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Children's interpretations of general quantifiers, specific quantifiers and generics

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Recently, several scholars have hypothesised that generics are a default mode of generalisation, and thus that young children may at first treat quantifiers as if they were generic in meaning. To address this issue, the present experiment provides the first in-depth, controlled examination of the interpretation of generics compared to both general quantifiers ('all Xs', 'some Xs') and specific quantifiers ('all of these Xs', 'some of these Xs'). We provided children (3 and 5 years) and adults with explicit frequency information regarding properties of novel categories, to chart when 'some', 'all' and generics are deemed appropriate. The data reveal three main findings. First, even 3-year-olds distinguish generics from quantifiers. Second, when children make errors, they tend to be in the direction of treating quantifiers like generics. Third, children were more accurate when interpreting specific versus general quantifiers. We interpret these data as providing evidence for the position that generics are a default mode of generalisation, especially when reasoning about kinds.

Keywords: generics; children; quantifiers

An important feature of our cognitive capacities is our ability to form broad generalisations on the basis of limited information. Educated adults typically endorse propositions such as 'Iron is magnetic' and 'All trees use photosynthesis', despite having experienced only a tiny fraction of existing iron samples or trees. This propensity to generalise is apparent early in human infancy (Baldwin, Markman, & Melartin, 1993) and is pervasive across content domains. Determining how and when people form generalisations is important for understanding the strategies and implicit biases that influence our knowledge representations.

What are the principles that govern human generalisations? One idea that has received initial support is that certain kinds of generalisations may be easier or more immediate than others. We distinguish here between generics and quantifiers. Generic sentences (such as 'Iron is magnetic' or 'Birds lay eggs') express generalisations that not only link to *kinds* (e.g. the abstract categories of iron or birds) but also allow for exceptions (e.g. male birds do not lay eggs and some kinds of iron are not magnetic). In contrast, quantified sentences (such as 'All trees use photosynthesis' or 'Some cats are tailless') express generalisations that are logically precise (e.g. 'all' permits no exceptions and 'some' applies for any non-null set).

Recently, some scholars have proposed that generic generalisations are a default mode of generalisation, while more logically precise quantified generalisations are more cognitively sophisticated and taxing (Leslie, 2008, 2012). Evidence in support of this view is that generic generalisations are easier, more automatic, developmentally prior and more robust than other forms of generalisation, such as quantified ones. For example, early in development, statements using quantifiers are interpreted as generic more often than the reverse (Hollander, Gelman, & Star, 2002), and both children and adults more often endorse generalisations conveying kind-relevant attributes (e.g. 'lions have manes') than those conveying frequency-matched attributes that are not kind-relevant (e.g. 'lions are male'; Brandone, Cimpian, Leslie, & Gelman, 2012). Moreover, when adults are asked to consider wholly novel categories, their endorsement of generics is affected by content- or theory-based information rather than quantitative information alone (Cimpian, Gelman, & Brandone, 2010a; Khemlani, Leslie, & Glucksberg, 2012; Prasada, Khemlani, Leslie, & Glucksberg, 2013).

Additional support for the ease of processing generics comes from language used to express generics versus quantification. Studies comparing generics to quantifiers suggest that generics are used more frequently in natural speech (Gelman, Hollander, Star, & Heyman, 2000) and are processed more rapidly (Meyer, Gelman, & Stilwell, 2011). Furthermore, and importantly, when asked to consider quantified generalisations, participants may often rely instead on their interpretation of the corresponding generic, thus assimilating quantified statements to generics (Leslie & Gelman, 2012; Leslie, Khemlani, & Glucksberg, 2011).

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For example, when given a recall task, both preschool children and adults tend to misremember sentences with quantifiers as if they were generic (e.g. 'All bears climb trees' is recalled as 'Bears climb trees') more often than they show the reverse pattern (recalling generics as quantified; Leslie & Gelman, 2012). Adults also show a tendency to endorse false universal generalisations when the corresponding generic is true (e.g. accepting 'all ducks lay eggs', despite knowing that male ducks do not lay eggs; Leslie et al., 2011), suggesting that they may sometimes rely on their judgement of the generic, rather than correctly evaluating the universally quantified statement. Further, this tendency increases when participants are sped up (Meyer et al., 2011). Additionally, a variety of otherwise puzzling adult reasoning errors concerning universal quantification are also explicable on the hypothesis that adults sometimes default to a generic interpretation of universal statements (Jönsson & Hampton, 2006; Sloman, 1993, 1998; see Leslie, 2012, for discussion).

If the generic-as-default hypothesis is correct, then two further predictions would follow. First, it should take longer for children to acquire quantifiers than generics. And second, when initially acquiring quantifiers, children should show a tendency to interpret them as generic. These results, if obtained, would be particularly interesting given that, from the standpoint of formal semantics, the semantics of quantifiers are much simpler and more straightforward to represent than the semantics of generics. For example, 'all' applies if each and every instance of the category has the relevant property. In contrast, the application of generics is quite variable, depending on the domain and content (e.g. we say 'birds lay eggs' but not 'birds are female', even though those sets are practically coextensive).

Several papers indicate some support for these predictions, by examining children's responses to generic or quantified questions regarding familiar categories, such as 'Are flowers yellow?' or 'Do all dogs have brown spots?', in English (Hollander et al., 2002), Mandarin (Tardif, Gelman, Fu, & Zhu, 2012), or Quechua (Mannheim, Gelman, Escalante, Huayhua, & Puma, 2011). In these studies, generics show adult-like patterns of interpretation from the earliest age, whereas quantifiers undergo developmental change, initially being interpreted similarly to generics. Thus, for example, English-speaking 3-year-olds tend to say 'yes' about equally often, whether they are asked, 'Are flowers yellow?', 'Are all flowers yellow?', or 'Are some flowers yellow?' In contrast, English-speaking 4-year-olds and adults distinguish all three questions from one another. Similar patterns obtain in Mandarin and Quechua, although the age at which children respond correctly to quantifiers is slightly older than that found in English speakers. Children's difficulty with quantifiers did not reflect an ignorance of the words 'some' and 'all' because on a control task, children performed quite well when quantifiers were applied to small quantities (e.g. when shown that two out of four crayons were in a box, children typically said 'no' to the question, 'Are all of the crayons in the box?').

