

The weakness of *must*: In defense of a Mantra

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There is a Mantra, for decades repeated mindlessly by researchers in modal semantics: “*Must* is weak”. So claim von Stechow & Gillies (2010; “vFG”) in reference to an influential line of thought going back to [K72]. Karttunen claims that an utterance of (1) indicates a weaker commitment than (2), in that (1) implies that “it is not yet an established fact that John has left”.

- (1) John must have left. (2) John has left.

[K91] formalizes this by making *must* a quantifier over a maximally normal subset of the epistemically possible worlds (\mathcal{E}); thus *must* p is compatible with there being $\neg p$ -worlds in \mathcal{E} .

vFG marshal an impressive variety of arguments against the Mantra, and in favor of an account according to which *must* indicates indirectness, but *must* p entails p . But there are problems. vFG’s negative arguments work against only some Weak theories. Their positive proposal fails to account for their flagship example, and also fails for new examples drawn from the ancestry.com discussion boards and presented in §4. Users of this website frequently use *must* to mark inferences about the lives of unknown, long-dead persons made on the basis of fragmentary information. vFG unambiguously predict that cooperative speakers should not use *must* under these circumstances. To explain these uses, §5 proposes a new account on which *must* is both weak **and** inferential.

vFG’s argument 1: *must* is not always weak. vFG emphasize the distinction between indirectness and weakness: conclusions derived from indirect evidence can be maximally strong. For instance, *must* is natural in proofs: “ x is prime. x is even. x must equal 2.” There is no hint of uncertainty.

If *must* p did not entail that $\mathcal{E} \subseteq p$, we might expect it to generate an uncertainty implicature. However, the reasoning only goes through if there is an uncertainty-free expression entailing *must* p . This may be a problem for [K91], if (e.g.) *certainly* is a quantifier over \mathcal{E} ; but the theory developed below treats *must* as semantically weak **and** indirect. A speaker could thus use *must* in order to mark inference explicitly; there is no entailment from purely epistemic items.

vFG’s argument 2: *must* is never weak. Consider #*It must be raining, but it might not*. vFG claim that a Strong theory is needed to explain the unacceptability of this example. But we can easily deal with this issue by defining *might* as the dual of *must*, rather than an existential quantifier over \mathcal{E} .

Consider *If* P , *must* Q . *P*. *Therefore*, Q . This seems to be valid reasoning. vFG treat it as evidence for the Strong theory; but this holds only on the assumption that our intuitions about argument strength track deductive validity. On Weak theories, the argument is **probabilistically** valid in the sense of [E95]: if the premises are true or highly probable, the conclusion is highly probable. In fact there is much psychological evidence that argument strength intuitions track probabilistic rather than strictly logical validity [OC07].

vFG’s argument 3: Strong semantics makes available an attractive account of evidential meaning. Like [P86], vFG treat *must* as an evidential. Their account goes as follows: there is a set of propositions \mathcal{K} (the **kernel**) known from direct experience. The epistemically possible worlds \mathcal{E} are equal to $\bigcap \mathcal{K}$, and the propositions known indirectly (by deductive inference) are those true throughout \mathcal{E} but not in \mathcal{K} : $\mathcal{I} = \{p \mid \mathcal{E} \subseteq p\} - \mathcal{K}$. *Must* p presupposes $p \notin \mathcal{K} \wedge \neg p \notin \mathcal{K}$, and asserts $\mathcal{E} \subseteq p$.

vFG’s example is this: Billy sees people coming into the office with wet raincoats, and utters u : “It must be raining.” The semantics predicts the appropriateness of u if $\mathcal{K} = \{\mathbf{people with wet raincoats, people only come in with wet raincoats when it’s raining}\}$: the closure of this \mathcal{K} entails **rain**.

But this characterization does not fit well with vFG’s central hypothesis. How could Billy come to know by direct experience the second item in \mathcal{K} — a proposition equivalent to “People never come in with wet raincoats when it’s not raining”? No amount of experience could grant Billy **direct** knowledge of the non-existence of a situation type: either she is confused, or vFG are wrong.

4. Corpus evidence. In natural discourse, speakers frequently use *must p* despite clearly being aware that they do not know anything (direct or indirect) which entails *p*. For instance:

- (3) [T]he 1880 census shows her living with mom, two brothers, and her daughter ... So David [the father] must have died before 1880. (source: ancestry.com)

\mathcal{K} would have to include **The only way the father of a family living in York County, PA in 1880 can fail to appear in the census is that he was dead.** No one could seriously self-ascribe knowledge of this; rather, (3) presents David's death as the *best explanation* of the census record [S94].

