



QUD effects on Epistemic Containment Principle: An Experimental Study



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I. Introduction

The Epistemic Containment Principle (ECP): epistemic modals must take wider scope than strong quantifiers. [2]

- # *Every student might be the murderer.*

MIGHT > EVERY, EVERY > MIGHT

A few systemic classes of counterexamples to the ECP:

- Objective vs. subjective (doxastic) [1], [5]

Objectively speaking, everyone might be the murderer.

EVERY > MIGHT, MIGHT > EVERY

- Quantifier type: *each, every, all, etc.* [1]

Each student might be the murderer.

EACH > MIGHT, ?MIGHT > EACH

Questions & Hypotheses

1. How robust is the ECP as an empirical phenomenon? Can it be captured experimentally and quantitatively?

2. Are there any systematic contextual factors that determine the ECP, that have not yet received attention?

- QUDs (Question Under Discussions; [4]), which create biases towards different scopal orderings
- The nature of the evidential source, which are in turn biased towards addressing different QUDs

3. What is the relationship between these and other factors that have been known to influence the ECP?

- Many of them can be reduced to the core effect of QUDs and pragmatic reasonings

II. Probing the intuitions

QUD effects (Experiment 2):

- Which of them has the possibility of being a murderer? (As far as I know,) everyone might be the murderer.*

EVERY > MIGHT, ?MIGHT > EVERY

Effects of evidential source (Experiment 1):

- How many bushes have a tiger?*

Based on what the zookeeper said, every bush might have a tiger.

MIGHT > EVERY, ?EVERY > MIGHT

- Which bush is more likely to have a tiger?*

Based on what I see, every bush might have a tiger.

EVERY > MIGHT, ?MIGHT > EVERY

VI. Summary of Results

Mixed effects logistic regressions fitted to data; key results:

- ECP:** elicited fairly robust true responses (i.e., ECP violations) even without any explicit adverbials or QUDs
- Experiment 1:** Adverbials biased towards giving ECP violating QUD answers (ADV(V)) elicited significantly more true responses than observing ones (ADV(O)).
- Experiment 2:** 'Which' QUDs elicited significantly more true responses (ECP violations) than 'How' QUDs.

VII. Additional free responses

Dispelling a potential confound in which true responses are not reflections of ECP violations, but rather the result of the adverbials generating an unrealistic modal base (cf. [3]).

- "...it's impossible for them all to have a tiger cub... BUT the possibility exists that each MIGHT have one."
- "...it's possible that any of the pots could have a lotus shoot. Though saying *every* isn't as clear as saying *any*."

*More examples and **References** can be found on the other side of the handout. Experiments, data, and statistical models can be found at: <https://github.com/sunwoojeong/ecp/>.

III. Experimental Paradigms and Stimuli

In the two experiments, participants read through 4–5 situations in which the epistemic base of the speaker was explicitly given via two types of visual stimuli (e.g., Fig. 1 and 2). They were then asked to judge whether a sentence uttered by that speaker was true or false. In target trials, the speaker's epistemic base rendered the sentence true only under the ECP-violating scopal ordering, but false under the ECP-observing one. 600 native English speakers were recruited for each experiment.

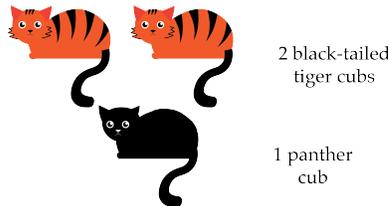


Figure 1: First type of visual stimuli

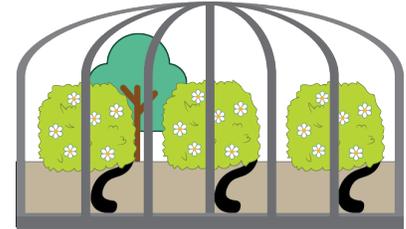


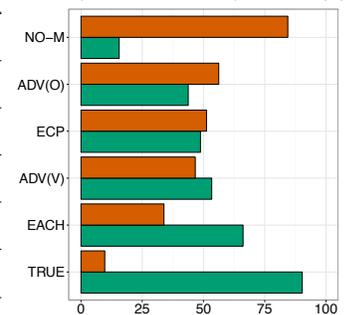
Figure 2: Second type of visual stimuli

IV. Experiment 1: evidential source and indirect QUDs

Sample prompt: Ron learns from the zookeeper that two tigers and one panther, which look as in Fig. 1, live in the silver cage (cf. TRUE: three tigers). They peer through the cage, which looks as in Fig. 2. At this moment, Ron says: [Sentence stimulus].

Conditions	Sentence stimuli	Predictions
NO-M	"Every bush has a tiger."	F given info in Fig. 1
ADV(O)	"Based on what the zookeeper said, every bush might have a tiger."	MIGHT > EVERY (F) EVERY > MIGHT (T)
ECP	"Every bush might have a tiger."	MIGHT > EVERY (F) EVERY > MIGHT (T)
ADV(V)	"Based on what I see, every bush might have a tiger."	MIGHT > EVERY (F) EVERY > MIGHT (T)
EACH	"Each bush might have a tiger."	?MIGHT > EACH (F) EACH > MIGHT (T)
TRUE	(Sees 3 tigers in Fig. 1) "Every bush might have a tiger."	MIGHT > EVERY (T) EVERY > MIGHT (T)

True responses: ■ False responses: ■ (%)

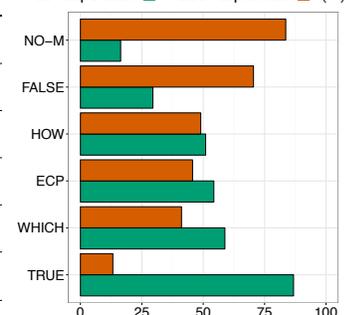


V. Experiment 2: direct QUDs

Sample prompt: Ron is a zookeeper. He keeps two tigers and one panther, which look as in Fig. 1, in the silver cage. One day a guest arrives and they peer through the cage, which looks as in Fig. 2. (The guest asks: [QUD].) Ron says: [Sentence stimulus].

