

QUD effects on Epistemic Containment Principle: An experimental study

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Introduction The Epistemic Containment Principle (ECP) is a widely recognized descriptive and theoretical claim according to which epistemic modals must take wider scope than strong quantifiers such as *every* or *most* (Von Stechow & Iatridou, 2003). Although fairly robust in its realization, a few systemic classes of counterexamples to ECP have been noted. Previous work that aims to account for these has focused on the subjective vs. objective distinction in epistemic modals (the former observes ECP, the latter violates it; Anand & Hacquard 2008, Tancredi 2007), and quantifier type (*every* observes ECP, *each* violates it; Tancredi 2007). In this paper, we introduce a new factor that also seems to systematically influence the ECP. We argue that the nature of evidential source associated with the epistemic modal blocks or facilitates ECP violations, by creating biases towards different Question Under Discussions (QUDs) that highlight one scopal interpretation over the other. To support this claim, we present an experimental study which not only corroborates the existence of QUD effects on ECP but also provides strong empirical evidence to the claim that ECP is a gradient phenomenon that arises as a consequence of systematic biases in different factors.

Motivation: QUDs and ECP Consider a situation in which Ron is at the zoo, where he hears from the keeper that 2 tigers and 1 panther, shown in plaque (i), are in the cage. Suppose that Ron utters one of (1a–e), upon seeing the cage in (ii). In this situation, we have an intuition that (1b) allows for ECP violating readings in which the quantifier *every* scopes over the epistemic modal *might*, and is thus interpreted as true (whereas the reading in which *might* scopes over *every* is false, as Ron knows there are only 2 tigers). In comparison, we have the intuition that (1a) and (1c) sound false because the ECP is more strictly enforced in these cases, and *might* has to scope over *every*.

- (1) a. ECP: Every bush might have a tiger. (MIGHT > EVERY (F)); ?EVERY > MIGHT (T))
 b. ADV(V): Based on what I see, every bush might have a tiger. (E > M (T))
 c. ADV(O): Based on what the keeper said, every bush might have a tiger. (M > E (F))
 d. EACH: Each bush might have a tiger. (EACH > MIGHT (T); ?MIGHT > EACH (F))
 e. NO-M: Every bush has a tiger. (F) f. TRUE: (sees 3 tigers in (i); then (ii)+(1a)); (T)

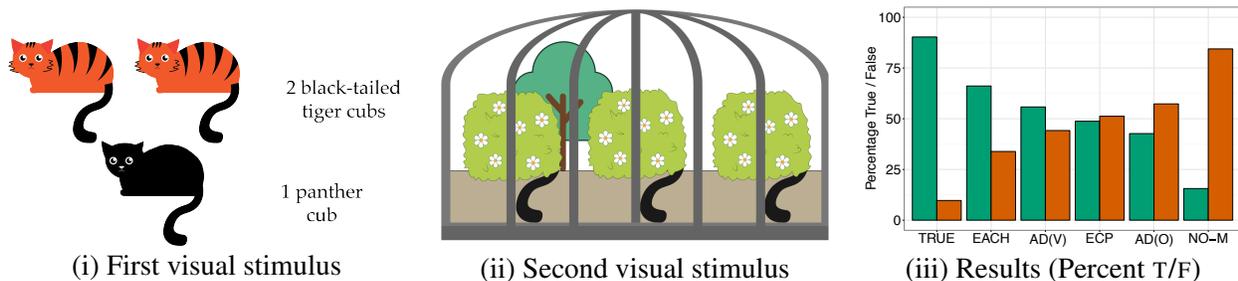


Figure 1: Sample pictures (a,b) and results (c: True responses: ■ False responses: ■)

In the scenario above, the crucial factor that influences the availability of ‘every > might’ readings seems to be whether the nature of the evidence highlighted by the adverbial phrase is biased towards providing an answer interpreted with ECP-observing scopal ordering (2a), or towards an answer interpreted with ECP-violating scopal ordering (2b). For instance, the speaker would have reason to highlight the information in (i), i.e. the number of tigers vs. panthers in the cage (picked out by the adverbial phrase ‘based on what the keeper said’) only if the QUD was of the type shown

in (2a). Likewise, the speaker would have reason to highlight the information in (ii), i.e. the equal visual likelihood of each bush hosting a tiger (picked out by the adverbial phrase ‘based on what I see’) only if the QUD was of the type shown in (2b). As the relevant answers to the two QUDs (as defined by Roberts (1996), a.o.) involve different scopal orderings, the QUDs evoked by the two types of evidence seem to nudge the scopal interpretations in different directions.

