

Concept Formation and Language Development: Count Nouns and Object Kinds

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The relationship between language and conceptual development is an old question that has intrigued psycholinguists, philosophers, and psychologists for decades. Recent years have witnessed a surge of interest in this area (see Bowerman & Levinson, 2001; Gentner & Goldin-Meadow, 2003; and Clark, 2004 for reviews). Many domains of conceptual representations and the corresponding linguistic representations have been investigated. At the syntactic level, researchers have explored the role of morpho-syntax in spatial representations (e.g., Hermer-Vasquez, Spelke & Katsnelson, 1999; Hermer-Vasquez, 2001; Schusterman & Spelke, 2005), and the understanding of false belief (e.g., de Villiers & de Villiers, 2003). At the lexical level, researchers have explored how words of various grammatical classes may impact on spatial category formation (e.g., Bowerman & Choi, 2003; Pederson, et al 1998), number representations (e.g., Carey, 2004; Spelke, 2003), and representations of objects and substances (e.g., Imai & Gentner, 1997; Lucy & Gaskins, 2003; Yoshida & Smith, 2003). Some researchers have argued that language is crucial for human's ability to represent genuinely new concepts that go beyond our initial, evolutionally-given representational capacities, while others have endorsed much weaker versions of such hypotheses by suggesting that linguistic categories may allow learners to shape categories that are formed without the help of language.

Much of the work on conceptual and language development addresses the issue of how cross-linguistic variations may change the pace of conceptual development. Here we focus on a universal aspect of language: representations of count nouns that refer to object kinds. Although not all languages make the count/mass distinction syntactically, it is well accepted that even in the absence of these syntactic markers, learners make the

conceptual distinction between kinds of objects (or kinds of individuals) and kinds of substances (or kinds of portions) (see Bloom, 2000 for a review).

The topic of this chapter – the relationship between count nouns and object kind representations -- has received considerable attention in the last few years. It raises the question of how learning count nouns that refer to object kinds may fundamentally change the child's ontology. Several researchers have suggested that infants expect words (most of them count nouns at the beginning of language development) to refer to kinds, and as such learning count nouns has important consequences for the child's conception of the world. Specifically, learning count nouns may change how children categorize objects, how they individuate objects and track them over time, and how they make inductive inferences about novel objects they have never seen before (e.g., Balaban & Waxman, 1997; Welder & Graham, 2001; Xu, 2002, 2005). This is a case where we observe the impact of language on concept formation very early in development. The question of when language effects are found is not only an important empirical and descriptive question but also one of theoretical importance. When language effects are found later in development, it may be the case that children have learned certain correlations between aspects of language and aspects of cognition without language being a causal factor in conceptual development. But if the language effects are found very early in development, one might argue that language in fact guides the formation of certain concepts. Given that children start language learning by acquiring single words towards the end of the first year and most of these words refer to object categories, the relationship between words and categories seems a promising candidate for such an investigation. In addition, other researchers have proposed alternative interpretations of

the findings and suggested a rather different view on why words (count nouns) may exert influences on category formation, object individuation, and inductive inference in infancy – a word, presented as a count noun, is just another feature of the object, albeit a heavily-weighted one (e.g., Sloutsky, 2003). What is the state of the evidence in this controversy?

Count nouns and categorization

Waxman and her colleagues have developed an elegant research program in the last ten years addressing the issue of how early noun learning impacts categorization in infants. One of their first studies investigated how presenting a common label across a set of visual displays facilitated categorization in 9-month-old infants (Balaban & Waxman, 1997). Infants were familiarized with pairs of displays depicting members of a category, e.g., rabbits. In the word condition, infants heard a count noun for the familiarization displays, “A rabbit.” In the tone condition, infants saw the same displays as in the word condition but they heard a tone instead of a count noun. On the test trials, the infants were presented with two displays, a new exemplar of the familiar category (i.e., another rabbit) and an exemplar from a new category (e.g., a pig). The proportion of the time the infants spent looking at each of the two displays was recorded. The rationale was that if infants had categorized all the exemplars from the familiarization trials, say the rabbits, as members of the same category, they should spend more time looking at the exemplar from a new category, i.e., the pig, on the test trials. Balaban and Waxman (1997) found that 9-month-old infants looked more at the pig than the new rabbit when they had heard a count noun during familiarization, but not when they had heard a tone during familiarization. In another experiment in the same series, they found

