical members of the *hiki* class (e.g., a cat) and the *tou* class (e.g., a tiger). A total of 30 late 4-year-olds and 30 late 5-year-olds were selected.

The selected subjects were assigned to one of the

Table 3. Materials used in the training study

Test type	Classifier class	Items
Pretest	*hiki*	dachshund, cat, baby bear
	tou	greyhound, tiger, bear
Post-test	*hiki*	beetle, dachshund, cat, puppy, koala bear
	tou	horse, elephant, lion, tiger, whale
	nin	children, dwarf
	wa	eagle, ostrich
Transfer test		
Real objects		[items used in the post-test plus new items]
	hiki	baby monkey, rat, baby bear, goldfish
	tou	white bear, elephant
	wa	eagle, ostrich
Imaginary objects		imaginary animals and monsters

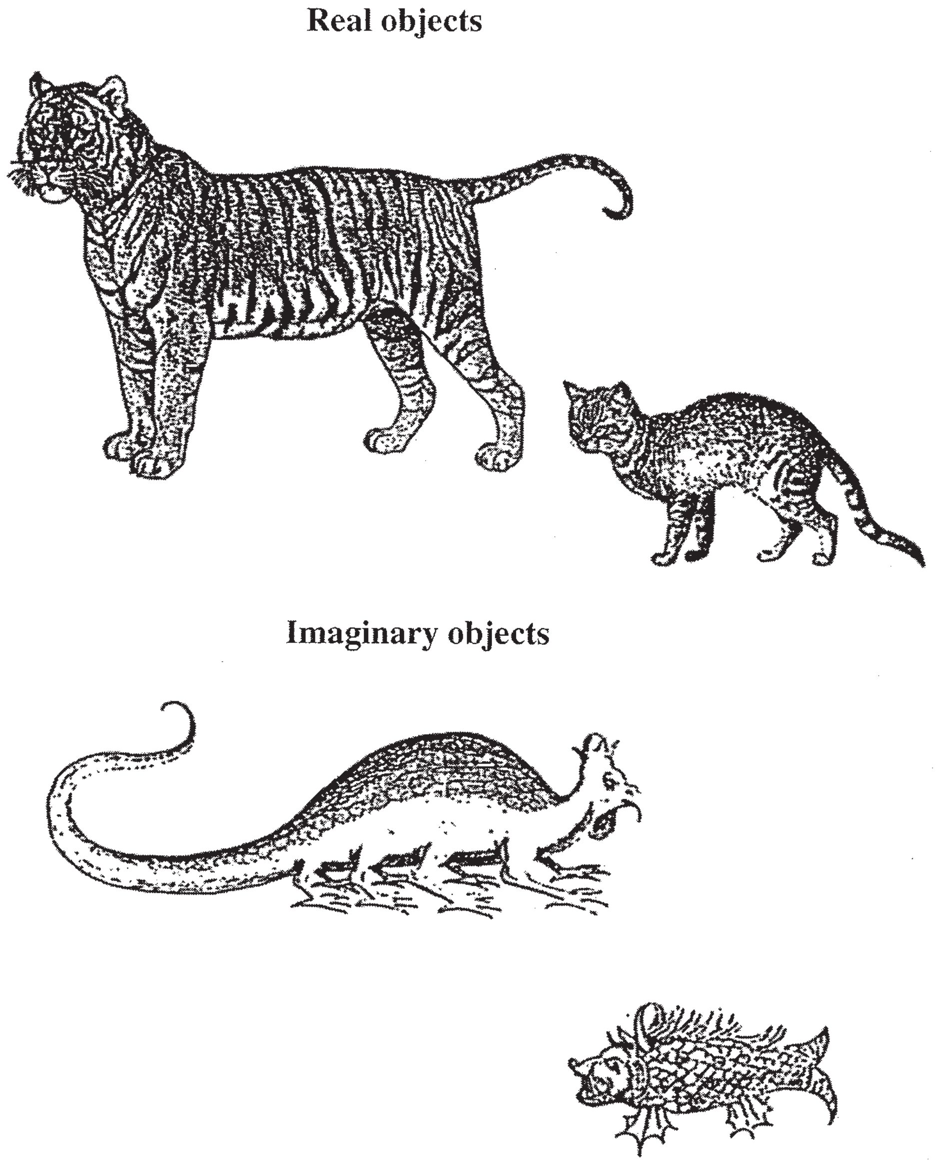

Figure 7. Examples of materials in the transfer task.

following three conditions: rule explicitly given, exemplars only, and control. In the first group, the children were explicitly taught how to count with the correct classifier. They were told that animals are generally counted with *hiki*, but that a different word, *tou*, should be used when counting big animals. The children in the exemplars-only condition observed the experimenter counting each test object using the proper classifier but were not provided with an explicit explanation. They were encouraged to repeat after the experimenter. The children in the control condition were asked to count the test objects without any training or feedback.

The experimental sessions were conducted on the subjects in the following order: (a) a training session, (b) an immediate post-test, and (c) a delayed post-test with a transfer task, conducted one week after the training session.

In the post-test, the children were tested on 15 objects for their classifier class membership. Five of the objects belonged to the *hiki* class and five to the *tou* class, and the remaining five were included to function as distractors, drawn from the classifier categories *nin* (for humans), *wa* (for birds), and *ko* (for three-dimensionally extended inanimate entities). In the test set for the delayed post-test, imaginary animals and monsters the children had not seen before were included with the "real" objects in order to examine whether the children would be able to apply the correct rule for each classifier class and determine the class membership for the novel objects. There were eight actual animals drawn from the *hiki*, *tou*, and *wa* classes. Two of the eight imaginary animals were small and should have been counted with *hiki*, and six were large and should have been counted with *tou* (Table 3 and Figure 7).