- (2) a. QUD: How many bushes are hiding the tigers?
Based on what the zoo keeper said, every bush might have a tiger. ($M \succ E$ (F))
- b. QUD: Which bush has the possibility of hiding a tiger?
Based on what I see, every bush might have a tiger. ($E \succ M$ (T))

Experiment & Analysis In order to test this hypothesis, as well as to test for other factors that may affect the ECP, we conducted an experiment in which we requested people’s judgments on a range of modalized/non-modalized sentences with quantifiers (6 conditions; examples in (1a–e) plus a TRUE condition (1f) where (i) included three tigers), embedded in 4 distinct situations with visual stimuli (like the one in Fig. 1i,ii). Upon reading each situation, 640 Native English speakers were asked to judge if a given target sentence spoken by the speaker in the situation was true.

The results of the experiment are summarized in Fig. 1iii, in which the 6 conditions are plotted against percent T/F responses (y-axis). Fig. 1iii suggests that the basic ECP condition (without any adverbial phrases) actually elicited gradient responses, suggesting that *every* \succ *might* reading isn’t categorically pre-empted. This was further corroborated by participants’ optional free responses, which included comments such as ‘ambiguity of *every*; could mean each individual or all three’. However, an effect akin to the ECP does seem to exist to some degree: the ECP condition consistently elicited significantly fewer True responses than the TRUE condition, which is unexpected if both scopal interpretations were equally available. The ECP condition also behaved significantly differently from the NO-M conditions and the EACH condition (corroborating the effect of quantifier type), resulting in the following %T order: TRUE > EACH > ECP > NO-M, across all situations.

Importantly, the results also corroborated the effect of the nature of the evidence (ECP-violating QUD bias vs. ECP-observing QUD bias), resulting in the following order: AD(V) > ECP > AD(O). In sum, evidence biased towards ECP-violating QUDs, i.e. AD(V), generated significantly more TRUE responses (i.e. ECP violations) than the baseline ECP condition, whereas evidence biased towards ECP-observing QUDs, i.e. AD(O), generated significantly more FALSE responses (i.e. ECP observations). The experimental results thus corroborate our main hypothesis that QUDs systematically affect the scopal interaction between epistemic modals and strong quantifiers. A series of mixed effects logistic regression models with T/F response as the dependent variable and relevant sets of conditions as independent variables further corroborated these results: the difference between all pairs for TRUE > EACH > ECP > NO-M were significant, and the difference between AD(V) and AD(O) was significant [$\beta = 0.51$, s.e. = 0.2, $z = 2.46$, $p < 0.05$].

There exists an alternative (albeit unlikely) explanation to the experimental results: participants (influenced by the evidential adverbials) could have posited ordering sources that are different from the given contexts (cf. Portner 2007), and thus responded true while observing the ECP. This unlikely scenario can be ruled out however, given participants’ free responses for the relevant cases (e.g., ‘it’s impossible for them *all* to have a tiger cub; *but* the possibility exists that each *might* have it’); True responses can thus be considered as genuine reflections of ECP-violating readings.

Conclusion & future work In light of these experimental findings, it seems worth examining whether ECP is an epiphenomenon that reflects a confluence of inherent biases in other more

fundamental factors (ECP observing QUDs, subjective modal interpretations, etc.). Future studies aim to further elucidate the connection between ECP and QUDs by conducting experiments in which different QUDs are directly provided in conjunction with the target sentences.

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