A cost and information-based account of epistemic *must*

A question of central importance to psycholinguistics is how speakers and listeners trade off the burden of production and interpretation cost. Information-theoretic approaches to language as a communicatively efficient system have provided evidence that in production, speakers choose the longer of two meaning-equivalent utterances when syntactic or phonological surprisal is high (?, ?, ?); in comprehension, more surprising utterances are processed more slowly (?, ?); in the lexicon, longer words are typically less frequent (?, ?, ?). A related observation in pragmatics is that marked meanings go with marked forms (?, ?). In general: speakers invest more effort into communicating more information.

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It has been proposed that a speaker who produces the *must* utterance in (2) will be taken to have made a weaker statement than a speaker who produces the *bare* utterance in (1), despite the semantics of the necessity modal *must* being stronger than that of the bare utterance (?, ?).

(1) It's raining.

(2) It must be raining.

Here, we ask whether a speaker's choice between (1) and (2) is affected by the directness of her evidence for whether it is raining (q); whether listeners' interpretations of (1) and (2) differ with respect to the strength of their resulting belief in q; and whether these beliefs are determined in part by the evidence they attribute to the speaker's choice between (1) and (2).

In **Exp. 1 (n=XXX)**, we collected estimates of the directness of a piece of evidence about a proposition. Participants on Amazon's Mechanical Turk rated the probability of q (e.g., of it raining) given a piece of evidence e (e.g., *You hear the sound of water dripping on the roof*) on a sliding scale with endpoints labeled "impossible" and "certain". These estimates were used for analysis in Exps. 2 and 3.

Exp. 2 (n=40) tested **whether speakers are more likely to use the more costly *It must be raining* as the directness of the evidence for rain decreases**. On each trial, participants were presented with a piece of evidence (e.g., *You see a person come in from outside with wet hair and wet clothes*) and were asked to choose one of four utterances—bare, *must*, *probably*, *might*—to describe the situation to a friend. Participants were more likely to choose the longer *must* form over the shorter bare form as the directness of evidence decreased ($\beta = 5.4, SE = 2.4, p < .05$), even when controlling for evidence type (perceptual, reportative, inferential).

Exp. 3 (n=120) tested **whether listeners' estimates of a) the probability of q and b) the directness of speakers' evidence for q differ depending on the observed utterance**; i.e. whether listeners take into account their knowledge of speakers' likely utterances in different evidential states in interpreting the bare and *must* form. On each trial, participants were presented with an utterance (e.g. *It's raining*), and were asked a) to rate the probability of q on a sliding scale with endpoints labeled "impossible" and "certain"; and b) to select one out of five pieces of evidence for the speaker knowing about q. Participants' believed q was less likely after observing the *must* utterance ($\mu = .65, sd = .21$) than after observing the bare utterance ($\mu = .86, sd = .15, \beta = -.21, SE = .02, t = -10.1, p < .0001$). In addition, average directness of evidence was lower after observing *must* ($\mu = .78, sd = .12$) than after the bare utterance ($\mu = .87, sd = .1, \beta = -.08, SE = .01, t = -6.8, p < .0001$).

Taken together, these results support an M-implicature account of the choice and interpretation of epistemic *must*: the longer, marked, *must* is interpreted by listeners as conveying the marked meaning that the speaker arrived at the conclusion that q via an evidentially less certain route than if they had chosen the shorter, unmarked, bare form. We discuss how a formal model of rational

inference in communication in the Bayesian/game-theoretic/information-theoretic tradition (?, ?, ?, ?, ?) can account for these results.

References