By later preschool (4–5 years of age), English-speaking children appropriately distinguish 'all' and 'some' from generics even when asked to provide judgements for novel categories in which the relevant quantities were made explicit (e.g. two out of six novel creatures – 'crullets') and had a target property (e.g. spots), and children were asked to judge the truth of generic sentences ('Crullets have spots') or quantified sentences ('All/most/some crullets have spots'; Brandone, Gelman, & Hedglen, in press). However, because that work included older children exclusively, it is unknown whether the developmental shift in interpreting quantifiers may reflect 3-year-olds' difficulty representing the relevant quantities in the test questions (e.g. what proportion of flowers are yellow), rather than changes in how quantifiers are interpreted per se. For example, it may be that 3-year-olds have insufficient world knowledge (e.g. perhaps they are unfamiliar with the full range of variation in flowers that adults have seen) or limited ability to access counterexamples (e.g. they may have seen flowers of a range of colours, but cannot pull them to mind in the absence of a stronger cue). Because inferences about children's interpretations of the sentences on this task rest on assumptions regarding the distributions of the properties that were tested, it would be ideal to ask children about sets in which the proportions are explicitly stated and controlled – particularly across the critical developmental period when prior research documented changes in interpretation of quantifiers, namely, from 3 to 5 years of age.

Moreover, it is puzzling that, in prior research, children showed such a divergence between a control task, in which they successfully applied 'some' and 'all' to small sets of crayons (e.g. correctly answering questions such as, 'Are all *of the* crayons in the box?'), and the main task, in which children fail to understand 'some' and 'all' when applied to broad categories (flowers, dogs and fire). It may be that such differences are due to differences in the clarity of the frequencies being questioned, as mentioned above: namely, the control task was explicit regarding the frequencies involved, since they were explicitly shown to participants. However, another intriguing possibility is that children may distinguish between what we will call *general quantifiers* (e.g. 'all dogs') and *specific quantifiers* (e.g. 'all of my dogs'). (Strictly speaking, the quantifiers themselves are neither specific nor general; rather, 'specific' and 'general' refer to the domains to which the quantifiers apply. We use this abbreviated terminology for ease of expression.) A general quantifier, in the sense we are using it here, is a quantifier that is applied to (or has as its domain) an entire, open-ended kind or category; in contrast, a specific quantifier is applied to only a particular, limited set of items that are salient in the context. For example, if one is holding a bunch of blue flowers, it would be wrong to say 'some *of these* flowers are yellow' (specific quantifier), but still correct to say 'some flowers are yellow', because the latter pertains to flowers in general, not just to the particular bunch at hand. To our knowledge, linguistic analyses do not standardly distinguish between these two kinds of quantifiers, instead assuming a single semantic representation that applies whether the quantifier is general (all dogs) or specific (all these dogs; e.g. Barwise & Cooper, 1981), so that the only difference between 'some of these flowers' and 'some flowers' would be that the domain of quantification of the former would be a subset of the latter. That is, the only semantic difference between the two constructions would be that the one has a more limited domain than the other. However, because general quantifiers modify kinds, they may be more susceptible to a generic interpretation than specific quantifiers, which select out a readily countable set. Generic generalisations apply to kinds, not to particular, limited sets, and so are more similar to general quantifiers than to specific ones (e.g. there is no generic counterpart of 'some of these flowers are yellow'; 'flowers are yellow' can only be interpreted as applying to the kind in general; Carlson & Pelletier, 1995). To process a specific quantifier, one need only consider a limited number of specific items; one does not have to consider the category in the abstract. However, as general quantifiers, like generics, require language users to make generalisations about the entire kind, there may be more of a tendency to default to the generic interpretation with them.

The literature reviewed thus far indicates substantial gaps in our understanding of how generics and quantifiers relate in early childhood. Specifically, more research is needed to document development between 3 and 5 years of age and to understand how specific and general uses of quantifiers (e.g. 'all of these dogs' vs. 'all dogs') compare to one another.

Prior developmental work on quantifier acquisition has tended to focus almost exclusively on specific quantifiers (e.g. Barner, Chow, & Yang, 2009; Brooks & Braine, 1996; Crain & Thornton, 1998; Halberda, Taing, & Lidz, 2008; Huang & Snedeker, 2009; Hurewitz, Papafragou, Gleitman, & Gelman, 2006; Noveck, 2001; Papafragou & Musolino, 2003; Papafragou & Schwarz, 2005; Smith, 1980). These studies indicate an early competence with quantifiers such as 'all' and 'some' when they are applied to a small set of items, in the sense that (1) children distinguish the two quantifiers in their responses, and (2) a number of children (though not all) give adult-like responses. ('Most', in contrast, may emerge later in development; Papafragou & Schwarz, 2005.)[1] However, this research does not provide information regarding how specific and general quantifiers relate to one another.

We are aware of just one prior investigation of the distinction between general and specific quantifiers in children (Hanlon, 1987, 1988). In these studies, the author predicted that specific forms of quantifiers (e.g. 'some of the hats') would be acquired before the equivalent more general forms (e.g. 'some hats'). Support for this prediction was found in the productive speech of three children from Roger Brown's longitudinal data (Adam, Eve and Sarah), regarding the quantifiers 'all' and 'some'. However, this research compared general and specific uses of quantifiers in production only, and thus provided no comparative data regarding comprehension.

The present study

The present study is designed to examine how young children and adults interpret and evaluate generics and both general and specific quantifiers. The goals are to address three previously unresolved questions:

(1) Can 3-year-olds distinguish generics and quantifiers? As noted earlier, prior studies have not controlled for 3-year-olds' prior knowledge and ability to access counterexamples. The present study provides such control with the use of novel categories and precise samples of evidence.
(2) To what extent do children across the preschool ages (3–5 years) assign generic interpretations to quantifiers? If this error in quantifier comprehension is found, it would support the hypothesis that generics are a default interpretation for children.
(3) Are there differences in children's comprehension of specific uses of quantifiers (e.g. 'all of the Xs') versus general uses of quantifiers (e.g. 'all Xs')? We predicted that the latter would be more susceptible to being treated as generics.