Each child was shown each of the test objects one at a time in random order and was asked to put each object into one of three toy houses: The first house was for objects counted with *hiki*, the second house for objects counted with *tou*, and the third house for objects that should not be counted with either *hiki* or *tou*.

Since our main interest was in how children who originally had not been able to differentiate between the *tou* class and the *hiki* class might have extracted the semantic rules for the two classes after the training, we will report the subjects' performance on the *tou* category.

Extracting the meaning of tou

The performance of the children on the immediate and delayed post-tests (performance on the real objects only) for each of the three conditions is depicted in Figure 8. There was a striking interaction between age and condition. There was no developmental difference between the 4-year-olds and 5-year-olds when the rule was explicitly given nor in the control condition in either test: The children in both age groups performed extremely poorly in the control condition (in which no training was given), which is not surprising since all children included in this study had not yet learned the meanings of *hiki* or *tou*.

In both age groups, the children showed almost perfect performance when the rules for *hiki* and *tou* were explicitly provided. However, a large developmental difference was observed in the exemplars-only condition. The performance of the 4-year-olds was poor, suggesting that they were not able to extract the meanings for *hiki* and *tou* after hearing the experimenter just give examples of the proper use of each of the two classifiers. In contrast, the 5-year-olds successfully extracted the meanings with only the examples of usage. Furthermore, they retained the rules a week after the training; in fact, the performance level of the 5-year-olds increased significantly over the one-week term of the experiment.

The children's performance on the novel objects was very similar to that on the real objects (Figure 9). When the rule was explicitly given, both 4- and 5-year-olds were able to apply the learned rules to determine the proper classifier for counting the animals they had never seen before. In the exemplars-only condition, the 4-year-olds were not able to determine the proper classifiers for the novel objects, while the 5-year-olds had almost as much success in doing so as the children explicitly taught the rules of application.

Implications of the training study: What is the prerequisite for the full acquisition of the meanings of classifiers?