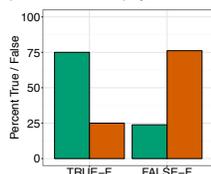
Conditions	QUD and sentence stimuli	Updated predictions
NO-M	"Every bush has a tiger."	F given info in Fig. 1
FALSE	(Sees different tails in Fig. 1–2; no QUD) "Every bush might have a tiger."	MIGHT > EVERY (F) ?EVERY > MIGHT (F)
HOW	"How many of the 3 bushes have a tiger?" "Every bush might have a tiger."	MIGHT > EVERY (F) EVERY > MIGHT (T)
ECP	(No explicit QUD) "Every bush might have a tiger."	MIGHT > EVERY (F) ?EVERY > MIGHT (T)
WHICH	"Which of the 3 bushes has a tiger?" "Every bush might have a tiger."	MIGHT > EVERY (F) EVERY > MIGHT (T)
TRUE	(Sees 3 tigers in Fig. 1; no QUD) "Every bush might have a tiger."	MIGHT > EVERY (T) ?EVERY > MIGHT (T)

True responses: ■ False responses: ■ (%)



VIII. QUD manipulations

Caveats to incorporating QUD manipulations: not all participants seem to pay close enough attention to them.



Filler trials involving QUDs: Two tigers and one fox in Fig. 1–2. Fox in the leftmost bush.

"Which of the left two bushes have tigers?" / "Both." (F)

→ 25% incorrect responses

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Discussion & Conclusion

1. The ECP is best analyzed as a gradient epiphenomenon that is derived from a confluence of biases in other more fundamental factors. One important factor is the QUD.

- Many implicit, default QUDs likely anticipate answers with ECP-observing scopal interpretations.
- However, if a particular QUD anticipates ECP-violating scopal interpretation as a (more) relevant answer, the latter is more likely to be accepted, obviating the ECP.

2. It remains to be seen if other factors, e.g., subjective vs. objective epistemic modal distinction, can ultimately be reduced to a QUD-based explanation.

Additional free responses

- (1) From those who chose ECP violating responses (i.e., True responses; primarily in response to ECP, ADV(V), and WHICH conditions)
 - a. *The leaves on both kinds of plants have the same appearance. So it's possible that any of the pots could have a lotus shoot. Though saying 'every' isn't as clear as saying 'any'.*
 - b. *It depends (on) whether she meant each one might have a cherry or every single one might have a cherry.*
 - c. *This one is interesting because while it's false that each ice cream sundae will have a maraschino cherry you could still reason that every one of them MIGHT have one.*
 - d. *It depends on if she emphasizes the word 'every' or 'might'.*
 - e. *It is tricky to know if George means there are 3/3 moss butterflies or (if he means) each beaker (could) possibly contain one.*
 - f. *I think I just adjusted my definition of 'every' to mean 'possibly' and not 'all'.*
 - g. *I think she means each statue has the potential to have a blue sapphire not that all of them will.*
 - h. *I suppose the vagueness in meaning comes from whether he means that it is possible for every bush to have a tiger cub or that it is possible that a tiger cub could be in every bush but not all.*
 - i. *'might' is an ambiguous word.*
- (2) From those who chose ECP observing responses (i.e., False responses; primarily in response to ADV(O), and HOW conditions), but also voiced some reserve due to the ambiguity
 - a. *Interesting. This depends on how you interpret 'every pot might...' I would lean towards (this meaning) that all 3 pots would have a desert lotus shoot and not just that each pot might potentially have a desert lotus root.*
 - b. *The more I think about it I guess every bush MIGHT have a tiger cub but it just is not the correct way to say this.*
- (3) From those who chose ECP observing responses (i.e., False) and were more sure about their judgements
 - a. *The correct phrase should be 'each pot might have a desert lotus shoot'. The word 'every' implies that all pots inclusively together have desert lotus shoots.*
 - b. *'Any of the bushes might have a tiger cub' would be true. 'Every bush' cannot have a tiger cub cause there are only two tiger cubs.*
 - c. *Any of the three could have the tiger cubs but only two at a time.*
 - d. *'Any of the bushes might have a tiger cub' would be true. Every bush cannot have a tiger cub cause there are only two tiger cubs.*

References

- [1] Anand, Pranav & Valentine Hacquard. 2008. Epistemics with attitude. In *Semantics and linguistic theory*, vol. 18, 37–54.
- [2] von Stechow, Kai & Sabine Iatridou. 2003. Epistemic containment. *Linguistic Inquiry* 34(2). 173–198.
- [3] Portner, Paul. 2007. Imperatives and modals. *Natural Language Semantics* 15(4). 351–383.
- [4] Roberts, Craige. 1996. Information structure in discourse: Towards an integrated formal theory of pragmatics. *Ohio State University Working Papers in Linguistics*. 91–136.
- [5] Tancredi, Christopher. 2007. A multi-modal theory of I-semantics. Manuscript, University of Tokyo.

For questions and comments, please email me at: sunwooj@stanford.edu. Experiments, data, mixed effects models, and a copy of the poster can be found at: <https://github.com/sunwooj/ecp/>.