We conducted a study in which participants were assigned to one of three wording conditions: generic, specific quantifiers and general quantifiers. The quantifiers (in both quantifier conditions) were 'all' and 'some'. In order to control for prior knowledge and attribute frequency, all trials involved samples of novel animal kinds, for which precise information was provided regarding the percentage of instances containing the attribute in question: 0%, 25%, 75% or 100%. We included 3-year-olds and 5-year-olds, since prior work found developmental change between 3 and 4 years of age (Hollander et al., 2002). Adults were included in order to allow an assessment of the developmental endpoint.

Evidence for the generics-as-default hypothesis would be a pattern of responding in which participants treat quantifiers ('all' and 'some') as if they were generics rather than precise logical statements. Specifically, the prototypical generic response is for endorsements to increase in stepwise fashion as the frequency levels increase from 0% to 25% to 75% to 100% (e.g. a generic statement is more likely to be considered true if 75% vs. 25% of the relevant category have the target property). In contrast, the logical 'all' pattern of response is to endorse a statement if and only if 100% of the category has the target property, and the logical 'some' pattern of response is to endorse a statement as equally true if 25%, 75% and 100% of the category has the target property. Thus, for example, if participants are asked, 'Do some Xs have Y?', and they say 'yes' more often when 75% of Xs have Y than when 25% of Xs have Y, this would provide support for the generics-as-default hypothesis.

Method

Participants

Participants in the main study included 48 three-year-olds (2.96–4.04; *M* age 3.47; 31 girls, 17 boys), 48 four- and five-year-olds (4.54–5.92; *M* age 5.27; 23 girls, 25 boys; henceforth referred to as '5-year-olds' due to their mean age and for ease of expression) and 121 adults (18–70; *M* age 37; 66 women, 55 men). All were native speakers of English. An additional 24 preschool children (3.32–5.95, *M* age 4.48) participated in a pretest of the items (described below). Twelve additional children were tested but dropped from the main study (nine 3-year-olds and three 5-year-olds): One had participated in the study previously at a different location (school vs. lab), one child's responses were unintelligible, two involved experimenter error, two did not complete the task and seven provided the same answer on every trial (either all 'yes' or all 'no'). The majority of participants were of European-American background.

Pretest

Items were pretested on a separate group of children to ensure that depicted properties were identifiable. Following a four-question warm-up task designed to ensure that children were willing to say 'yes' and 'no' as appropriate (e.g. 'Is this a car?' when shown a car), participants were presented with a series of 36 novel creatures, one at a time. For each, the novel creature was named, and the child was asked whether it possessed the target property (e.g. 'Look, this is a wug. Does this wug have big hair?'). Half of the items displayed the property and half lacked it, although any given participant did not see both the positive and negative instance of the same animal. Items selected for the main experiment were those which children consistently judged both the presence and absence of the features correctly. Of the 16 items selected (see Figure 1), children correctly judged the feature to be present 98% of the time and absent 98% of the time.

Items

Items were 16 picture sets (laminated cards for children; presented on computer for adults), each presenting four instances of a novel animal category (see Figure 2, for example). Each card had a distinctive feature on zero, one, three or four of the instances; altogether there were four cards of each type (four with a distinctive feature in one instance, four with a distinctive feature in three instances, etc.). The test questions always concerned the distinctive feature (e.g. big hair).

Within each age group, participants were randomly assigned to one of three conditions: general quantifier (all Xs/some Xs), specific quantifier (all of these Xs/some of these Xs) or generic (Xs). Participants in the general quantifier condition received eight questions concerning 'all Xs' (e.g. 'Do all wugs have big hair?') and eight questions concerning 'some Xs' (e.g. 'Do some murbs have stars?'). Participants in the specific quantifier condition received eight questions concerning 'all of these Xs' (e.g. 'Do all of these wugs have big hair?') and eight questions concerning 'some of these Xs' (e.g. 'Do some of these murbs have stars?'). Participants in the generic condition received all 16 questions concerning 'Xs' (e.g. 'Do wugs have big hair?', 'Do murbs have stars?'). In each condition, with each type of wording, there were equal numbers of questions concerning a card depicting the target property on zero, one, three or four of the four instances. We refer to these as 0%, 25%, 75% and 100% frequency levels.

Procedure

Children were tested individually in a quiet room in an on-campus lab or a preschool. Adults were recruited using Amazon's Mechanical Turk, a crowd-sourcing platform that allows people to complete online tasks for compensation. We offered the survey only to native-English-speaking individuals in the USA.

Children first received a warm-up task including four items with easy yes/no questions, two of which had a correct answer of 'yes' and two of which had a correct answer of 'no' (e.g. 'Is this a hat?' when showing a picture of a shoe). The purpose of the warm-up was to indicate to children that both yes and no answers were appropriate and to give them confidence in answering questions. Following the warm-up, children received the first two blocks of test trials, with each block containing one item at each frequency level. For each item, participants first saw a card depicting four instances of a novel category. The experimenter labelled all the pictures on the card ('Look, these are murbs! Can you point to the murbs?'). If a child failed to point to any of the pictures on the card, he or she was corrected ('This is a murb, too'). Then the test question was asked ('I have a question for you about (all, some, all of these, some of these) murbs.

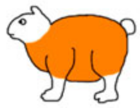
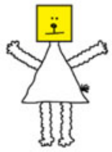
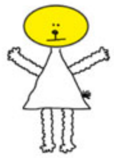
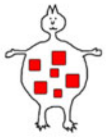
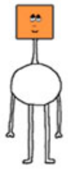
Novel Name	Property	Property Presence	
		Positive	Negative
Ackle	Orange hands		
Boker	Zig zags		
Dassie	Square head		
Dax	Purple legs		
Fral	Nose		
Gorp	Red body		
Lan	Stripes		
Lep	Triangle head		

Figure 1. Creatures, properties and labels used in the study.

Do (all, some, all of these, some of these) murbs have stars?'). The child's yes/no response was recorded. If a child failed to provide a 'yes' or 'no' answer, they were prompted at least twice ('So do (all, some, all of these, some of these) Murbs have stars?'). If the child still failed to provide a yes or no response (fewer than 1% of trials, at any age), a non-response was recorded. After the first two blocks of test questions (eight test questions total), the child received a two-minute break in which they played an Oreo matching game with the experimenter, followed by the second two blocks of test questions (eight test questions total).