that content-filtered words, which sounded like speech although the identity of the words was obscured, behaved like count nouns in facilitating categorization. One conclusion drawn from these experiments was that the presence of a count noun invited the infants to look for commonalities across exemplars, thus speeding up the categorization process (see also Fulkerson & Haaf, 2003). In the absence of a count noun, categorization at the basic-level does occur but at a much slower speed (e.g., Quinn, Eimas, & Rosenkrantz, 1993).

For superordinate categories, there is little evidence that infants can form these categories without the help of language. Using manipulation time as the dependent measure, Waxman and Markow (1995) presented 12-month-old infants with sets of objects (e.g., four different animals) during familiarization. Then on the test trials, the infants were allowed to play with either another animal or an object from a novel superordinate category, e.g., a piece of fruit such as an apple. Three conditions were included: a noun condition, in which the infants heard a novel word, “See, a fauna?” during familiarization; an adjective condition, in which infants heard “See the faun-ish one?” and a no-word condition, in which infants heard “See here?” On the test trials, all infants heard the identical phrase, “See what I have?” Results showed that the infants did not show a novelty preference for the object from a new superordinate category in the no-word condition, whereas they showed such a preference in both the novel noun and novel adjective conditions. These findings suggest that infants encode category-based commonalities early on, and before they can syntactically distinguish nouns and adjectives, both form classes encourage them to form categories, especially at the superordinate level.

To further specify the role of count nouns in category formation, Waxman and Braun (2005) showed that only consistent naming (i.e., the same count noun for all four animals presented during familiarization) facilitated categorization in an object manipulation task with 12-month-old infants. If the infants had heard different count nouns applied to the objects during familiarization, no categorization behavior was observed during the test phase of the experiment.

At around 13 months, there is also some evidence that infants begin to differentiate count nouns from adjectives. Waxman (1999) and Waxman and Booth (2001) found that when presented a count noun, infants formed shape-based categories and when presented with an adjective, infants used color or texture as the basis for categorization. This is an important finding since in the mature lexicon, count nouns refer to kinds, which are a subset of all categories that are initially mostly based on shape and with rich inductive potential (see Bloom, 2000, Gelman, 2003, and Xu, 2005 for discussions).

These studies provide strong evidence that starting at around 9 months, infants are able to use language input in the form of count nouns to guide the categorization process. The presence of a count noun allows them to look for commonalities across exemplars and form categories, at both the basic level and the superordinate level. One question that remains open is whether language in the form of count noun labels would exert even more powerful influences on shaping the formation of these concepts and categories. For example, would labeling change category boundaries? A study by Landau and Shipley (2001) addressed this issue with older children. Two-, three-year-old children and adults were shown two pictures of objects (animal-like or artifact-like), and either both objects

were labeled with the same count noun (“a blicket”) or two different count nouns (“a sted” and “a blicket”). A set of objects that were intermediate from these two standards (by applying morphing software) was presented to the children and the adults. The question was whether the initial labeling (No word vs. one count noun vs. two count nouns) would change the generalization pattern for the intermediate objects. In this case, since the two objects looked quite different from each other, adults and children assumed that they should have two different names, that is, there was no difference between the no word condition and the two word condition – in each case a category boundary was imposed somewhere in the middle of the continuum. However, when the two standards were labeled with the same count noun, all intermediate objects were accepted as members of the category with the two standards as the two extreme ends. Data from younger children are lacking at the moment. It would be very informative to know if infants who are at the beginning of language development would also be influenced by the naming pattern in forming their categories.

