Conservative meanings with only one set: evidence from verification

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All quantifiers have conservative meanings. Using a sentence verification task to probe which set(s) participants represent during evaluation, we test the predictions of three explanations for this semantic universal: (i) a stipulation on which relations make good determiner meanings, (ii) a consequence of the interpretation of quantifier raising in the compositional semantics, or (iii) a property of the logical structure of quantifier meanings. Our results support (iii).

A quantificational relation is conservative when its first argument can be intersected with its second argument without a change in truth conditions, as in (1) (e.g., (2a) & (2b)) [1,2]. In other words, the truth of a conservative quantifier depends on nothing outside of the extension of its first argument. Languages thus have no determiners expressing relations like (4) – the inverse of *every* in (3) – or like (5), which is true when both arguments are coextensional. Moreover, children do not seem to consider such non-conservative meanings when learning a novel quantifier [3], suggesting that conservativity reflects a deep fact about the language faculty.

On the "lexical" approach of (i), quantifiers express relations between two sets, as in (6), but only conservative relations get lexicalized [2]. On the "interface" approach of (ii), quantificational sentences have meanings like (7), which will be non-trivial and learnable only when *Q* is conservative [4]. On the "logical" approach of (iii), quantifiers express one-place first-order relations relativized to their first argument, as in (8), and conservativity logically follows [5-6].

To pit these views against each other, we asked whether sentences like (2a) are represented by speakers in terms of a relation between two independent sets (e.g., *the big circles are a subset of the blue things*), as in (6-7), or in terms of attributing properties to the members of a single set (e.g., *relativized to the set of big circles, each thing is blue*), as in (8). Participants saw displays and were asked to judge the truth of *every*-statements (Fig.A). After responding, they were asked how many circles of a particular type there were (e.g., *big*, *blue*, or *big blue*). To determine the accuracy of their estimates, responses were fit with the standard psychophysical model of cardinality estimation [7]. The resulting parameter was compared against responses to baseline questions (e.g., *how many big circles are there?*), which represent the best possible performance the visual system will afford. We expect participants to represent sets implicated by the statement's meaning, and thus to have good estimates of their cardinality [e.g., 8].

Consistent with the "logical" view, we find that when asked about the cardinality of the set denoted by the first argument (e.g., big circles), participants (n=48) performed as well as baseline (χ^2=0.02, p=.88), meaning they knew the cardinality as well as their visual systems would allow. But when asked about the set denoted by the second argument (e.g., blue circles) or by the intersection of both arguments (e.g., big blue circles), they performed significantly worse than baseline (second arg: χ^2=13.61, p<.001; intersection: χ^2=26.61, p<.001; Fig.B).

In a second experiment, participants (n=54) had the option to opt out of the "how many?" questions with an "I don't know" button. We observe two patterns: participants are more likely than baseline to opt out when asked about the second argument (t_{49}=2.94, p<.005) or about the intersection (t_{49}=3.09, p<.005), but not when asked about the first argument (t_{49}=0.19, p=.85; Fig.D); and when performance is measured on trials they did not opt out of, the pattern matches exp1 (first: χ^2=2.59, p=.11; second: χ^2=40.02, p<.001; intersection: χ^2=31.46, p<.001; Fig.E).

In a third experiment, participants (n=48) were shown similar images but asked to verify statements with the focus-operator *only* (e.g., *only big circles are blue*). Participants performed worse than baseline on all questions (first arg: χ^2=10.51, p<.005; second arg: χ^2=62.34, p<.001; intersection: χ^2=15.05, p<.005; Fig.C). This excludes the possibility that participants represent the set described by the first NP they encounter regardless of the sentence's meaning.

These results suggest that *every*'s meaning implicates only a single set, as in (8). This supports an explanation of conservativity rooted in the logical structure of quantifiers.