For adult participants, assignment of item to frequency level and order of presentation of frequency level was randomised separately for each participant, with the constraint that there was exactly one item for each frequency level, within each block. For the child participants, these factors were counterbalanced, as described below, in order to minimise any potential effects of content. Specifically, animals were presented in four blocks, and the presentation of these blocks was counterbalanced using a between-subjects, Latin-square design. Each block contained a test question with each frequency level (0, 25, 75 and 100%). The first two blocks (first eight test questions) were

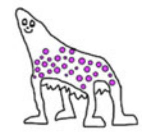
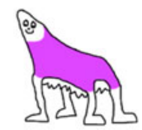
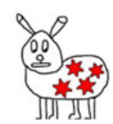
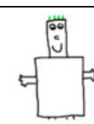
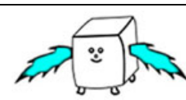
Luzak	Spikes		
Murb	Stars		
Saper	Spots		
Scobbit	Ears		
Twano	Green arms		
Vardie	Tail		
Wug	Big hair		
Zammle	Wings		

Figure 1. Continued.

presented using the same order (e.g. 0%, 75%, 25% and 100%). The second two blocks (second eight test questions) were presented in the reverse order (e.g. 100%, 25%, 75% and 0%). Between subjects, all possible non-sequential orders of frequency level were used. All of the above was balanced within each condition.

Scoring

Responses of ‘yes’ were scored as ‘1’, responses of ‘no’ were scored as ‘0’, responses of ‘I don’t know’ or ‘maybe’ were scored as missing and were left unscored. Scores (excluding missing data) were averaged across all items of a given quantifier, condition and frequency level, resulting in composite scores that were used in the analyses (below).

The data were analysed separately for the two quantifiers, *all* versus *some*.

Results: ALL

The data are depicted in Figure 3(a–c). We conducted a 3 (age group: 3-year-olds, 5-year-olds, adults) × 3 (condition: generic, general quantifier, specific quantifier) × 4 (frequency level: 0%, 25%, 75% and 100%) repeated-measures analysis of variance (ANOVA), with age group and condition as between-subject variables and frequency level as a within-subject variable. Preliminary analyses revealed no significant effects involving block order (‘all’ vs. ‘some’ first), and so order was not included as a factor in the analysis. The dependent variable was the proportion of trials on which participants gave a ‘yes’ response to the test questions for items of that type.

Every main effect and interaction was statistically significant. There was a main effect of age group, $F(2,208) = 26.78$, $p < .001$, $\eta_p^2 = .20$, a main effect of condition, $F(2,208) = 27.43$, $p < .001$, $\eta_p^2 = .21$, a main

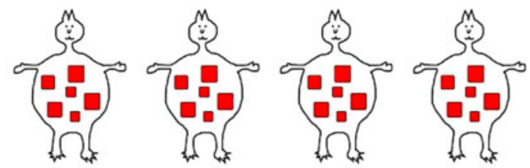
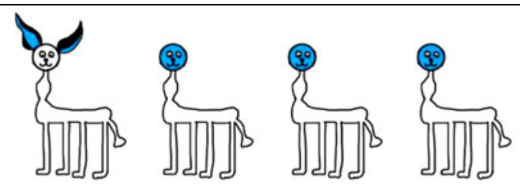
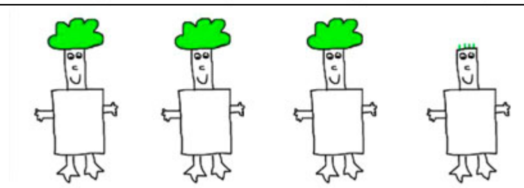
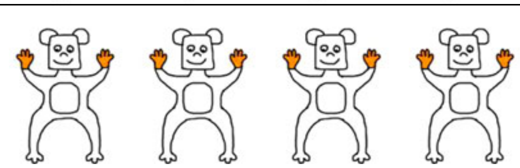
Instances of Property	Image
0% (stripes)	
25% (ears)	
75% (big hair)	
100% (orange hands)	

Figure 2. Sample item sets.

effect of frequency level, $F(3,624) = 351.06$, $p < .001$, $\eta_p^2 = .63$, an age group × condition interaction, $F(4,208) = 5.72$, $p < .001$, $\eta_p^2 = .10$, a frequency level × age group interaction, $F(6,624) = 12.34$, $p < .001$, $\eta_p^2 = .11$, a condition × frequency level interaction, $F(6,624) = 40.15$ $p < .001$, $\eta_p^2 = .28$, and an age group × frequency level × condition interaction, $F(12,624) = 3.04$, $p < .001$, $\eta_p^2 = .55$.

Given that the main effects and two-way interactions are subsumed under the interaction involving age group × condition × frequency level, we focus on the three-way interaction. Adults showed a clear distinction between generics (which demonstrated a stepwise increase with frequency level) and ‘all’ (which demonstrated a strict cut-off). For the generic condition, ‘yes’ responses increased in stepwise fashion as the frequency levels increased from 0%–25% to 75%–100%. Each frequency level was significantly different from the others, *p*s < .01. In contrast, for both quantifier conditions (both general quantifier and specific quantifier), responses to 0%, 25% and 75% did not differ from one another (*p*s > .15), but did significantly differ from responses to 100% (*p*s < .001). Thus, the signature for adult interpretation of ‘all’ is two-fold: high endorsement of 100% and low-and-equal endorsement of frequency levels below 100%.

Now we turn to the children. For generics, both 3-year-olds and 5-year-olds showed the adult pattern of increasing endorsement with increasing frequency levels, though the patterns differ somewhat across ages. Three-year-olds demonstrated stepwise increases in ‘yes’ responses with increasing frequency levels, although they reached ceiling at 75%, and thus there was no significant difference between 75% and 100% levels. All other responses were significantly different from one another, *p*s ≤ .002. Five-year-olds indicated a break between the lower frequency levels (0%, 25%) and the higher frequency levels (75%, 100%), *p*s < .001. However, there was no difference between 0% and 25% or between 75% and 100%.[2]

Most interesting, however, were the child patterns for the quantifier. Like adults, children at both ages endorsed both ‘all’ and ‘all of these’ more often at the 100% level than all other levels (*p*s < .001). However, unlike adults, children also showed differentiation among the lower frequency levels. Thus, the 25% and 75% levels differed significantly from one another for 3-year-olds with the general quantifier, $p < .04$. There was also a non-significant tendency for greater endorsement of the 75% level than the 25%, for 3-year-olds hearing a specific quantifier and for the 5-year-olds hearing a general quantifier, *p*s < .10. This differentiation among frequency levels below 100% is consistent with the generic interpretation pattern and distinct from the ‘all’ signature pattern. Finally, for 5-year-olds with the specific quantifier, the 25% and 75% levels were significantly lower than the 0% level, *p*s < .01, though this result likely reflects the difficulty with 0% frequency levels, as noted earlier.