Count nouns and individuation

Another line of research has suggested that in addition to supporting categorization, count nouns also support individuation – establishing the number of distinct objects in an event via the representation of object kinds/categories. Although all words provide criteria for categorization (e.g., a verb such as “walk” is applied to all instances of walking; an adjective such as “red” is used to refer to all instances of redness), only count nouns provide criteria for individuation (Hirsch, 1982; Macnamara, 1987; Wiggins, 1980). The concepts that underpin count nouns are what cognitive psychologists have called “kinds” and what philosophers have dubbed “sortals” or “sortal

concepts.” Several studies have shown that towards the end of the first year, infants begin to use representations of kinds or sortals to establish how many distinct objects are in an event (see Xu, 2005 for a review and the suggestion that “sortal kind” may be a more accurate term). For example, if a toy duck repeatedly emerges from behind an occluder then returns behind it, followed by a ball repeatedly emerging from behind the same occluder then returning behind it, 12-month-old infants but not 10-month-old infants would expect two distinct objects (a duck and a ball) to be behind the occluder. When the occluder is removed to reveal the objects, 12-month-olds would look longer at the unexpected outcome of one object (the duck or the ball) than the expected outcome of two objects (the duck and the ball), but the 10-month-olds do not do so. Furthermore, at 12 months, it is only the kind contrasts (duck vs. ball; bottle vs. cup) that lead the infants to expect two objects behind the occluder. If shown a red ball vs. a green ball, or a large cup vs. a small cup, the infants fail to establish a representation of two distinct objects in the event. Xu and her colleagues have argued that towards the end of the first year, infants begin to represent object kind/sortal concepts and these concepts provide criteria for object individuation (Xu, 1997; Xu & Baker, 2005; Xu & Carey, 1996; Xu, Carey, & Quint, 2004; Van de Walle, Carey, & Prevor, 2000; see Bonatti, et al., 2002; Wilcox & Baillargeon, 1998; Xu 2005; and Xu & Baker, 2005 for discussions of other relevant data and some of the controversy surrounding this line of research). Once the developmental progression has been established, an immediate question arises: What is the mechanism that drives these developmental changes? It is perhaps no accident that infants also begin to comprehend words for object categories towards the end of the first year (e.g., Huttenlocher & Smiley, 1987; Oviatt, 1980). It was hypothesized that learning count

nouns may play a role in the acquisition of kind concepts. What is the empirical evidence for this claim?

Several studies have shown that infants are able to use naming as a means by which to establish how many distinct objects there are in an event. Xu (2002) conducted a series of experiments in which labeling information was provided on-line during an object individuation task as described above. Nine-month-old infants were randomly assigned to one of two conditions: a two-word condition and a one-word condition. In the two-word condition, when an object, say a toy duck, emerged from behind an occluder, the experimenter labeled the object, “Look, [baby’s name], a duck!” in infant-directed speech. Then the duck was returned behind the occluder. Next a ball emerged from the other side, “Look, a ball!” This was repeated several times and sometimes the object was left stationary on the stage for the infant to look at. In the one-word condition, as each object emerged from behind the occluder, the infant heard “Look, a toy!” each time. The question was whether infants could use the presence of the two distinct count nouns to establish a representation of two objects behind the occluder. On the test trials, the occluder was removed to reveal two objects (the expected outcome) or one of the two objects (the unexpected outcome). Looking times were recorded. Results showed that in the two-word condition, the infants looked longer at the unexpected outcome of one object, but they did not do so in the one-word condition. Once it has been established that infants can use two words to facilitate object individuation, the question of whether such effects are language specific arises. In the next three experiments, Xu (2002) replicated these results with other objects and nonsense words (e.g., a blicket vs. a tupa) in the two word condition. But instead of using one word as a contrasting case, the

infants heard two tones, or two very different complex sounds, or two emotional expressions (i.e., Ah vs. Eww) . None of these stimuli helped infants determine the number of objects behind the occluder. Xu (2002) suggested that count nouns, by virtue of being symbolic and referring to kinds, played an important role in the process of acquiring kind concepts and establishing distinct objects in this task. Count nouns are “essence-placeholders”(Xu, 2005).