The training experiment demonstrated a large developmental improvement between 4-year-olds and 5-year-olds in their ability to extract rules from exemplars and to apply the rules spontaneously to new instances. What is the cause of this developmental change? One obvious possibility is the development of some form of domain-general cognitive ability. Large leaps in other cognitive domains have also been observed. For example, Uchida (1982, 1985) noted that it is between 4 and 5 years of age that a striking improvement takes place in a child's ability to explain a causal relation of an event coherently, even when the causative event and the resulting event are presented in reverse order (i.e., the

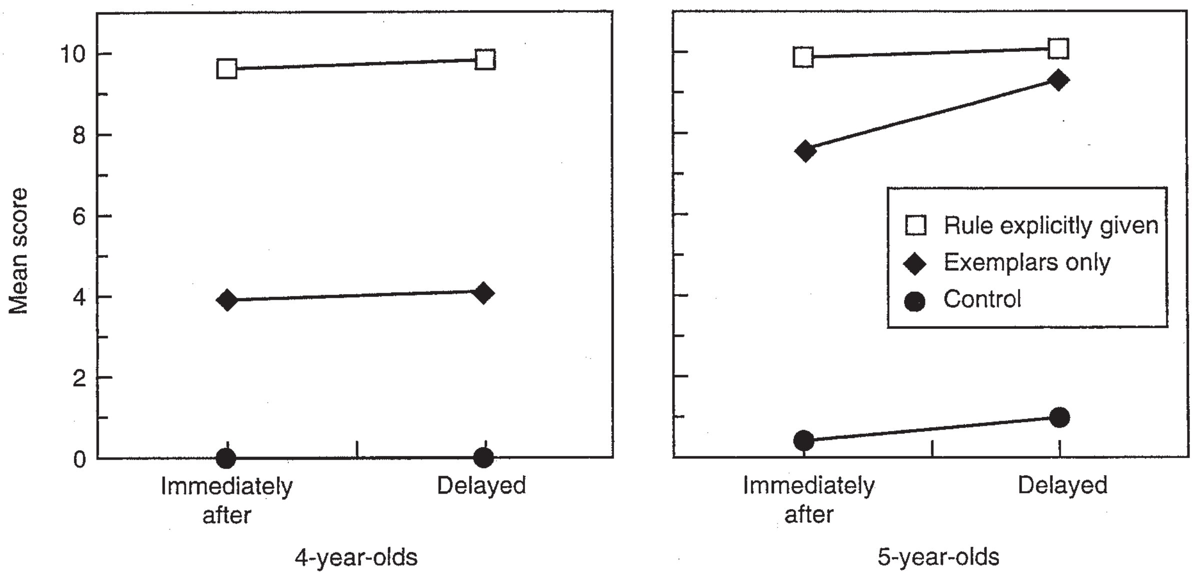

Figure 8. Mean scores (maximum = 10) for extracting the meaning of *tou* across the three experimental conditions.

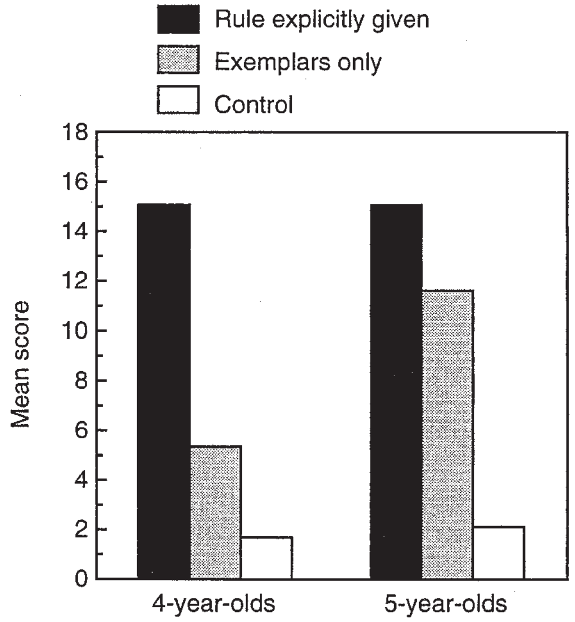

Figure 9. Mean scores (maximum = 18) for the transfer task across the three experimental conditions.

result is shown before the cause). In other words, children seem to learn the rules for discourse (Uchida, 1996 b), how to place temporal events in an appropriate sequence to produce a coherent story.

