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

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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): \(\Delta RT = RT_{DE} - RT_{UE} \geq \text{sig} \ 0\). 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:

\[
(1) \begin{align*}
\text{a. There are more blue circles than yellow circles} & \quad \text{T} \\
\text{b. There are fewer yellow circles than blue circles} & \quad \text{F}
\end{align*}
\]

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

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:

\[\begin{align*}
\text{a. More cats than snakes died} & \Rightarrow \text{More mammals than snakes died} & \{\text{cats}\} \subset \{\text{mammals}\} \\
\text{b. More cats than reptiles died} & \Rightarrow \text{More cats than snakes died} & \{\text{snakes}\} \subset \{\text{reptiles}\}
\end{align*}\]

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

\[\begin{align*}
\text{a. Fewer mammals than snakes live in deserts} & \Rightarrow \text{Fewer cats than snakes died} & \{\text{cats}\} \subset \{\text{mammals}\} \\
\text{b. Fewer cats than reptiles live in big cities} & \Rightarrow \text{Fewer cats than reptiles live in big cities}
\end{align*}\]

For DEC, \((1a)\) and \((1b)\) do not differ in that they both contain a DE environment \((+ \text{ a UE environment})\). Assuming DEC, we expect \(RT_{\text{more}} \approx RT_{\text{less}}\), or \(\Delta RT \approx 0\), 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. \( \Delta RT \) 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: \( n_{DE}(LF_2) > n_{DE}(LF_1) \Rightarrow RT(LF_2) >^* RT(LF_1) \). Next, we show how this refinement makes our paradigm theoretically informative: counting DE operators \( (n_{DE}) \) and measuring their effect on response time can now be used as a tool to discover potentially hidden DE operators (e.g., where \( 2n*DE =nUE) \) 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? 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 \( \Delta RT=RT_{fewer} - RT_{more} \approx 0 \), 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
The talk will also discuss monotonicity truth-value interactions, further behavioral predictions, as well as possible underlying reasons for the DEC effect, and its neural reflexes.