So far, however, the exact role of words remains unclear. Two important questions remain open. First, it may be argued that words simply played the role of a very efficient and useful mnemonic. Perhaps the presence of the words allowed the infants to remember the objects better in the object individuation task. That is, maybe words do not play a causal role in this process but they facilitate the process by aiding memory of the young infants. Second, these studies have only shown that the presence of two words lead the infants to expect two distinct objects, but there is no evidence that infants expect count nouns to refer to kinds of objects. Several further studies addressed both of these questions.

In a series of experiments, 12-month-old infants were seated in front of a table, and the experimenter showed them a box with a front slit whose content was invisible. The experimenter pulled open the front of the box, looked in, and announced, “Look, a fep!” followed by “Look, a wug!” Or sometimes she looked in and announced “Look, a blicket!” twice. The question was whether infants would use the number of count nouns to predict how many objects should be inside the box, even though they have not been shown any objects in the labeling phase of the study. The box was then pushed towards the infant so she can reach in to retrieve the objects. On both the one-word and the two-

word trials, infants retrieved one object out of the box. After a few seconds, the object was taken away and the infant sat in front of the box empty-handed. Then the critical part of the experiment began. Since the infant had nothing else to do, she was expected to reach into the box again on all trials. However, the box was empty. What would the infant do then? On the one-word trials, infants were expected to search cursorily then give up once she found the box empty. On the two-word trials, however, infants were expected to search more persistently for a second object if they had used the two count nouns to establish a representation of two objects inside the box. Indeed, 12-month-old infants searched longer on the two-word trials than on the one-word trials, suggesting that they had used the number of count nouns to decide how many objects should be in the box. Since no object was shown during the labeling phase, it was not possible to interpret these results as infants using words as mnemonics to help them remember the number of objects in a particular location. Furthermore, using two emotional expressions did not lead the infants to search longer for a second object. Again, the effect may be language specific.

With 9-month-old infants, a series of studies using the object individuation task was conducted to address the issue of whether words were just mnemonics. A 2x2 design was employed, in which the number of objects (1 vs. 2 distinct objects) was crossed with the number of labels (1 vs. 2 count nouns). In two of these conditions, the one-word-one-object and the two-word-two-object conditions, the linguistic information was consistent with the perceptual information. In the other two conditions, the one-word-two-object and the two-word-one-object conditions, the linguistic information was inconsistent with the perceptual information. The question was whether infants would weight one type of

information heavier than the other. All four labeling conditions were also compared with two no-word conditions (one with one object, the other with two objects). The results showed that when infants were given perceptual information alone without labeling, their judgment was ambiguous between one or two objects. When infants were given one label (regardless of one or two objects), they had established a representation of one object behind the occluder. When infants were given two labels (regardless of one or two objects), they had established a representation of two objects behind the occluder. It appears to be the case that the number of labels was the deciding factor in how infants had perceived the events. The linguistic information was powerful enough to override perceptual information. Since in some of the conditions only a single object was shown, the fact that infants had expected to see two objects upon hearing two distinct labels supports the idea that words were not just mnemonics that help infants remember the number of objects. Instead, the very presence of two distinct labels was the basis for positing two numerically distinct objects in the event (Xu, 2006).