An analogous developmental phenomenon was found in Imai's investigation into how young children overcome their initial shape bias to extend labels on the basis of taxonomic similarity without relying on shape similarity (Imai, 1994; see also Imai, 1997). In her previous study on children's early noun learning, she and her colleagues pitted shape similarity and taxonomic similarity against each other in such a way that a target object whose shape was similar to the originally named object was not actually related to the original, while the object belonging to the same taxonomic category as the original object had a very dissimilar shape. In English (Imai et al., 1994), American 3- and 5-year-olds extended novel labels on the basis of shape similarity rather than on taxonomic similarity. In Japanese (Uchida, 1996 a), 5-year-olds, but not the 4-year-olds, were able to extend on taxonomic similarity.

In a following study, Imai (1994) included a new target object, belonging to the same taxonomic category and also having a similar shape to the original (as well as to the similar-shape, noncategory item and the dissimilar-shape, same-category item), to her experiment. She found some evidence that 5-years-olds, but not 3-year-olds, were able to use the new item to "bootstrap" themselves from the shape-based label-extension rule to the category-based label-extension rule.

What is demonstrated in the 5-year-olds in Uchida's (1982, 1985, 1996 a, 1996 b) studies, Imai's (1994) study and in those in Uchida and Imai's (1996) study, and in the training study on the learning of the classifier *tou/hiki* described above, is the children's ability to extract new rules just from exemplars, without any explicit instructions, "bootstrapping" themselves up to a new stage[4]. Perhaps what takes place between the ages of 4 and 5 years is the development of their ability to synthesize pieces of partial knowledge that have been fragmented and have not been formed into a cohesive whole, in terms of a causal structure or a coherent theory. Four-year-olds or even younger children are known to have a lot of knowledge about certain things. Yet when the target domain does not have a cohesive structure itself and requires the synthesis of pieces of fragmented information (as in the cases discussed above), younger children seem to have much difficulty in learning such a domain on their own.

However, although this is an interesting possibility, much more research is needed to be conclusive about this issue. In particular, even if the above conjecture is correct, an important question still needs to be answered: Does the ability to synthesize fragmentary knowledge and bootstrap oneself to a coherent, causally structured theory arise from the accumulation of knowledge *per se*, or from the maturity of the general cognitive architecture, such as the ability to operate multiple sources of information at one time in working memory?

How are classifier acquisition and noun acquisition different?

We have discussed the acquisition of classifiers, which classify entities in the world into categories just as nouns do, yet have very different lexical structures from nouns. As already discussed, our research conducted across two languages has demonstrated that the acquisition of classifiers is slow and gradual, a conclusion which is consistent with other research on classifier acquisition (e.g., Carpenter, 1991; Matsumoto, 1987). Our research has shown that the acquisition of classifiers proceeds through different phases. In the first phase, children are not even aware of the existence of classifiers. In other words, they either do not care to add any classifier to a numeral in referring to the quantity of the given object, or, even when they do produce a classifier, they seem to treat the whole phrase of the numeral-classifier combination as an unanalyzed lexical unit. In the second phase, children become aware of the grammatical role of classifiers but are not yet sensitive to their semantic aspect: They overuse general unmarked classifiers, even crossing important ontological boundaries such as the animate-inanimate distinction. In the third phase, they start to extract meanings for each classifier. However, pinning down specific meanings for different classifier classes, especially for marked ones, takes a long time. The results of the above training study (Uchida & Imai, 1996) suggest that extracting meanings for marked classifiers from exemplars may require certain general cognitive abilities such as the synthesizing of fragmented knowledge into a coherent explanatory rule or theory.

