Mapping Properties to Individuals in Language Acquisition

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1. Introduction

A child's task in learning a new predicate – for example, an adjectival expression like *is happy* or a verb phrase like *is laughing* – involves not only determining what kind of property it picks out in the world (such as the color or shape of an object, or someone's mental state), but also semantic information, such as distributional constraints arising from restrictions on which other lexical items it can or cannot compose with in the semantic representation. These semantic constraints have consequences for the nouns the predicate describes and the truth conditions of the sentences in which it appears.

One such semantic dimension involves the level at which a predicate applies. While some predicates apply at the atomic level to individuals, others apply to the group that comprises those individuals, and still others permit predication at either level. In this research, I investigate the onset of children's recognition that certain predicates – predicates that are frequent and/or familiar to young children – obligatorily apply at the individual level. The findings demonstrate that this knowledge is nascent at least by 3 years of age, and that it applies to groups of individuals referred to not only by count nouns, which have overt plural morphology, but also by object mass nouns, which lack it. Thus, I argue that children are driven by their conceptualization of the mereology of groups, rather than surface morphosyntax, and are sensitive to the fact that the lexical semantic representations of predicates may also tap into this structure.

2. Background

A plural expression such as *the children* denotes a group (or plurality) of individuals who are all children. When this expression composes with a predicate, as in the examples in (1), the property may be predicated of either the
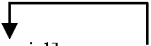
entire group, or the individual members of the group, depending on the semantics of the predicate.

(1) a.   The children drew a dinosaur.
     b.   The children gathered in a circle.
     c.   The children are short.

In (a), the predicate *draw a dinosaur* is a 'mixed predicate', and allows for the property to apply at either level. These predicates therefore give rise to sentential ambiguity when the predicate combines with a plurality, allowing for (at least) a *collective* and a *distributive* reading (Gillon 1987; Landman 1996; Lasersohn 1998; Link, 1983, 1987, 1991; Schwarzschild 1994, 1996). The collective reading of the sentence describes an atomic event in which all participants were involved, while the distributive reading describes a situation with multiple events, each of which had one of the participants as an agent. (The wide/narrow scope of the indefinite *a dinosaur* also correlates with these readings.) Consequently, this sentence could be true in a situation in which the children work together collectively to draw one dinosaur (e.g., Addie draws the legs, Ben draws the head, Colin draws the tail, and Dorothy draws the spikes along the back), and in a situation in which each individual child draws his/her own dinosaur. Other examples of mixed predicates include *lift a block*, *read a book*, and so on. There is now robust experimental evidence that adults and young children and can access both the distributive and collective reading of such sentences (Syrett & Musolino 2013, *under revision*).

In (b), the predicate *gather (in a circle)* is obligatorily collective, and as such, must predicate of the group as a whole. That is, one child cannot gather; it takes more than one child (and perhaps at least three) to do so. The same is true of predicates like *meet* and *agree*. By contrast, in (c), the predicate *be short* is what Schwarzschild (2011) has called a **stubbornly distributive predicate**. It must apply at the individual level, and not at the group level. That is, (c) expresses that each child in the group (or at least the vast majority of children in the group, if we loosen our standards, cf. Lewis 1979) is short – not that the collective height of the group is short. Other examples of distributive predicates include *have brown eyes, be round/square*, and *be intelligent*.

Not all nouns permit individuation in this way. **Count nouns**, such as *girl* or *book* denote individuals, and their plural form denotes a set of individuals (Bloom 1999; Gillon 1992; Quine 1960). Thus, they are able to combine with distributive predicates. When they do, the distributive predicate applies to the individuals inside the group, with the plural morpheme taking wider scope, as shown in (2).

(2) [The girl]s are smart.

By contrast, **mass nouns** such as *rice* or *water* are not licensed with distributive predicates, as shown in (3). These nouns do not take plural marking,

but more importantly, also do not denote individuals, and so cannot provide a distributive predicate with the mereological structure it requires for predication.[1]

(3) a. *The water is round.
    b. *The rice is long.

This is not to say that such mass nouns can *never* appear with distributive predicates. In fact, they can, when the noun is collectivized, and the distributive predicate can then apply to the noun denoting that individual collection, as shown in (4)-(5).

(4) a. *The water is round.
    b. The <u>drops</u> of water are round.
(5) a. *The rice is long.
    b. The <u>grains</u> of rice are long.

Similarly, a collectivizing noun (e.g., *stack, line, group*) can force a plurality to be treated as an individual (or a *singularity*), in which case a distributive predicate is then applied to the group, rather than the individuals in it, as in (6).