In a third series of experiments, Dewar and Xu (2005) asked whether these early words refer to kinds (types) or just individual objects (tokens). The studies addressed this question by asking what characteristics the infants expect the objects to have upon hearing two distinct count nouns applied to them. A looking time method was used. In Experiment 1, 9-month-old infants watched the events presented on a puppet stage. During familiarization trials, the front of a large box was opened to reveal pairs of objects inside: either two identical objects or two objects that differed in shape, color, and texture. The test trials followed the same procedure to show the outcomes, and used the same pairs of objects as in the familiarization trials. But before the box was opened, the

experimenter looked into the top of the box that had a slit and described its contents with either two labels (“I see a wug!” and “I see a dak!”) or the same label twice (“I see a fep!”). For an adult, hearing the content of the box being labeled with two different words would lead to the expectation of seeing two different kinds of objects and hearing the same label twice would lead to the expectation of one kind of object. The results showed that infants shared adult’s intuition. Upon hearing two different labels, infants looked longer at two identical objects inside the box (the unexpected outcome) than two different objects (the expected outcome). This pattern was reversed when infants heard a single label repeated twice: they looked longer at two different objects than two identical objects. In Experiment 2, using the same procedure, infants were presented with either pairs of identical objects or pairs of objects that differed only in shape. The results showed that when they heard two distinct labels, infants looked longer at two identical objects than at two objects differing in shape. In contrast, when they heard one label twice, the infants looked longer at two objects differing in shape than at two identical objects. In Experiment 3, infants were presented with either pairs of identical objects or pairs of objects that differed only in color. This time the infants did not find the linguistic information informative. They looked longer at two different-colored objects irrespective of the number of labels.

These findings suggest that infants at the beginning of word learning may expect distinct labels to refer to distinct kinds of objects. The property of shape is a salient cue to kind membership (e.g., Diesendruck & Bloom, 2003; Landau, Smith, & Jones, 1988), and 9-month-old infants expect that objects that differ in shape should have different labels.

These studies present the first evidence that 9-month-old infants hold certain expectations regarding the referents of novel count nouns.

These studies provide evidence that one characteristic that is unique to count nouns – namely their role in individuation – may play a causal role in the acquisition of kind concepts in infancy. The very process of acquiring count nouns for objects may be an important part of the process of constructing representations of kinds.

Count nouns and inductive inference

A third line of research suggests that count nouns also promote inductive inference of non-obvious object properties in infancy. Baldwin, Markman, and Melartin (1993) first investigated whether infants between 9 and 18 months are able to use perceptual similarity to make guesses about which objects are likely to have certain non-obvious sound properties (e.g., goes ‘moo’ when turned over). The experimenter first demonstrated a non-obvious property to the infant and then handed the object over for the infant to imitate the action. Most infants happily did so since the sounds themselves were pleasant and reinforcing. Then a set of test objects were given to the infant, some were very similar to the demonstration object and some were not. Importantly some of the test objects were broken such that they could not produce the sound property. The idea was that if the infant had expected an object to have the non-obvious property but she couldn’t get the object to work, she would persist in producing the relevant action. Thus the dependent measure was the number of times the infant attempted the relevant action in order to produce the sound on a non-functional object. Baldwin et al. found that infants used perceptual similarity as their guide: the more similar an object was to the demonstration object, the more likely the infant would persist in performing the relevant

action to produce the sound property. Taking this research a step further, Welder and Graham (2001) replicated the main findings of Baldwin et al. and asked if providing a common label would change the generalization pattern with 18-month-old infants. They found that overall infants produced more actions on the objects when the demonstration object and the test object were labeled with the same count noun, “See, a blicket!” However, their results were ambiguous as to whether the presence of the count noun provided any information to override perceptual similarity. Perhaps the presence of a label simply increased the attention of the infant. Using objects that were members of real artifact kinds (e.g., a toy accordion set, or desk bells), Joshi and Xu (2005) found that in the absence of a count noun label, 18-month-old infants used similarity as a guide to make inferences about object properties, but the presence of a count noun allowed the infants to override perceptual similarity and produce many more target actions on low similarity objects. In addition, they found that the language effects were only true of count nouns but not adjectives. With younger infants, Graham, Kilbreath, and Welder (2004) found that at 13 months, consistent naming but not variable naming facilitated inductive inference. However, the overall response rate was rather low, making it more difficult to interpret the results. Perhaps a different methodology is called for with young infants who may not yet have the requisite motor skills.