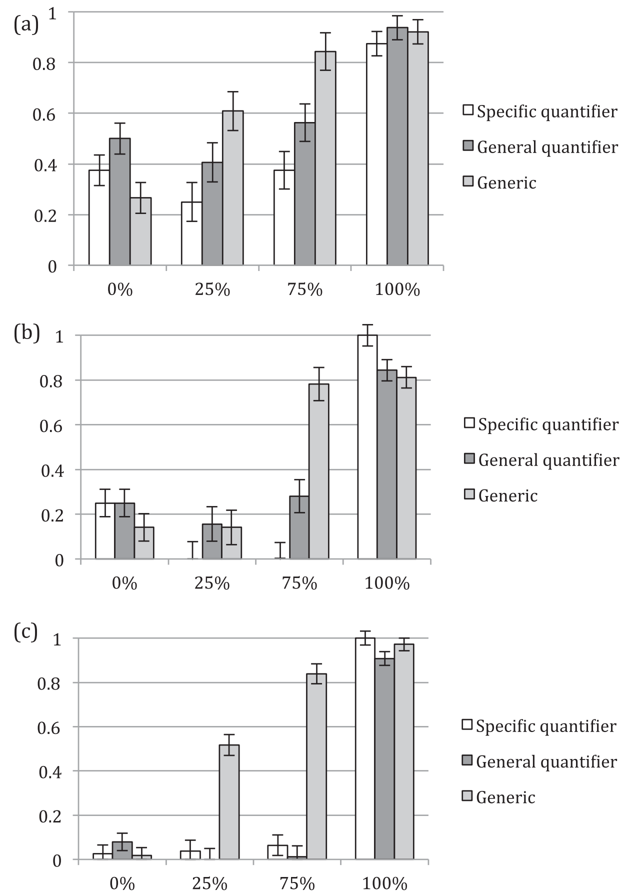


Figure 3. ALL conditions ('all Xs', 'all of these Xs', 'Xs'). (a) 3-year-olds; (b) 5-year-olds; (c) Adults.
Note: *y*-axis indicates the mean proportion of 'yes' responses.

Another way to examine the data is to focus on condition comparisons, within each age group and frequency level. For adults, the primary and striking differences were between generics and quantifiers: generics yielded higher 'yes' responses than both specific quantifiers and general quantifiers, at both 25% and 75% frequency levels, *p*s < .001. The only other significant condition effect for adults was at the 100% frequency level, where the specific quantifier ('all of these Xs') yielded significantly greater agreement than the general quantifier ('all Xs'), $p < .04$. Most likely this result indicates the inherent uncertainty in drawing conclusions about an abstract category on the basis of a specific sample (e.g. even though all four wugs in the picture have big hair, it does not necessarily follow that 'all wugs' [including those not in the picture] have big hair).

Like adults, children also distinguished generics from quantifiers. For 3-year-olds, generics differed from quantifiers at the 0% level (general quantifier, $p < .01$), the 25% level (specific quantifier, $p = .001$; general quantifier, $p = .064$) and the 75% level (both specific and general quantifiers, *p*s < .01). For 5-year-olds, generics differed from quantifiers at the 75% level (both specific and general quantifiers, *p*s < .001) and the 100% level (specific quantifier, $p < .01$).

Importantly, however, children also responded significantly differently to general versus specific quantifiers. Three-year-olds showed a non-significant tendency to differentiate specific vs. general quantifiers at the 75% level, $p = .074$, and 5-year-olds significantly differentiated these quantifiers at both the 75% and 100% levels, *p*s < .05. Whereas the distinction at the 100% level was the same as that shown by adults, indicating an appropriate distinction between a sample and the larger category, the distinctions at the 75% level suggest a greater tendency to respond generically when given a general quantifier as compared to a specific quantifier.

Response patterns

Although the analyses above are informative, it is also important to examine individual response patterns, to determine if the results obtained by averaging across participants also reflect the patterns of individual subjects. We classified each participant's set of answers into one of three response patterns: generic, 'all' or other. For this analysis, responses to the 0% frequency level were excluded, given that many children had difficulty determining whether an attribute applied, in its absence, as noted earlier. Furthermore, there were no predicted differences in response to the 0% frequency level, when comparing among wording conditions. A participant was classified as showing an 'all' response pattern if he or she answered 'yes' on every trial at the 100% frequency level and 'no' on every trial at the 25% and 75% frequency levels. A participant was classified as showing a generic response pattern if he or she answered 'yes' on every trial at the 100% frequency level, 'yes' on at least one other trial, and equal or monotonically decreasing responses at the 75% and 25% frequency levels, respectively. Finally, all other response sets were coded as 'other'.

The chance probability of showing the 'all' response pattern was 1% (1 out of 125 possible patterns), the chance probability of showing a generic response pattern was 11% (14 out of 125 possible patterns) and the chance probability of showing an 'other' response pattern was 88% (110 out of 125 possible patterns). Note that the 'other' response pattern is by far the most likely, by chance alone. Table 1 provides all possible response patterns for 'all' and Generic, and a sample of the possible response patterns for Other. The data appear in Table 2.

As predicted, adults typically interpreted both the specific quantifier ('all of these Xs') and the general quantifier ('all Xs') in accord with the logical interpretation of 'all' (endorsed at 100% only). In contrast, the generic ('Xs') showed a distinctly different pattern, in which frequency levels below 100% were also endorsed,

Table 1. Response patterns (proportion of 'yes' responses to each of three frequency levels) that would be coded as 'All', Generic or Other.