(6) a. The <u>group</u> of buttons is round.
    b. The <u>line</u> of girls is long.

While the contrast in acceptability between the count nouns and mass nouns appearing with distributive predicates above is robust, it is not the case that distributive predicates can never combine directly with mass nouns. In fact, distributive predicates do not require that the noun with which they combine be overtly marked as a plural noun; rather, what they require is that this noun refers to a set of individuals, or contain singularities (Schwarzschild 2011). Thus, while distributive predicates cannot combine with the **substance mass nouns** above, they can, however, combine with **object mass nouns**, as in (7).

(7) a. The pasta is long.
    b. The furniture is round.

Object mass nouns, such as *pasta, furniture, mail, clothing,* and so on, share with their substance mass counterparts a lack of plural marking, in contrast with count nouns, as shown in (8), but diverge from their substance mass counterparts

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1. Singular count nouns and these sorts of mass nouns in particular also diverge with respect to cumulativity of reference (if a=x and b=x, then a+b=x, where x=*water* or *a book*), and divisity of reference (if a=x, then a portion of a=x, again where x=*water* or *a book*), both of which had been claimed to hold of mass nouns and not count nouns (cf. Cheng 1973; Quine 1960). However, it has been shown that this breaks down when one takes into account pluralization of count nouns, and a further distinction within mass nouns, discussed below.

in permitting individuation (Chierchia 1998; Gillon 1999).[2] This contrast between substance and object mass nouns has led some (e.g., Gillon 1999; Barner & Snedeker 2005, 2006) to propose that while count nouns require individuation, mass nouns are under-/non-specified.

(8) a.   count noun:
         #some book, a book, books
    b.   substance mass noun:
         some rice, *a rice, *rices
    c.   object mass noun:
         some furniture, *a furniture, *furnitures

Thus, in (7) above, the distributive predicate *be long/round* applies to the individual pieces of pasta or furniture, and not the whole. Gillon (1999) has also pointed out that the same set of individuals can be referred to by either a plural count or object mass noun (e.g., *suitcases* v. *luggage*; *leaves* v. *foliage*; *guests* v. *company*; *cannons* v. *artillery*; *shoes* v. *footwear*, and so on). Moreover, experimental evidence has shown that participants (young children and adults) can be led to conceive of a collection as individuable or not, depending on the type of noun with which it is referred to, and whether the noun initially referred to one object or a set of objects (cf. Barner & McKeown 2005; Barner & Snedeker 2005; Gordon 1985; Wisniewski, Imai, & Casey 1996).

    Taking all of this together, we see that when a distributive predicate combines directly with a noun denoting a plurality (or put another way, composes with the DP in which the non-collectivized noun appears), the property expressed by the distributive predicate is distributed over the individuals in the group, rather than predicated of the group itself. This holds regardless of whether the noun is a plural count noun or an object mass noun, because what matters is that the noun represents a group with individuable, atomic subparts. The experiments presented in this paper were designed to investigate whether children who are first acquiring these distributive predicates – and adjectives specifically – are aware of this constraint on predication, and whether they are further aware that the mereological requirements of the group representation are not tied to the plural morphosyntax such that the constraint on predication applies uniformly to count nouns and object mass nouns alike. To address these questions, we can take advantage of the fact that the group and the individuals in the group need not share the same properties, and that when they diverge, distributive predicates are obligatorily linked to the latter.

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2. The # in (a) indicates that there are some circumstances in which one could refer to a book substance (due to the 'universal grinder', Pelletier 1975). *A rice* is marked as *, but there are circumstances in which one could refer to 'a rice' – for example, when referring to kinds of rices (cf. also *a bread, a wine*). Likewise, 'a water' is licensed in some circumstances – for example, when ordering at a restaurant.

3. Experiment 1
3.1. Participants

63 children (32 girls) and 24 undergraduate controls participated. Children were divided evenly into five groups, based on age, and controlling for gender: I: 2.5-3 years/28.0-35.9 mos. (M: 32.8 mos.); II: 3-3.5 years/36.0-41.9 mos. (M: 38.6 mos.); III: 3.5-4 years/42.0-47.9 mos. (M: 44.3 mos.); IV: 4-4.5 years /48.0-53.9 mos. (M: 50.7 mos.); V: 4.5-5 years/55.0-66.0 mos. (M: 60.4 mos.).