Why is the process of classifier acquisition so different from that of noun acquisition, in which children as young as 2 years are able to fast-map the meanings of novel lexical items? As discussed earlier, one possible reason for this is that classifiers do not carry information that is indispensable to the discourse. To understand what adults say to them, children do not need to understand the meaning of a classifier itself; they can make adults understand what they want to say without using a classifier correctly. However, we doubt that this account is correct, since there are cases in which children do grasp semantics before learning the grammatical function of closed-class function words: Although articles and quantifiers governed by English count/mass syntax are function words like classifiers, English-speaking children become sensitive to the semantic distinction crucial for the syntax very early, even prior to word learning (Imai & Gentner, 1997; Soja, Carey, & Spelke, 1991).

The difference between noun acquisition and classifier acquisition does not lie solely in the speed of learning. Noun learning is a top-down process in that it is guided by so-called word-learning principles, which may be characterized as a meta-theory of how the noun lexicon is semantically organized. Although the issue of whether these principles exist before the first use of words (e.g., Waxman & Markow, 1995) or emerge through observations of how nouns and objects are linked (e.g., Landau et al.,1988) remains controversial, by the age of 2 years, children across different languages do have implicit expectations about how the noun lexicon is organized and on what basis nouns should be extended (see Haryu & Imai, 1999; Imai, 1999), and hence they do not have to go through numerous exemplars to link a new word to its meaning. In sharp contrast, the acquisition of classifiers is mostly bottom up: Children do not seem to have a priori expectations of how meanings of classifiers are organized or what semantic features they should be attentive to. They thus have to go through large numbers of exemplars to assign a meaning to each classifier.

Why are the word-learning principles available so early to children for nouns but not available at all for classifiers? What is obviously different between nouns and classifiers is the transparency/cohesiveness of their lexical meanings. The noun lexicon is deeply linked to our natural (possibly innate) way of partitioning the world. Categories denoted by nouns are also largely supported by perceptual similarity: Members belonging to the same category, especially at the basic level, tend to have similar shape. In a way, noun lexicon is divided at the level where our cognitive biases and the natural clusters in which the world presents itself to us merge (Malt, 1995; see also Imai, 1999).

In contrast, the semantic organization of classifiers is incoherent and loose. The relevant semantic features themselves may not be too hard to extract, since the major features in both Japanese and Chinese, and many other classifier languages, are animation, size, functionality, and shape dimensionality (Adams & Conklin, 1973; Croft, 1990). What makes the semantics of the classifier system complex and opaque is the way the features are combined to make up different classifier categories. For most classifier classes, the semantic rules consist of complex and unintuitive *conjunctions* of multiple features, and how the features are combined seems to be fairly inconsistent across different classifiers in a language. For example, in Japanese, even the easiest animal classifier, *hiki*, is made up of the rule [animate *and* small size]; the rule for *hon* is something like [inanimate *and* long *and* thin]; the rule for *dai* may be given as [inanimate *and* large *and* has a mechanical function]. Thus, all learners can do is to learn the meanings of each classifier one by one in a bottom-up fashion, since building a meta-theory of how classifier meanings are organized in a particular language is almost impossible, perhaps even for linguists.

Given this, the path children take to learn classifiers seems to be quite reasonable. Children do not tackle classifiers with strong top-down expectations. They proceed with their learning very conservatively, in a bottom-up fashion that relies largely on input. When they become aware of the grammatical function of classifiers, children do not attempt to sort out the very complex and opaque semantic system right away. In many cases, they use the unmarked generic classifier for inanimate entities, *tsu* or *ko*, presumably because these are the classifiers they hear most frequently. They then gradually come to know that there are some semantic features that are relevant in selecting a classifier for a given noun. In learning the Japanese classifier system, which honors the ontological distinction between animals and inanimate objects, children probably come to notice this distinction first. Once they know that different types of classifier must be used for animals and for inanimate objects, they rarely use animal classifiers for inanimate entities or inanimate classifiers for animate entities.

