Using bounds set by modals to investigate the status of partial objects and count nouns

Previous work has revealed a surprising pattern: faced with a display such as Figure 1 and asked to 'count the forks', children, unlike adults, treat discrete fork-parts and whole forks on par, counting 6 (Shipley & Shepperson 1990, Brooks et al. 2011, Srinivasan et al. 2013, a.o). In recent work, Syrett & Aravind (2022) argue that children's treatment of partial objects is consistent with the underlying semantics for count nouns, which are **vague** and **context-sensitive.** Where children and adults diverge is in their ability to restrict a count noun's application in a given context. Supporting this hypothesis, they showed that preschoolers are less likely to allow a count noun like 'fork' to pick out a partial form if the speaker specifies a goal of using the fork for eating. However, Syrett & Aravind employed tasks that probed categorization – i.e., whether or not a count noun like 'fork' can apply to an object – and did not highlight counting or quantification. Thus, it remains an open question whether contextual factors can influence how children and adults resolve the ambiguous status of partial objects in a numerically-oriented task. The current research seeks to fill this gap.

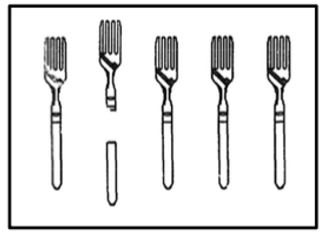

Figure 1: Display of forks from Shipley & Shepperson (1990).

Background and hypotheses: We manipulated contextual requirements with a goal-oriented introduction phase, followed by a modal statement, as in (1)-(2).

(1) To get a star, you have to have three balls. *(universal modal; lower bound, 'at least')*

(2) To get a star, you're allowed to have three balls. *(existential modal; upper bound, 'at most')*

The difference in these modals lies in how they trigger varying bounding conditions for numerals in their scope. Universal modals induce lower bound interpretation of numerals: the *minimum* number of balls required to meet the requirement is 3, and surpassing the lower bound is acceptable. In contrast, existential modals induce an upper bound: the *maximum* number of balls allowed is 3, though deviation below this upper limit is permissible. We manipulated whether the set of objects on display counting towards these limits included a partial object. See Figure 2. The key question is whether the partial object is treated as meeting or exceeding the limit. If so, given (1), the lower limit is met; otherwise, it is not.

Figure 2: Sample of *have to* stimuli with 2.5 objects

Experiment: Adults (N=73) were randomly assigned to two between-subject modal groups (*have to* or *allowed to*). Children (N=21/30 run, mean age 4;10) participated in the *have to* variant of the study. (Data collection with *allowed to* is ongoing.) Both groups were shown characters possessing a combination of whole and partial objects alongside sentences such as those in (1) or (2), and asked, "Is what they have okay?" The child task was set up as a counting game among aliens (see Figure 2), in which they were asked to assign a calculator ("no") or star ("yes") for each trial. Otherwise, the design was identical to adults. Trial types (see Table 1) featured controls probing the availability of bounded readings, critical items with whole and partial objects, and a strictly whole object comparison set.

Trial Type	Number of Objects
Control	2 whole
	4 whole
Critical	2 whole, 1 partial
	3 whole, 1 partial
	3 whole

Table 1: Experiment trial types

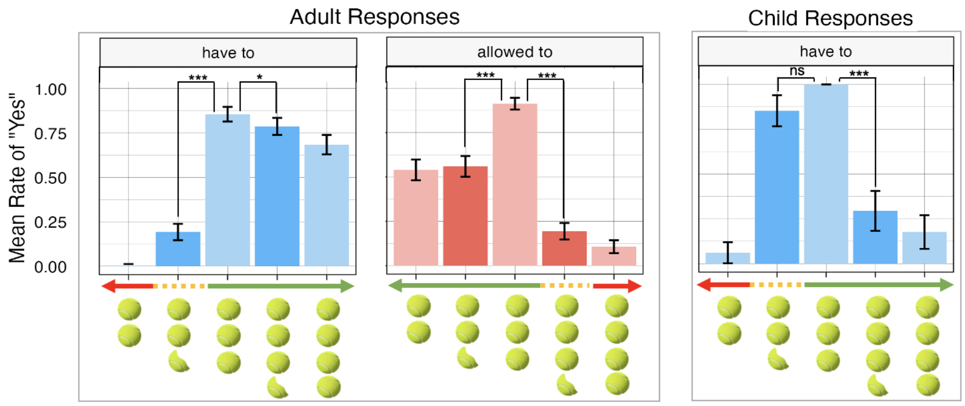

Figure 3: Mean "Yes" responses (+/-1 SEM) by modal and trial type for each population

Results: Figure 3. Adults patterned as expected, accepting sets of 3 whole objects and greater in the *have to* condition (reflecting an 'at least' reading), and accepting sets of 3 whole objects and fewer in the *allowed to* condition. A partial object *did not* help meet the lower limit for *have to* (2.5 vs 3: β=-6.804, p<.001), yet incurred a penalty for exceeding the upper limit for *allowed to* (3 v. 3.5: β=-4.94, p<.001). Taken together, adults' behavior on partial-object trials suggests that they considered these objects as affecting the numerosity of the counted set, but in a more granular way: *for adults, a partial ball increases the size of the set by a fraction less than 1***.** Children in the *have to* condition differed from adults in two ways. They largely did not accept 2-whole or 4-whole trials, reflecting an exact numerical preference. Consistent with this preference, they were also significantly less likely to accept 3-whole-1-partial scenarios than 3-whole ones (β=-4.37, p<0.01). Crucially, they did not distinguish between 2-whole-1-partial and 3-whole scenarios (β=-1.74, p=.11). Thus, a partial object and a whole object have comparable status in helping to meet the required lower bound of the modal: *for children, a partial ball increases the size of the set by 1***.**

Discussion: Consistent with previous work, children treated partial objects on par with wholes when counting instances of a count noun. This behavior is reinforced by their strong preference for 'exact' interpretation of numerals, well-attested in earlier work (e.g., Papafragou & Musolino 2003; Musolino 2004). Crucially, for children, partial objects help satisfy this exact interpretation. Adults opt for an 'at least' reading with 'have to' and an 'at most' reading with 'allowed to', but in neither case did they flexibly shift their criteria for a noun's application to let partial objects meet limits set by modals. Instead, they employed a more fine-grained counting system, quantifying a partial object as a fractional portion. Thus, in a numerically-oriented task, the child-adult difference is again reinforced. We consider two possibilities consistent with these results. One ties the child-adult distinction to differences in the measurement scales accessible to the two populations: unlike adults, children are unable to count and measure in fractional quantities. Another possibility is that differences in recruiting contextual information underlies the child-adult difference in numerical tasks as well, more in line with Syrett and Aravind's hypothesis. Contexts where object *quantity* matters, rather than object *kind*, lead adults to opt for a more granular measurement scale; children, despite in principle having access to such scales, fail to do so.

Selected References: Brooks, N. et al. (2011). Piecing together numerical language. *Dev. Science;* Shipley, E. & Shepperson, B. (1990). Countable entities: Developmental changes. *Cognition*; Srinivasan, M. et al. (2013). Sortal concepts and pragmatic inference in children's early quantification of objects; *Cognitive Psychology;* Syrett, K. & Aravind, A. (2022). Context sensitivity and the semantics of count nouns. *Journal of Child Language.*