	Frequency level		
Response pattern	25%	75%	100%
'All'	0	0	1.0
Generic	0	.25	1.0
Generic	0	.50	1.0
Generic	0	.75	1.0
Generic	0	1.0	1.0
Generic	.25	.25	1.0
Generic	.25	.50	1.0
Generic	.25	.75	1.0
Generic	.25	1.0	1.0
Generic	.50	.50	1.0
Generic	.50	.75	1.0
Generic	.50	1.0	1.0
Generic	.75	.75	1.0
Generic	.75	1.0	1.0
Generic	1.0	1.0	1.0
Other (example)	0	.25	.75
Other (example)	0	.75	.50
Other (example)	.25	0	0
Other (example)	.25	.75	.75
Other (example)	.50	.50	.50
Other (example)	.50	1.0	.25
Other (example)	.75	0	1.0
Other (example)	.75	.25	1.0
Other (example)	1.0	.50	.25
Other (example)	1.0	1.0	0

Note: Out of 125 possible patterns, 1 pattern would be classified as 'All', 14 patterns would be classified as Generic, and 110 would be classified as Other.

and the generic pattern predominated. For adults, response pattern interacted with condition, χ^2 (df = 4) = 68, $p <$ .001. Five-year-olds also demonstrated a significant interaction between response pattern and condition, Fisher's exact test, $p < .001$. They showed similar patterns to the adults for both the specific quantifier (endorsed at 100% only) and the generic (not limited to 100%; all increases were monotonic with frequency). Interestingly, however, for the general quantifier, 5-year-olds were much less likely than with the specific quantifier to show the 'all' response pattern, and instead more often displayed a generic interpretation, as compared to the specific quantifier condition. Finally, 3-year-olds showed only a non-significant trend towards an interaction between response pattern and condition, Fisher's exact test, $p = .07$. For the generic and general quantifier wording conditions, 3-year-olds most often demonstrated a generic response pattern; for the specific quantifier wording condition, the generic response pattern was the second-most frequent pattern (following 'all'). Thus, the response patterns confirm the results of the mean 'yes' responses, namely, a tendency to default to generic interpretations when interpreting quantifiers, especially when the quantifiers apply generally to the category.

Table 2. ALL condition, response pattern data (% of participants showing each response pattern, as a function of age group and condition).

Age group	Condition	'All' (%)	Generic (%)	Other (%)
3 years	Specific 'all'	37	34	19
3 years	General 'all'	25	56	19
3 years	Generic	0	68	31
5 years	Specific 'all'	100	0	0
5 years	General 'all'	44	25	31
5 years	Generic	0	62	37
Adult	Specific 'all'	90	8	3
Adult	General 'all'	84	3	13
Adult	Generic	11	77	11

Results: SOME

We conducted a 3 (age group: 3-year-olds, 5-year-olds and adults) × 3 (condition: generic, general quantifier and specific quantifier) × 4 (frequency level: 0%, 25%, 75% and 100%) repeated-measures ANOVA, with age group and condition as between-subject variables and frequency level as a within-subject variable. Preliminary analyses revealed no significant effects involving block order ('all' vs. 'some' first) and so order was not included as a factor in the analysis. The dependent variable was the proportion of trials on which participants gave a 'yes' response to the test questions for items of that type. Note that the data from the generic condition are identical to those reported in the analyses of 'all' reported above but are used here in comparison to 'some Xs' and 'some of these Xs'.

The following effects were statistically significant: condition, $F(2,208) = 3.66$, $p = .027$, $\eta_p^2 = .03$, frequency level, $F(3,624) = 302.77$, $p < .001$, $\eta_p^2 = .59$, frequency level × age group, $F(6,624) = 15.64$, $p < .001$, $\eta_p^2 = .13$, frequency × condition, $F(6,624) = 7.01$, $p < .001$, $\eta_p^2 = .06$, and age group × condition × frequency level, we focus on the three-way interaction, $F(12,624) = 2.18$, $p = .011$, $\eta_p^2 = .04$, which is depicted in Figure 4(a–c). The effects of age group and age group × condition were non-significant, ps > .07.

Given that the main effects and two-way interactions are subsumed under the three-way interaction, we focus on the latter. Adults showed two distinct patterns: the stepwise increase for generics (as noted in the previous section) and consistently high responding for 'some' when frequency levels were above 0%. For the general quantifier ('some Xs'), responses to 25%, 75% and 100% were all higher than responses to 0% (ps < .001), and the non-zero levels did not differ from one another (ps > .3). For

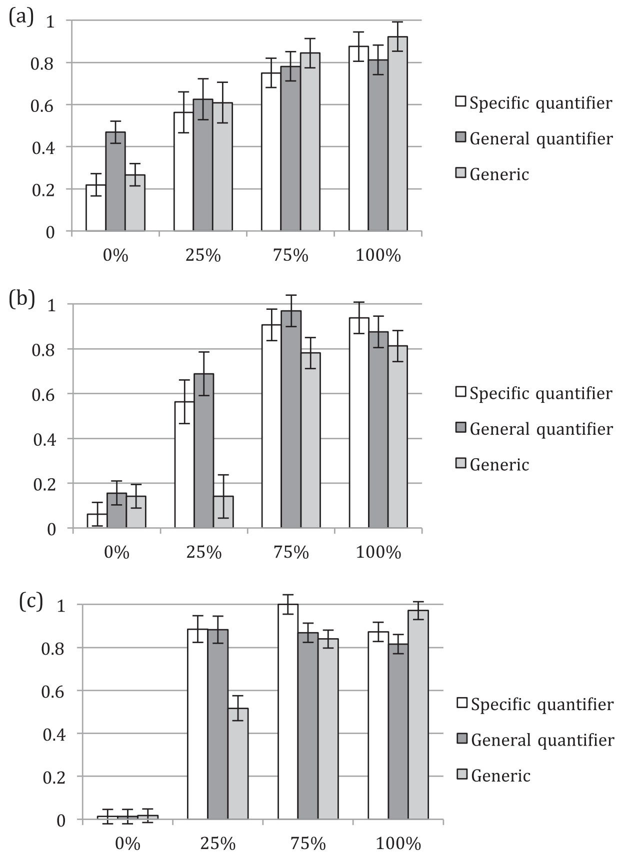


Figure 4. SOME conditions ('some Xs', 'some of these Xs', 'Xs'). (a) 3-year-olds; (b) 5-year-olds; (c) Adults.Note: *y*-axis indicates the mean proportion of 'yes' responses.

the specific quantifier ('some of these Xs'), responses to 25%, 75% and 100% were all higher than responses to 0% (*p*s <.001). The non-zero levels were all high, but the 75% level was higher than either the 25% level (p = .053) or the 100% level (p = .025). The latter result may reflect a scalar implicature effect among some adults. Thus, the signature for adult interpretation of 'some' is two-fold: low endorsement of 0% and high (and relatively equal) endorsement of frequency levels above 0%.