3.2. Stimuli

Visual stimuli were clipart images presented on a MacBook Pro computer screen (for preschoolers) or iMac (for adults in the lab). Linguistic stimuli accompanying each screen were as shown in the last row of Figure 1 below. Children were presented with verbal instructions delivered by an experimenter, while adults were presented with written instructions accompanying the slides on the computer screen.
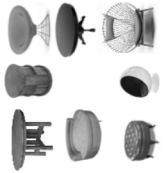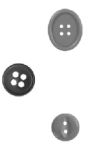
3.3. Procedure

For children, the experimental session proper was preceded by a brief pretest session, which involved an elicitation task designed to confirm that children could distinguish between singular and plural morphosyntactic marking, and between count and mass nouns, and produce adjective+noun combinations. Children were shown a choice between two sets of objects on each side of the screen (side of target counterbalanced from screen to screen), and asked to name the images as indicated by the experimenter, controlling for count/mass and singular/plural status.

For example, children saw a contrast between two loaves of bread on one side and two keys on the other, and were asked of one, "What do you see here?" and then the same of the other. Images were all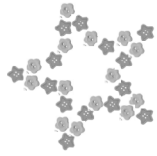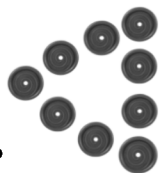 selected to be familiar to the children.[3] Examples of elicited words/phrases included *pig* (singular count noun), *bread* (mass noun), *apples* (plural count noun), *blue sand* (modified mass noun), and *red balloons* (modified plural count noun). Children were required to be successful on more than half of the items in order to proceed to the test session. Children who did not meet this criterion were replaced in the design.

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3. One exception, however, was the sand, which many children took to be paint or glitter, because it was colored. Some children unexpectedly referred to the bread as "sausages" or "hot dogs," in which case, we told them that that was not what it was, and gave a hint such as, "You can eat this! You can use this to make sandwiches." (The deictic *this* was used to refer to either set of objects, regardless of noun status.)

	Familiarization Phase			Test Phase	
	1	2 or 3	2 or 3	group	individual
'count' trial					
'mass' trial					
linguistic stimuli	*Look at my furniture/buttons!*	*Furniture/Buttons can be different shapes, sizes, and colors.*	*You can move furniture/buttons around to make different shapes.* [blank screen] *Now I'm going to show you some new furniture/buttons.*	*Now look, they're different!* *Point to the round furniture/buttons.*	

Figure 1: Example trial structure for object mass noun: furniture and count noun: buttons

The test session consisted of eight test trials, each with the same structure, as shown in Figure 1. Each trial began with a Familiarization Phase, in which participants were shown exemplars of the target object kind (e.g., buttons, furniture). Within this phase, participants were shown that the shape, size, and color of the objects could vary at the individual level, and that these individuals could then be assembled into a group, which had its own property (order of individual/group counterbalanced). Children were proficient at labeling shapes and colors, even if in some cases the name of the shape was incorrect. When the children saw the group, the experimenter made a comment such as, "Huh, look what I made here!" or "Hey, what's that?" to draw the child's attention to the group-level property. Many children commented in turn, saying something like, "Look, you made a star!" or "It's a square!" Thus, we can be confident that children not only attended to both the individual and group level during Familiarization, but knew that a label could map onto either property.[5]

Participants then saw a blank screen and were told that they would see some new instances of these objects (e.g., *Now I'm going to show you some new buttons/furniture!*). They then proceeded to the Test Phase. During this phase, they were shown a screen presenting a choice between a group of objects where the group had the property in question, and a group where the individual objects each had the property in question (e.g., a round group of square furniture v. a square group of round furniture). The participant was asked to choose (for children, to point to, and for adults, to select on a response sheet) the side that had the [adjective noun(s)] (e.g., *Point to the round pillows/furniture!*)

Within the eight test trials, there were two target dimensions (shape and size), and four target distributive predicates, two per dimension (shape: *square, round*; size: *big, tall*). There were four plural count nouns, and four object mass nouns, as follows: plural count nouns: *buttons, pillows, cups, blocks*; object mass nouns: *candy, furniture, fruit, pasta*.[6] Each distributive predicate occurred both with a plural count noun and an object mass noun (ex. *round buttons, round candy*). The order of the trials was pseudorandomized, so that trials with the same distributive predicate were separated from each other, and count and object mass nouns alternated.

3.4. Results

The results for Experiment 1 are presented in Table 1.

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5. Previous evidence also demonstrates that children are highly attuned to shape when categorizing objects and extending word meaning (cf., Bloom 2000; Diesendruck & Bloom 2003; Gentner 1978; Landau, Smith, & Jones 1988).
6. All lexical items in the task were selected based on evidence that they were familiar to children this age, and/or are attested in the early speech or children-directed speech from children this age, as seen in CHILDES corpora (Macwhinney 2000), baseline information from previous experiments (Barner & McKeown 2005; Gordon 1985), and vocabulary norms (Dale & Fenson 1996).

