The Analysis of *less*-Comparatives: Evidence from the Processing Cost of Downward Entailingness

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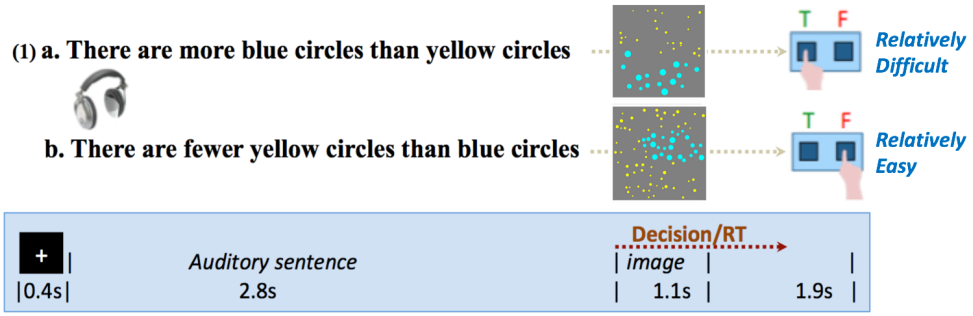
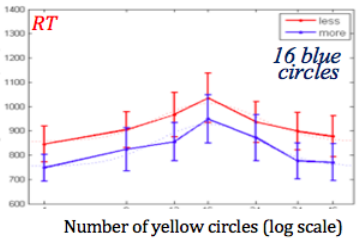
The landscape: it is widely accepted that the monotonicity of (proportional or degree) quantifiers has a processing signature – in tasks that time sentence verification against proportion-depicting images, Downward Entailing (DE) environments manifest significantly higher Reactions Times (RTs) than Upward Entailing (UE) ones (Deschamps, Agmon, Loewenstein & Grodzinsky, 2015; Geurts & van der Slik, 2005; Just & Carpenter, 1971): $\mathbf{\Delta RT=RT_{DE}-RT_{UE} >^{sig} 0}$. We call this a DE Cost (DEC) effect. We review 2 published tests, report the results of a 3rd one, and motivate a refined DEC, which helps to identify hidden DE-operators in *less*-comparatives, a topic of debate (Büring, 2007, Heim, 2006, Rullman, 1995).

Deschamps et al. (2015) also report the results of 2 speeded verification tests (n=22), in which matched auditory *phrasal comparatives* (containing *more/less* but no degree adjective) were coupled with images of blue and yellow circles (1), where blue/yellow proportion was a 7-valued parameter determining both truth-value (T/F), and DEC-independent task ***difficulty***:



Both tests found that $\mathbf{\Delta RT}(= RT_{(1b)} - RT_{(1a)}) >^{sig} \mathbf{0}$, across all 7 values of the proportion parameter (x-axis in (2)): 1. with a base of 16 blue circles (image 1a), [t(21)=6.647, p<.001]; 2. with a base of 24 blue circles (image 1b), [t(21)=8.014, p<0.001]. No monotonicity-by-proportion interaction was found – RT curves in (2) (blue=UE, red= DE) are parallel.

(2)



The RT puzzle: a DEC effect is not expected in (1): the monotonicity of comparative quantifiers is "mixed", their structure being "A-not-A" (Schwarzschild, 2008): *–er*, the comparative morpheme (part of *more/fewer*) is typically analyzed as an existential quantifier over degrees, whose first argument is UE, with a negation in the *than*-phrase, which makes its second argument DE. This type of analysis is corroborated by the reversed entailment pattern of the arguments:

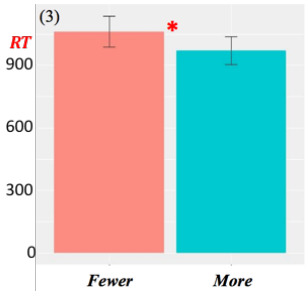
(3) a. More **cats** than snakes died ⇒ More **mammals** than snakes died ({**cats**}⊂{**mammals**})
b. More cats than **reptiles** died ⇒ More cats than **snakes** died ({**snakes**}⊂{**reptiles**})

The pattern in *less*-comparatives (realized as *fewer* in the absence of an adjective) is opposite:

(4) a. Fewer **mammals** than snakes live in deserts ⇒ Fewer **cats** than snakes live in deserts
b. Fewer cats than **snakes** live in big cities ⇒ Fewer cats than **reptiles** live in big cities

For DEC, (1a) and (1b) do not differ in that they both contain a DE environment (+ a UE environment). Assuming DEC, we expect $RT_{more} \approx RT_{less}$, or $\mathbf{\Delta RT \approx 0}$, contrary to fact.

Paths to a solution: this theory/data mismatch may be due to (***i***) experimental reasons, (***ii***) an incorrect definition of DEC, (***iii***) incorrect assumptions regarding comparative structure.