Numbered examples

(1) $Q(A, B) \leftrightarrow Q(A, A \cap B)$

(2) a. Every big circle is blue
b. Every big circle is a big circle and is blue

(3) $\text{Every}(A, B) \equiv A \subseteq B$

(4) $\text{Yreve}(A, B) \equiv A \supseteq B$

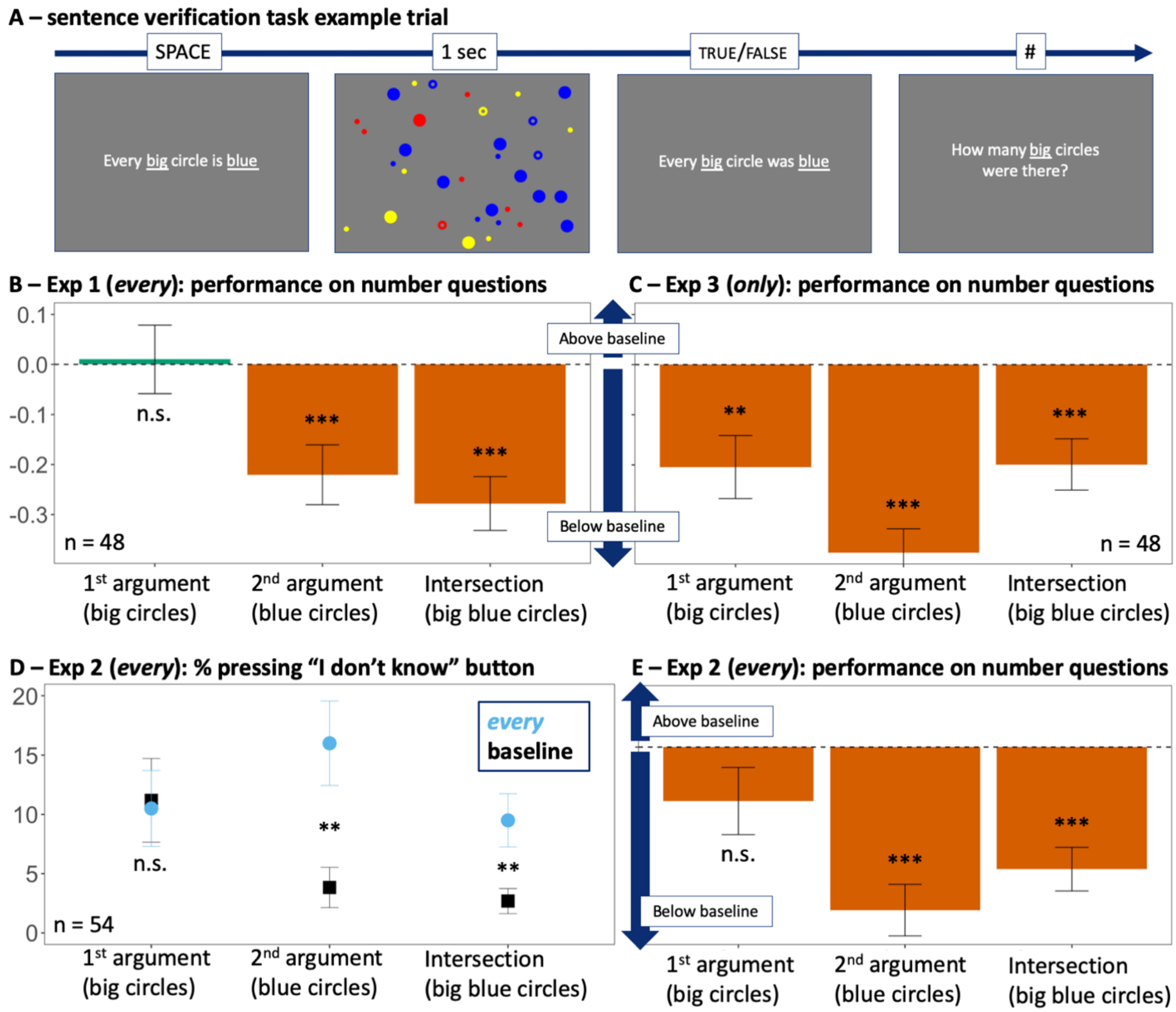
(5) $\text{Equi}(A, B) \equiv A = B$

(6) $Q(A, B)$

(7) $Q(A, A \cap B)$

(8) $Q/A(B)$

Figures



References

[1] Barwise & Cooper (1981) *Generalized quantifiers and natural language* [2] Keenan & Stavi (1986) *A semantic characterization of natural language determiners* [3] Hunter & Lidz (2012) *Conservativity and learnability of determiners* [4] Romoli (2015) *A structural account of conservativity* [5] Pietroski (2018) *Conjoining meanings* [6] Westerståhl (2019) *Generalized quantifiers* [7] Odic et al. (2016) *PsiMLE: A maximum-likelihood estimation approach to estimating psychophysical scaling and variability more reliably, efficiently, and flexibly* [8] Lidz et al. (2011) *Interface transparency and the psychosemantics of most*