Table 1: Percentage selection of set where individuals have the target property by children and adults in Experiment 1

Dimension	Predicate	2.4-3		3-3.5		3.5-4	
		count	mass	count	mass	count	mass
shape	square	66.7%	66.7%	100.0%	75.0%	100.0%	66.7%
	round	75.0%	75.0%	92.3%	84.6%	83.3%	91.7%
size	big	83.3%	83.3%	92.3%	92.3%	100.0%	100.0%
	tall	8.3%	8.3%	53.8%	76.9%	66.7%	50.0%

Dimension	Predicate	4-4.5		4.5-5.5		ADULTS	
		count	mass	count	mass	count	mass
shape	square	100.0%	76.9%	92.3%	92.3%	100.0%	100.0%
	round	84.6%	92.3%	84.6%	92.3%	100.0%	100.0%
size	big	84.6%	100.0%	92.3%	100.0%	100.0%	95.8%
	tall	61.5%	69.2%	53.8%	53.8%	91.7%	95.8%

Table 2: Percentage selection of set where individuals have the target property by children in Experiment 2 ('group')

Dimension	Predicate	Noun Type	
		count	mass
shape	square	66.7%	66.7%
	round	53.3%	46.7%
size	big	53.3%	86.7%
	tall	20.0%	20.0%

Every age group was significantly more likely than chance (where chance is $p=.5$) to select the individuals with the property: I (65.6%, $p=.004$; II (82.6%,) III (82.3%), IV (83.7%), V (83.7%), Adults (97.9%), all $p<.0001$). Two-tailed Mann-Whitney tests comparing the means of the age groups showed that only the youngest age group differed from the others in the selection of the individuals with the target property (I v. II: $U_A=40$, $p=.04$; I v. III: $U_A=105$, $p=.06$ (and by transitivity, all older age groups); II v. III: $U_A=40$, $p=.98$; II v. IV: $U_A=90.5$, $p=.78$; III v. IV: $U_A=71$, $p=.73$; IV v. V: $U_A=84$, $p=1.0$). However, every child age group differed significantly from the adults, with adults being the most likely to select the individuals overall (I v. adults: $U_A=5.5$, $p<.0001$; II v. adults: $U_A=41$, $p=.0003$; III v. adults: $U_A=28.5$, $p<.0001$; IV v. adults: $U_A=63$, $p=.003$; V v. adults: $U_A=52.5$, $p<.001$).

The one notable exception to this robust selection of individuals is how children responded to the *tall* trials. These trials exhibited the lowest percentage of selection of individuals of all trials. There is no semantic reason that could account for this performance: *tall*, like *big*, is a gradable adjective that indicates positive and significant deviation from a normative size standard (Cresswell 1976; Kamp & Partee 1995; Kennedy 1999; von Stechow 1984), and it is not treated any differently as a distributive predicate with respect to its lexical representation. I therefore have no explanation for children's responses to the *tall* trials, other than a suggestion that there may be something about speakers' usage of this size term that might license its application at the group level.

3.5. Discussion

The results of this experiment demonstrate that children are aware that the distributive predicates investigated here apply at the individual level (or to singularities), rather than to the group itself. Even taking into account the somewhat deviant pattern of responses for the *tall* trials, as mentioned above, children still patterned above chance level in the youngest age group. That this performance held despite the equal relative salience of the individual and group properties within the experimental session demonstrates that children were driven by the lexical semantics of the terms, rather than by perceptual features. Moreover, there was no difference between count noun and object mass noun trials, demonstrating that children are aware that the semantic and conceptual requirements of these predicates are not tied to the surface morphosyntax.

An open question, however, is whether children simply have a proclivity to predicate of individuals. One way of determining if this is the case is to take advantage of the force of the collectivizing noun, as in (6), which instead serves as the noun that is modified by the distributive predicate. Experiment 2 was designed to test this possibility, targeting the collectivizing noun *group*. If children consistently think that the property expressed by the distributive predicate applies to individuals, regardless of the presence of a collectivizing noun, they should continue to pattern as in Experiment 1. However, if they are sensitive to the presence of the collectivizer, and know that *it* is the noun being

modified, they should be more inclined to select the group with the property than they were in Experiment 1.

4. Experiment 2
4.1. Participants

15 children (9 girls) participated. The age range was 35.8-57.2 mos., with a mean of 45.3 mos. This age range was chosen, based on the age at which children in Experiment 1 appeared to consistently map the properties onto individuals across trials.