As noted previously, children show fairly similar patterns to adults with respect to generics. For quantifiers, however, there are striking developmental differences. For 3-year-olds, general quantifier scores are lower at 0% and 25% levels than at 75% and 100% levels (0% < 75% and 100%, *p*s < .001; 25% < 75% and 100%; *p*s range from .078 to .092). For general quantifiers, there are no differences between 0% and 25%, or between 75% and 100%, at age 3. For 3-year-olds with specific quantifiers and for 5-year-olds with both general and specific quantifiers, all frequency levels differ from one another, *p*s ranging from .078 to < .001, with the exception of 75% and 100%, which are equal to one another. Thus, children show a pattern in which the quantifier 'some' yields differentiation between 25% and 75% frequency levels – a pattern that is similar to that found with generics.

Another way to examine the data is to focus on condition comparisons, within each age group and frequency level. For adults, the primary differences were between generics and quantifiers: generics yielded lower 'yes' responses than both specific quantifiers and general quantifiers at the 25% frequency level (*p*s < .001), lower than the specific quantifier at the 75% frequency level (p = .01), and higher than the general quantifier at the 100% frequency level (p <.02). Thus, at the 25% and 75% levels, the results reflect the contrasting response patterns mentioned earlier: stepwise increases with frequency levels for generics, compared to broad and relatively equal endorsement across non-zero frequency levels for 'some'. The contrast at the 100% frequency level likely reflects a scalar implicature effect (with some adults contrasting 'some' with 'all' and thus showing less endorsement of the quantifier at the 100% level). The only other significant condition effect for adults was at the 75% frequency level, where the specific quantifier ('some of these Xs') yielded significantly greater agreement than the general quantifier ('some Xs'), p = .04, although in both cases, agreement was extremely high (100% and 87%, respectively).

Five-year-olds' patterns were quite similar to those of adults. At this age group, generics and quantifiers were clearly differentiated: at the 25% frequency level, generics yielded lower 'yes' responses than both specific quantifiers and general quantifiers (*p*s < .01), and at the 75% frequency level, generics yielded lower 'yes' responses than the general quantifier (p =.06). In contrast, 3-year-olds showed no condition differences whatsoever at the 25%, 75% and 100% levels. The only condition effects at age 3 involved the 0% level, in which the general quantifier ('some Xs') was higher than either the generic ('Xs') or the specific quantifier ('some of these Xs'), *p*s < .01. Because none of the other age groups shows this effect, it may simply reflect confusion on the part of 3-year-olds regarding the quantifier.

Response patterns

Once again, participants' responses were coded as showing the response patterns of 'all', generic and other. Additionally, given our interest in the quantifier 'some' in this condition, the generic response patterns were subdivided into two types: those consistent with an interpretation of 'some' (if a participant answered 'yes' on every trial at the 25%, 75% and 100% frequency levels), and all other generic patterns. The data are presented in Table 3. Because our primary interest here is in the 'some' and non-'some' generic response patterns, for the statistical analyses reported below, the 'all' and

Table 3. SOME condition, response pattern data (% of participants showing each response pattern, as a function of age group and condition).

Age group	Condition	'All' (%)	Generic		Other (%)
			'Some' generic (%)	Non-'some' generic (%)	
3 years	Specific 'some'	19	37	25	19
3 years	General 'some'	6	56	12	25
3 years	Generic	0	12	56	31
5 years	Specific 'some'	6	44	37	12
5 years	General 'some'	0	56	25	19
5 years	Generic	0	6	56	37
Adult	Specific 'some'	0	74	8	18
Adult	General 'some'	3	63	10	24
Adult	Generic	11	34	43	11

'other' response patterns were collapsed into a single response category.

As predicted, adults typically interpreted both the specific quantifier ('some of these Xs') and the general quantifier ('some Xs') in accord with the logical interpretation of 'some' (endorsed fully at 25%, 75% and 100% frequency levels). Generics ('Xs') were also interpreted this way about one-third of the time, but more often showed the classic generic interpretation, in which increases in endorsement were monotonic with frequency level. For adults, response pattern interacted with condition, χ^2 (df = 4) = 22, $p < .001$. Five-year-olds also demonstrated a significant interaction between response pattern and condition, Fisher's exact test, $p < .05$. They showed similar patterns to the adults, with the modal response being the 'some' response pattern for both the specific quantifier and the general quantifier, and the generic response pattern when presented with generics. However, when deviating from the 'some' pattern in the quantifier conditions, the most common pattern was the generic response pattern. Finally, 3-year-olds showed an interaction between response pattern and condition, Fisher's exact test, $p = .051$. In every wording condition, the modal response pattern was generic, when combining the 'some' generic and non-'some' generic patterns. Thus, the response patterns confirm the results of the mean 'yes' responses, namely, a tendency to default to generic interpretations when interpreting quantifiers, especially when the quantifiers refer generally to the category.

Discussion

The question of how generic statements compare to quantifiers in their meaning and interpretation is one that has received attention in recent years but little direct test. From the standpoint of descriptive simplicity, quantifiers should be easier to acquire, as they can be expressed with a simple and straightforward rule. However, from the theoretical position that generics are a default mode of generalisation, we would predict that young children would at first treat quantifiers as if they were generic in meaning, only gradually differentiating the two.

Furthermore, if children have a default tendency to revert to generics when considering generalisations about kinds, they may interpret general quantifiers (e.g. 'all dogs') differently than specific quantifiers (e.g. 'all of these dogs'; see also Hanlon, 1987, 1988). Most prior research examining quantifiers has focused exclusively on specific quantifiers, i.e. quantifiers that refer to small, often countable sets. An important novel feature of this experiment is that we compared two kinds of quantifiers: bare quantifiers that apply to abstract kinds (e.g. 'all dassies', 'some wugs') as well as specific quantifiers that refer to particular subsets (e.g. 'all of these dassies', 'some of these wugs'). The latter comparison is particularly important for allowing us to determine the source of errors and to separate out the extent to which children's difficulty reflects the semantics of the quantifiers themselves (some, all) versus difficulty applying quantifiers to abstract sets.