- (4) **A1:** [Y]our man Lazarus must have sustained injuries at [Buena Vista] by his death date. ...
B: I check the killed and wounded list ... Lazarus wasn't listed under killed and wounded.
A2: Curious. I was only assuming that since Lazarus is listed as dying [a week after Buena Vista], it was from wounds suffered the week prior ... [A]s we all know, disease took a heavier toll on the troops than actual enemy fire. [But] when I see a death date that close to the battle date, I tend to think that wounds played a part. (source: ancestry.com)

A's choice to use **A1** is not plausibly accounted for by supposing that he thought he knew **wounded**. **A2** explains "I was only assuming ...", and continues by giving **statistical** considerations pushing in each direction: most soldiers died of disease [low $P(\text{wounded}|\text{died})$], but most who died within a week of a battle were wounded [high $P(\text{wounded}|\text{battle}, \text{died})$]. Lacking specific evidence when **A1** was formulated, A chose *must* to mark "wounded" as the best explanation of the available data.

5. Abductive and threshold semantics. Our account combines ideas from [K72, S94, Y11] with a perspective from AI and psychology in which epistemic states are represented using structured probabilistic models [P88, T11]. Let \mathcal{V} be the set of questions (= random variables) that an agent represents. \mathcal{V} is partitioned into \mathcal{V}_D , whose values have been observed directly, and \mathcal{V}_I , for which a distribution is inferred by conditionalizing on \mathcal{V}_D . An epistemic state thus determines a posterior $P(Q|\mathcal{V}_D)$ on answers to each $Q \in \mathcal{V}$. We can formalize the "best explanation" intuition as:

- (5) If $q \in \mathcal{Q}$, then *must q* {is felicitous only if $Q \notin \mathcal{V}_D$; $\{= 1 \text{ iff } \forall q' \neq q \in \mathcal{Q} : P(q|\mathcal{V}_D) > P(q'|\mathcal{V}_D)\}$ }.

(5) presents q as the answer to Q which best explains the observations \mathcal{V}_D . If $Q = \text{Was David alive in 1880?}$ and \mathcal{V}_D includes the census record, (3) indicates $Q \notin \mathcal{V}_D$ and $P(\text{dead}|\mathcal{V}_D) > P(\text{alive}|\mathcal{V}_D)$.

Problem: this semantics is too weak. If Q has many possible answers, the most likely may still be very improbable. Since *must q* is clearly false when $P(q)$ is low, we strengthen (5) to (6):

- (6) If $q \in \mathcal{Q}$, then *must q* {is felicitous only if $Q \notin \mathcal{V}_D$; $\{= 1 \text{ iff } P(q|\mathcal{V}_D) > \theta\}$ }.

(6) entails (5), as long as θ is at least .5. Our examples suggest that (6) is right to leave the meaning of *must* vague (and itself subject to inference, cf. [LG13]). Both definitions are neutral about what, if anything, determines the epistemic state relevant to evaluating a given utterance of *must q* (and so the difficult question of whether **A1** was true, false, or neither when uttered: see [Y11]).

The free parameter θ in (6) suggests the possibility of binding. Many examples confirm this prediction: e.g., (7) indicates indirectness, but with reduced commitment associated with *figured*.

- (7) If the handgun was engraved or had some sort of fancier finish then I figured he must be a "pistolero."
I might have been wrong but those were my initial impressions.

(source: <http://americanhandgunner.com/handgun-esthetics/>)

6. Conclusion. *Must* is weak! *Must* is weak! *Must* is weak! *Must* is weak! *Must* is weak! ...

Refs: [E95] Edgington, On conditionals [vFG] von Fintel & Gillies, *Must...stay...strong!* [K72] Karttunen, Possible & *must* [K91] Kratzer, Modality [LG13] Lassiter & Goodman, Context, scale structure, and statistics in the interpretation of positive-form adjectives [OC07] Oaksford & Chater, *Bayesian Rationality* [P86] Palmer, *Mood & Modality* [P88] Pearl, *Prob. Reasoning in Intelligent Systems* [S94] Stone, The reference argument of epistemic *must* [T11] Tenenbaum et al., How to grow a mind: Structure, statistics, and abstraction [Y11] Yalcin, Nonfactualism about epistemic modality