

## Non-literal Quantification as Reasoning about Strength

We show how a general model of rational inference in communication, together with a standard semantics for quantification and modality, delivers the at times puzzling non-maximal interpretation for universal quantifiers in three seemingly disparate domains. Each of the following sentences admits a non-literal interpretation such that *all* means most, *always* means usually, and *must* means very likely. In addition to weaker interpretations, use of these terms communicates information about the speaker’s relationship to the statement she is making. With *all* and *always*, this information concerns the speaker’s affective dimension (e.g., feeling positively or negatively about some state of affairs). With *must*, this information concerns the quality of the speaker’s evidence. As we show below using both experimental evidence and structured probabilistic models, this evidential information with *must* plays the same role as the affective information with *all* and *always*: Given our prior knowledge about the world, we know it is highly unlikely that the literal, maximal interpretation of the terms could be true. We therefore infer that the speaker intends to communicate 1) a slightly weaker but much more likely statement, and 2) an additional dimension of meaning.

- (1) John ate all of the pie!  $\Rightarrow$  John ate most of the pie and I am unhappy about it.
- (2) John always arrives late!  $\Rightarrow$  John usually arrives late and I am unhappy about it.
- (3) John must be in the kitchen!  $\Rightarrow$  John is very likely to be in the kitchen but I do not have direct evidence of this fact.

Because it has received the most scrutiny (and been subject to the most contention), we focus here primarily on the epistemic necessity modal *must*. Since Karttunen 1972, researchers have debated the lexical entry for this modal, arguing about its semantic strength. At issue is the failed inference in (4): How could  $\Box p$  not entail  $p$ ? Karttunen and decades of semanticists that follow posit that the inference fails because *must*  $p$  is a weaker statement than bare  $p$ .

- (4) It must be raining.  $\nRightarrow$  It is raining.

von Fintel and Gillies 2010 claim that the “*must* is weak” mantra cannot be right, showing first that it is not always weak, and then that it never is. They propose instead that *must*  $p$  quantifies universally over epistemically possible worlds while presupposing that the speaker has no direct evidence of  $p$ . However, the strength of *must*  $p$  requires the speaker to have direct evidence of something that entails  $p$ . Lassiter *to appear* shows how this implementation of a strong semantics for *must* makes unreasonable claims about the knowledge states of speakers, and proposes instead a weak probabilistic semantics: *must*  $p$  entails that the likelihood of  $p$  given the speakers direct knowledge is greater than chance, and requires that the question of whether  $p$  not be resolved by this direct knowledge.

Our approach incorporates elements from both von Fintel and Gillies 2010 and Lassiter *to appear*: *Must* is strong, but reasoning about its strong meaning yields a weaker interpretation. First, to establish the relative strength of *must*, we asked XX subjects on Mechanical Turk to rate the likelihood of a state of affairs given a modalized or bare statement. The results qualitatively confirm Karttunen original observation, and quantitatively demonstrate the relative weakness of *must*: whereas subjects rate the likelihood of  $p$  after hearing a bare statement at XX%, after hearing *must* (also *know*) subjects rate  $p$ ’s likelihood at XX%.

To address the source of *must*'s weakness, we added a free response to the rating paradigm. Subjects commented on the epistemic state of the speaker: "How do you think they know about *p*?" Responses were annotated and separated into three main classes: a) perceptual (direct perceptual or experiential access to the state of the world), b) reportative (hearsay, source is a friend or the weather report, etc.), and c) inferential (state of the world is inferred based on other evidence or the way the world 'usually' is). Comparing responses to bare and modal statements, we see that in the former subjects attribute perceptual knowledge to the speaker XX% of the time, whereas in the latter subjects attribute perceptual knowledge XX% of the time. In other words, *must* communicates information about how the speaker came to their epistemic state. However, the XX% of responses that do attribute direct perceptual evidence to *must* statements argues against coding evidentiality into the semantics of this modal.

The model.

## References

- Karttunen, L. (1972). *Possible and must*. In J. Kimball (Ed.), *Syntax and Semantics*, Volume 1, pp. 1–20. New York: Academic Press.
- Lassiter, D. (*to appear*). The weakness of *must*: In defense of a mantra. In T. Snider (Ed.), *Proceedings of SALT 24*.
- von Fintel, K. and A. S. Gillies (2010). *Must ... stay ... strong!* *Natural Language Semantics* 18, 351–383.