*(**i**) A possible experimental wrinkle and its fix*: All image stimuli in (1) are 2-colored (blue/yellow). In this context, the parsing of the matrix alone, "*there are more/fewer blue circles…*", will suffice for verification. If parsing stops there, then DEC should only be computed on the first part of the comparative, which is UE in *more*-comparatives, and DE in *less*-comparatives. ΔRT>0 *is* therefore expected, but then RT results would teach us little about structure, as parsing is incomplete. This potential wrinkle was removed in a new (Hebrew) experiment (n=22). It used the same sentences (1), but forced complete parsing of the comparative, by adding an image (and response) type – Infelicitous – to True and False (e.g., an image with blue and *red* circles for (1a); with yellow and *red* circles for (1b)). The correct response was now discoverable only at the end of the sentence. The effect persisted (3) under this tighter test paradigm [F(1,21)=97.236, p<.000...]. The RT puzzle remains.

*(**ii**) Refining DEC*: parsing mixed monotonicity may mean that each DE operator contributes to processing cost. We thus let DEC be determined by the number of DE-operators n_{DE} in a given LF: $\boldsymbol{n_{DE}(LF_2) > n_{DE}(LF_1) \Rightarrow RT(LF_2) >^{sig} RT(LF_1)}$. Next, we show how this refinement makes our paradigm theoretically informative: counting DE operators ($\boldsymbol{n_{DE}}$) and measuring their effect on response time can now be used as a tool to discover potentially hidden DE operators (e.g., where 2*n**DE =*n*UE) through RT patterns.

*(**iii**) The linguistic puzzle and debate*: there is an apparent mismatch between entailment and NPI licensing patterns (exemplified here with phrasal comparatives): ***I.*** *more/less* comparatives have the entailment pattern in (3)-(4). ***II.*** this pattern is expected to correlate with the pattern of NPI-licensing. ***III.*** the observed correlation is only partial: as expected, *more* licenses an NPI just in the *than*-phrase (5); but contrary to expectation, *less* licenses NPIs in both of its arguments (6), and in particular, its UE argument (6b) (Seuren, 1973):

(5) a. #This city has more cats that *ever* meow than snakes
   b. This city has more cats than snakes that *ever* bite

(6) a. This city has fewer cats that *ever* meow than snakes
   b. This city has fewer cats than snakes that *ever* bite

Whence this mere partial correlation between NPI-licensing and entailment patterns? The non-decompositional view (Rullman, 1995): Under certain conditions (too involved for an abstract), NPIs are licensed not only by DE quantifiers, but also, by non-DE, negative adjectives. The unexpected NPI licensing in the *than*-phrase of (6b) is thus independent of the DE-ness of *fewer*. The decompositional view (Büring, 2007; Heim, 2006): the effects are derived through an LF with two DE pieces, that together form a UE(=DE+DE) pattern in the *than*-phrase. One DE piece comes from *few*, a quantifier over degrees; the other, from the "comparative negation". Each DE piece licenses an NPI in its scope, and the pattern follows.

Our main claims: (i) all experimental results are accounted for with a refined DEC, and only when the decompositional analysis is assumed; (ii) Juxtaposing a correct DEC to structural assumptions becomes a powerful tool for linguistic discovery. We now show that.

Predictions with a refined DEC: the refinement harbors clues on the decomposition debate. The non-decompositional view assumes that LFs of both *more*- and *less*-comparatives contain 1 DE-quantifier - *–er*; when coupled with the refined DEC, it (falsely) predicts that $RT_{more} \approx RT_{fewer}$. The decompositional view, by contrast, takes *more*-comparatives to contain 1 DE operator (*–er*), and *less*-comparatives to contain 2 (*–er, little*). With DEC, it predicts $\boldsymbol{\Delta RT} = RT_{fewer} - RT_{more} >^{sig} \boldsymbol{0}$, as found. The decompositional view is experimentally supported.

Conclusions: this robust DEC effect in phrasal comparatives (i) sharpens our view of the way the processing cost of DE-ness should be defined; (ii) supports a decompositional view of *less*-comparatives, and (iii) underscores the value of experimental work in discovering hidden

structure. The talk will also discuss monotonicity *X* truth-value interactions, further behavioral predictions, as well as possible underlying reasons for the DEC effect, and its neural reflexes.

References: Büring, Daniel (2007). *CLS*. Deschamps, Isabelle et al. (2015). *Cognition.* Heim, Irene (2006). *SALT* 16. Geurts, Bart & Frans van der Slik (2005). *Journal of Semantics*. Just, Marcel A., & Patricia A. Carpenter (1971). *Journal of Verbal Learning and Verbal Behavior*. Rullmann, Hotze (1995). Ph.D. thesis, UMass, Amherst. Schwarzschild, Roger (2008). *Language and Linguistics Compass*. Seuren, Pieter (1973). *Generative Grammar in Europe*.