

The reaction times associated with processing “few” and “many” are more similar to proportional quantifiers than to degree adjectives (Special session)

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“Few”/“many” have a split personality: they are sometimes analyzed as quantifiers and sometimes as adjectives (Hackl, 2009; among others). Like other quantifiers, they denote a function from sets to sets of sets (semantic type $\langle et, \langle et, t \rangle \rangle$). However, unlike other quantifiers, they can appear in predicate position, similar to adjectives (*the students are many*/ **more than half/ tall*). In addition, like antonymous pairs of degree adjectives, they are grouped into pairs of **negative/positive** antonyms, which differ on whether their degree is denoted to be **below** or **above** some contextual standard: “few”/“many”, like the adjective “short”/“tall”, denotes that the degree argument is **below/above** some contextual standard (of cardinality or height). However, unlike antonymous degree adjectives but like other pairs of quantifiers, “few”/“many” have an opposite monotonicity pattern: the negative “few” is downward entailing (DE), i.e. supports inferences from sets to subsets, thus reversing the entailment direction of its upward entailing (UE) counterpart “many” (given a fixed context):

(1) **Many** students took semantics. \Rightarrow **Many** students took linguistics.

(2) **Few** students took linguistics. \Rightarrow **Few** students took semantics.

As opposed to the negative adjective “short”, which does not reverse the direction of entailment of its positive counterpart “tall”:

(3) **Tall** students took semantics. \Rightarrow **Tall** students took linguistics.

(4) **Short** students took semantics. \Rightarrow **Short** students took linguistics.

So on the one hand, “few”/“many” are on a par with degree adjectives, but on the other hand they are on a par with quantifiers. Furthermore, data from language processing has shown that “few”/“many” is processed similarly to “less than”/“more than”, as the DE quantifiers are more difficult to process than UE quantifiers, manifested in longer reaction times (RTs) (Deschamps, Agmon, Loewenstein, & Grodzinsky, 2015). What is the cognitive source of this contrast? Two hypotheses will be tested against each other – the Polarity Hypothesis and the Monotonicity Hypothesis. According to the Polarity Hypothesis, polarity, whether in negative ording to Acc. load quantifiers or in adjectives, is manifested in the same processing affects hesis, on the other hand, downward monotonicitythe Monotonicity Hypot should be larger than “few”/“many” hence the polarity contrast in ,load processing .grouping it with proportional quantifiers, the polarity contrast in adjectives

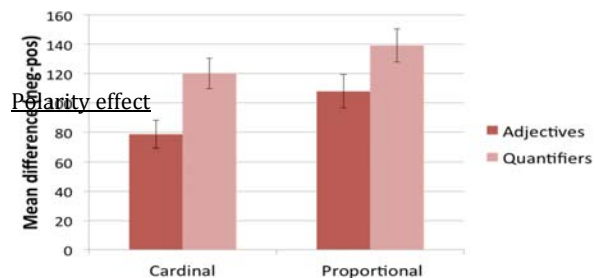
RT experiment: Subjects heard sentences in English of the structure “X of the circles are blue/yellow”, where X is an expression of quantity (e.g. X is “*more than half*” or “*a small number*”). Subjects had to decide as fast and as accurately as they could whether the sentence correctly described a picture that immediately followed it. RTs were measures, and polarity effect of negative expressions was calculated as the difference

between RT of negative expressions and RT of positive expressions. The expressions of quantity X were categorized in a 3-factor design: **Type (quantifier/adjective)**, **Polarity (positive/negative)** and **Standard of comparison (proportional/cardinal)**. We verified that the Negative Adjective sentences were not DE (for instance, they do not license NPIs, a hallmark of DE-ness: **a small number of students have ever taken semantics*). The following table summarizes the expressions of quantity used in this experiment:

			Polarity		
			Positive	Negative	
Standard	Proportional comparison	Type	Quantifier	<i>More than half</i>	<i>Less than half</i>
		Type	Adjective	<i>A high proportion</i>	<i>A low proportion</i>
Standard	Cardinal comparison	Type	Quantifier	<i>Many</i>	<i>Few</i>
		Type	Adjective	<i>A large number</i>	<i>A small number</i>

Predictions: (i) In accordance with previous results, we predict that RT to Negative would be longer than RT to Positive, namely a main effect of Polarity. (ii) If DE-ness of quantifiers is determinant in their processing, then we should find that the Quantifier condition has an overall larger polarity effect (=RT difference between negative and positive) than the Adjective condition, namely a statistical interaction of Type×Polarity. (iii) Given (ii) was found, if “few” patterns like degree adjectives, then we should find that the difference between the polarity effect of “few”/“many” and the polarity effect of “a small number”/“a large number” is not as large as the difference between the polarity effect of “less than half”/“more than half” and the polarity effect of “a low proportion”/“a high proportion”, namely a three-way interaction of Type×Polarity×Standard.

Figure. Each bar is the averaged difference in RT between the negative and the positive (negative – positive = polarity effect). For each condition of comparison (Cardinal/Proportional), the polarity effect for quantifiers is larger than the polarity effect for adjectives. Error bars represent one standard error of the mean.



Standard of Comparison

Results: (i) Replicating previous results, we found a main effect of Polarity ($p < 0.001$, $F(1,31) = 267.09$). (ii) As predicted, a significant interaction of Type×Polarity was found ($p < 0.001$, $F(1,31) = 22.72$). (iii) no significant interaction of Type×Polarity×Standard was found ($p = 0.44$, $F(1,32) = 0.6$). We replicated these results in Hebrew (Polarity: $p < 0.001$, $F(1,29) = 139.13$; Type×Polarity: $p < 0.001$, $F(1,29) = 25.47$; Type×Polarity×Standard: $p = 0.38$, $F(1,29) = 0.8$).

Conclusions: “Few”/“many” are processed like proportional quantifiers. Moreover, DE-ness is determinant in processing quantifiers, as it adds to RT more than the just the effect of being a negative antonym adds to RT.

fMRI experiment: Results from a currently ongoing fMRI study, designed similarly to the RT experiment described, will also be presented.

REFERENCES Deschamps, I., Agmon, G., Loewenstein, Y., & Grodzinsky, Y. (2015). The processing of polar quantifiers, and numerosity perception. *Cognition*, *143*, 115-128. Hackl, M. (2009). On the grammar and processing of proportional quantifiers: most versus more than half. *Natural Language Semantics*, *17*(1), 63–98.