Learning the full semantic system still takes a long time. In doing so, children still largely rely on the generic unmarked classifiers, but at later stages they use them within the appropriate ontological category (*tsu/ko* for inanimate, *hiki* for animals). At the same time, they are in the process of extracting further relevant semantic dimensions. But the way they do so seems much more conservative than when they are learning words in different, more cohesive and transparent lexical classes such as nouns. In a sense, even when children have extracted the semantic rules for a given classifier class, they seem to be prepared to encounter exceptions. They seem to be willing to suspend the rules, giving way to the input. This is a reasonable thing to do, since the classifier system includes many instances that are only loosely associated with the prototypical members of a given class and thus cannot be predicted from the semantic rules.

Implications for the theory of early word learning

In the literature, a dominant view is that word learning is top down and theory driven. We have demonstrated that not all word learning is this way. How children learn words depends largely on the semantic nature of a given lexical class. When the semantic organization of the lexical class is coherent and cohesive, learning appears to be fast and top down. However, when the semantic structure of the target lexical class is noncohesive and complex, children take quite a different route in learning the meanings of the words in that class.

We have focused on the acquisition of nouns and classifiers, but in future research it will be important to consider the acquisition of other lexical classes, such as verbs and prepositions. The acquisition of verbs seems to be particularly interesting because of the two characteristics of verb meanings. First, verb meanings are more abstract and less tangible, hence conceptually less transparent than noun meanings (Gentner, 1982). Yet, unlike classifiers, verb meanings are constrained in top-down fashion by at least two sources: the argument structure of a given verb (e.g., Levin & Rappaport Hovav, 1994), and the language-specific lexicalization pattern, that is, which of the universal semantic features for describing events (figure, ground, manner, path) tend to be incorporated in verb meanings most dominantly in the target language (Talmy, 1985). The literature suggests that children are indeed able to use these to constrain verb meanings (e.g., Fisher, Hall, & Gleitman, 1994; Gleitman, 1990, for the evidence for the former source; Choi & Bowerman, 1991, for the latter). However, it is not clear how strongly these constraints are applied, or to what extent children rely on contextual and/or pragmatic information (Clark, 1997; Clark, Carpenter, & Deutsch, 1995; Tomasello, 1997), or to what extent fast-mapping is possible and successful for verbs.

We would like to conclude by noting that we need to investigate lexical acquisition in a broad perspective, studying the acquisition of a wide range of lexical classes, including nouns, verbs, prepositions and classifiers, and to consider how different lexical structures influence patterns of word learning.

Notes

1 In fact, the seemingly semantic opacity and complexity of the Chinese system to the authors, who are native speakers of Japanese, may result from their having learned the system that divides classifier classes differently. What seems complex and opaque to Japanese people may not seem so to native speakers of Mandarin (cf. Lakoff, 1987).

2 Because the 3-year-olds were at a floor level even on the comprehension measure, they were excluded from this analysis.

3 Note, however, that the Japanese children we examined showed earlier acquisition of the marked animal classifiers, *tou* and wa, than the subjects studied by Matsumoto (1987). In his study, even 6-year-old children showed very poor performance in tests on *tou* and wa, overusing the general animal classifier *hiki* for the situations where those classifiers should have been applied. It is not clear exactly how this discrepancy between studies arose. One possibility is that the error-detection paradigm we employed not only enabled us to assess children's knowledge in comprehension, but also elicited their production ability more sensitively than the method used in his study.

4 Readers may notice that this process is similar to and compatible with the idea of the zone of proximal development (see Vygotsky, 1932/1962/1968).

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