To address these questions, the present experiment provides the first in-depth, controlled examination of the interpretation of generics compared to both general and specific quantifiers, at different points in development. We provided participants with explicit frequency information regarding properties of novel categories to chart when 'some', 'all' and generics are deemed appropriate. This approach allowed us to control for participants' knowledge regarding the distributions of features, thus ensuring that developmental changes could not be attributed to differences in prior knowledge or differences in the ability to call counterexamples to mind.

The data reveal three main findings. First, using these more sensitive testing methods, we see that even 3-year-olds can distinguish generics from quantifiers. Prior work had found that such understanding did not emerge until

4 years of age. Second, when children do make errors, they tend to be in the direction of treating quantifiers like generics. For example, 3-year-olds do not differentiate generics from the quantifier 'some' at the 25% level, in contrast to 5-year-olds and adults, who are much more likely to endorse 'some' than generic at this level. Similarly, when interpreting the quantifier 'all', both 3- and 5-year-olds differentiated among levels below 100% – which is a generic pattern, not the adult universal quantifier pattern. This is not just due to errors or deviations from the adult pattern. As discussed previously and illustrated in Table 1, generic response patterns were much less likely than all other response patterns, based on chance alone.

Third, for 'all', children differentiated specific versus general quantifiers, with greater accuracy on specific than general. Both 3- and 5-year-olds showed a greater tendency to respond generically when given the general quantifier (e.g. 'all wugs') as compared to the specific quantifier (e.g. 'all of these wugs').

We have argued thus far that the differences obtained between general and specific quantifiers are due to children defaulting to a generic interpretation more often when considering an abstract set than when considering a small, countable set. However, one possible alternative interpretation of these results is that they reflect a rational judgement. Specifically, evaluating the general quantifier involves an extra cognitive step, namely, determining how the sample represents the larger category (because the specific quantifier refers to the sample itself ['all of these lans'], whereas the general quantifier refers to the larger set ['all lans'] of which the sample is just a small subset). From a logical perspective, judgements for the sample vs. the entire set should differ in just a limited number of cases. For 'all', these differ only in the 100% case (i.e. there might be some non-striped lans that simply are not in the sample, thus legitimising a response of 'no'). In contrast, for 'some', these differ in the 0% case (i.e. there might be some striped lans that simply are not in the sample, thus legitimising a response of 'yes'). Additionally, the conditions would differ for 'some' in the 100% case, for those who interpret 'some' as contrasting with 'all' (i.e. there might be some non-striped lans that simply are not in the sample, thus legitimising a response of 'yes').

For adults, the differences between general and specific quantifiers (i.e. 'all' vs. 'all of these') are exclusively of this rational sort, reflecting knowledge of imperfect sampling. Five-year-olds also show this rational distinction. However, both 3- and 5-year-olds also demonstrate a distinction at the 75% level, which is not predicted by rational inferences regarding sampling. Thus, the differences obtained between general and specific quantifiers for children reflect a stronger tendency to default to the generic in the former case.

The results reported here provide further evidence that young children have a tendency to interpret quantifiers as generic, thus supporting the generic-as-default hypothesis. In future research, it will be important to determine whether the tendency to interpret quantifiers as generic can be manipulated (either enhanced or suppressed) by priming or contextual cues. For example, in the present study, we included a simple warm-up task designed to ease children into the main task by providing a few simple yes/no questions to which they already knew the answers. This warm-up focused on the labels of familiar objects. Perhaps because this task involved endorsing or rejecting object labels, it may have encouraged a focus on kinds more generally in these young children. It would be interesting to know, in future research, whether children would interpret quantifiers in a more adult-like manner if the warm-up task were to involve a numerical task instead (e.g. counting).

The generic-as-default hypothesis, if correct, has several important consequences for our understanding of human cognition. A range of evidence suggests that generic generalisations, unlike quantified generalisations, are sensitive to rich semantic and causal factors – not just to the statistical prevalence of the property among members of the kind (e.g. Brandone et al., 2012; Cimpian, Brandone, & Gelman, 2010b; Cimpian et al., 2010a; Khemlani et al., 2012; Leslie, 2008, 2012; Prasada et al., 2013). Thus, if generic generalisations are indeed a fundamental, default mode of generalising, then this suggests that the cognitive system is profoundly attuned to such factors, which go far beyond unstructured statistical distributions. In this way, the generic-as-default hypothesis fits most naturally with theory-based accounts of cognition (e.g. Carey, 2009; Gelman, 2003; Gopnik & Meltzoff, 1997), which propose that our knowledge of kinds and categories involves the representation of rich, causal and explanatory structures.

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Notes

1. There are also two notable respects in which children systematically differ from adults, in their interpretation of specific quantifiers. The first concerns the extent to which

children are sensitive to *scalar implicatures* (Grice, 1975) – for example, the extent to which they take 'some' to be incompatible with 'all'. Adults are more likely than children to think that, e.g. 'some of these coins are in the box' is false when each and every coin is in the box (Noveck, 2001). Second, young children's interpretations of specific universal quantifiers are susceptible to *spreading*. That is, if children are shown a picture in which, e.g. five rabbits each have a carrot, but in which there are two additional carrots with no attendant rabbit, they exhibit a tendency to deny that 'every rabbit has a carrot' (Drozd, 2005; Roeper, Pearson, & Grace, 2011). (Even though 'every rabbit has a carrot' does not contain an explicit restriction to *these rabbits*, and so may appear syntactically like a general quantifier, the noun phrase 'every rabbit' (unlike 'all rabbits') is interpreted as applying only to the contextually salient set of rabbits (e.g. Stanley & Szabó, 2000), and therefore functions semantically like a specific quantifier.).
2. One unexpected result is that many children had difficulty with the 0% frequency level, in which cards depicted no instances with the property. When the property was absent, many children reinterpreted other features as if they were the targeted feature (e.g. saying that a yellow colour looked a little bit green, or that an animal with short hair had big hair). Responses were much more consistent when the target feature was present in at least one instance on the card (i.e. all other response levels).

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