4.2. Stimuli, Materials, and Procedure

The visual stimuli and procedure were the same as those in Experiment 1. The only difference was in the linguistic stimuli during the Test Phase. Instead of being asked to point to the [adjective noun(s)], children were asked to point to the [adjective group of noun(s)] (e.g., *Point to the round group of pillows/furniture!*) The prediction was that the addition of the collectivizing noun would pull participants toward selecting the group that had the target property, rather than the group where the individuals had the target property. Note that we do not necessarily predict a high rate of selecting the group as the referent, but rather that the rate of selecting the individuals would be depressed. The reason for this is that it is common in English to use pseudopartitive expressions to express that the individual, and not necessarily the collectivizing noun before *of*, has the target property, as in these attested examples: *the perfect cup of coffee*; *a delicious, rich cup of hot chocolate*; *a yummy box of chocolates*.

4.3. Results

The results for Experiment 2 are presented in Table 2. Children in Experiment 2, who heard the collectivized noun phrase *adjective group of x* during the Test Phase, were pulled away from selection of the individuals with the target property and towards selection of the group that instantiated the target property. Their performance (51.7% overall selection of individuals) did not differ from chance level (p=.79).

Indeed, the children in Experiment 2 were significantly less likely than those every age group in Experiment 1, with the exception of the youngest group, to select the individuals who had the target property (two-tailed Mann-Whitney analysis: Expt 1, group I (65.6%) v. Expt 2 (51.7%): U_A=122, *p*=.12, n.s.; Expt 1, II (82.6%) v. Expt 2 (51.7%): U_A=168.5, *p*=.001; Expt 1, III (82.3%) v. Expt 2 (51.7%): U_A=158, *p*=.001; Expt 1, IV (83.7%) v. Expt 2 (51.7%): U_A=171, *p*<.001; Expt 1, V (83.7%) v. Expt 2 (51.7%): U_A=171.5, *p*<.001). Thus, children in Experiment 2 demonstrated an awareness that the predicate applied to the collectivizing noun, and made their selections accordingly, and different from as in Experiment 1.

4.4. Discussion

The results of Experiment 2 complement those from Experiment 1 to demonstrate that children do not indiscriminately predicate of individuals in a set. Rather, they are aware that the distributive predicates tested here obligatorily apply to the atomic parts of the group (with selection of the individuals becoming more consistent through age four), and that the presence of the collectivizing noun *group* influences the choice at Test, pulling selection away from the individuals and toward the group with the target property.

5. General Discussion and Conclusions

The experiments reported here demonstrate that as early as three years of age, young children are sensitive to the semantic constraints of distributive predicates, which obligatorily apply at the level of the individual, rather than to the plurality of which these individuals are members. Thus, at this age, children recognize that groups have a decomposable structure with individuable parts, and further, that distributive predicates modify these parts, regardless of whether the group is referred to with a plural count noun such as *buttons* or an object mass noun such as *furniture*. It is children's understanding of mereology that allows them to appreciate that the individuals that make up a group may have distinct properties from the group itself, and their knowledge of the lexical semantics of distributive predicates that allows them to recognize that the properties expressed by these predicates apply to these individual parts. Given these findings, we might ask how this knowledge meshes with other conceptual and linguistic knowledge attributed to them based on other independent evidence.

Three main lines of research, some of which was already mentioned in the Background section, complement these findings. First, there is evidence that by four years of age, children are sensitive to lexical differences between count nouns, substance mass nouns, and object mass nouns and can use this information when extending the reference for word meaning (Barner & McKeown 2005; Gordon 1985). Further, they are aware that object mass nouns quantify over individuals (Barner & Snedeker 2005, 2006). By three, they also possess the knowledge that number morphosyntax encodes the singular/plural difference (Kouider *et al.* 2006). Second, children at this age are aware of other aspects of the lexical semantic representations of adjectives such as *big* and *tall*, such as their reliance on the context to set the standard of comparison and allowing it to shift (Syrett, Kennedy, & Lidz 2010). Thus, the lexical entry for such adjectives is rich, and is at once both flexible and constrained.

Finally, four-year-olds access multiple interpretations of sentences in which 'mixed predicates' such as *read a book* appear, allowing both collective and distributive interpretations (Syrett & Musolino 2013, *under revision.* These findings demonstrate that they represent pluralities with an internal structure,

and can allow for a predicate to apply at either the group or the atomic level. The present findings indicate that they are aware that not every predicate permits both options – and therefore that they are guided by the lexical semantics of the specific predicates they encounter. Taken together, then, these combined findings reveal that children possess sophisticated knowledge about the part-whole structure of groups, and recruit this knowledge not only when learning about nouns, but also when acquiring a range of predicates.

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