An alternative view: a word is just another feature of the object

In the last few years, Sloutsky and colleagues have suggested an alternative view on the role of labeling/count nouns in early conceptual development (e.g., Sloutsky, 2003). In particular, Sloutsky has suggested that there is nothing special about words as far as facilitating categorization, individuation, and inductive inference are concerned.

Instead, he advocates a view that explains the various findings reviewed above in terms of how auditory processing interacts with visual processing. The basic idea is that when infants look at objects and they hear some auditory input at the same time, there is an attention bottleneck – the infants have to choose between attending to the visual input or the auditory input. If the auditory input is familiar (e.g., words or speech sounds in general), it is relatively easy to process both visual and auditory inputs simultaneously. If the auditory input is unfamiliar (e.g., tones or other sounds), it is difficult for infants to process everything simultaneously. Instead the infants selectively attend to the auditory stimuli at the expense of the processing of the visual stimuli. This is the source of why words appear to be special in shaping the various aspects of early conceptual development. In other words, if the infants were familiarized with the novel tones or sounds before a categorization or individuation task, they would use the extra auditory information as much as they do words – after all, a word is just another feature of the object; surely a sound can also be another feature of an object. Any additional feature can help with the categorization and individuation process. This view is in sharp contrast with the view that suggests that words refer to kinds and that is the basis of the observed effects of language. Appealing as Sloutsky’s view may be to some, there is also evidence in the existing literature that argues against it. In categorization research, the fact that using a consistent label (the same count noun applying to all the objects) facilitated categorization but using variable labels (a different count noun for each object) did not is evidence that it is not simply a matter of being familiar with the auditory input (Waxman & Braun, 2005). This finding supports the view that using the same count noun invites infants to look for commonalities across objects and that is a critical part of the process of

categorization. In the case of object individuation, several studies included manipulations that are relevant for the alternative view. Xu (2002) found that count nouns – whether familiar (e.g., duck, ball) or unfamiliar (e.g., blicket, tupa) helped infants individuate objects, and emotional expressions, which are highly familiar, did not. This, again, argues against the view that the crucial factor is the familiarity of the auditory input. In the Xu et al. (2005) studies, infants were not shown any objects during familiarization. They simply looked on as the experimenter opened the front box and announced the content of the box, “I see a fep! I see a wug!” Infants were able to use the linguistic information to determine how many objects were inside the box. In addition, two contrastive emotional expressions did not lead the infants to posit two objects inside the box under identical circumstances. These results support the view that count nouns are informative because they are symbols that refer. Count nouns are not attached to objects as one of their features. Lastly, Graham et al. (2004) reported a finding that was parallel to that of Waxman and Braun (2005), namely only consistent labels, not variable ones, promoted inductive inference in 13-month-old infants. In addition, Joshi and Xu (2005) found that only count nouns, but not adjectives, facilitated inductive inference and allowed infants to override perceptual similarity. In these studies, novel words (e.g., blicket, tupa) were used. Again, these results provide evidence against the view that the observed effects were due to auditory processing competing with visual processing, and the familiarity of the auditory input was the crucial factor that predicted successes or failures.

Conclusions

What is the role of language in concept formation in infancy? More specifically, does learning count nouns play a causal role in infants' acquisition of object kind concepts? The state of the evidence reviewed above suggests an affirmative answer. Pre-linguistic infants have some ability to categorize and individuate the objects around them, and they can use perceptual similarity to make guesses about non-obvious object properties. When a count noun is used to refer to an object, the infant assumes that the count noun refers to a kind of object. At least three consequences follow: if another object is referred to with the same count noun, it is a member of the same kind (for now, we leave open the interesting case of homonyms); if another object is referred to with a different count noun, it belongs to a different kind and it cannot be the same object as the first object; if another object is referred to with the same count noun, it is likely to have the same internal, non-obvious properties. To quote Lewis Carol (1895), "When I make a word do a lot of work like that, I always pay it extra."

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