Modal Competition in Inferential Contexts: Evidence from Force-Choice Experiments

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We show that speakers drawing explicit inferences strongly prefer `must`, except in deductive contexts. We argue this supports a weak (non-veridical) semantics for `must`.

Introduction. When making explicit inferences, speakers may use a modal expression, or none at all. Observing that someone's car is gone, one might say:

(1)　She { *must be* / *has to be* / *will be* / *is probably* } at work.　　(2)　She's at work.

In this study we probe which choice is preferred across different types of inferences. Various authors predict different preferences: Winans[9] argues that `will` is dispreferred in abductive contexts; others debate whether `must` and `haveto` differ in logical strength, with the result that one would be preferred in more certain inferences.[2–7] We test these predictions using the inference typology of Douven & Verbrugge[1]: *abductive* (inference to the best explanation), *deductive* (inference to a logical consequence), and *inductive* (inference from prior frequency).

Across three forced-choice experiments, how the inference-context modulates speakers' preference for `must` over other modal competitors (`probably`, `haveto`, `will`, or an bare). Under the assumption that `must` is veridical, i.e. must p entails p[5–7], speakers should prefer it when the inferential warrant guarantees the conclusion – that is, in deductive contexts. Instead, we find that speakers prefer `must` less in deductive contexts, and choose bare sentences or `haveto`, supporting non-veridical `must` accounts.[2–4,8]

EXPERIMENTS were conducted in PCIbex where participants chose a conversational follow-up (*Fig 1*). Exp1 manipulated the conversational context (within-subject: abductive: C_A, inductive: C_I, deductive: C_D) and modal competitors (between-subject: `bare`, `will`, `probably`, `haveto`). Exp2 used the same manipulations, but we varied whether the conclusion was embedded in a conditional (*If she's not here, she must be at work*) or asserted without a conditional frame (*She's not here. Well then, she must be at work*). We reasoned that the two structures might be associated with different preferences,

Fig1:　Example Trial for all experiments (N_{exp1}=21, N_{exp2}=79, N_{exp3}=41).

since in our materials the conditionals repeat the propositions that serve as premises, and make the inferential relation more explicit. Exp3 replicated Exp1 with more participants whose age mean is the same as Exp2. Our **RESULTS** show that `must` was the majority choice in most conditions across experiments (see Fig2 for mean choice proportions). Following our research question, we compare the preference for `must` across inference contexts for each competitor. MUSTxPROB: In abductive contexts, `must` was less preferred when competing with `probably` (Exp1:∼30%; Exp2:∼45%; Fig2), whereas in deductive contexts participants preferred `must` over `probably` across both preamble types (about 70–75%). A Bayesian GLM with a Bernoulli link (coding `must` as 1) confirmed robust effects of context in both experiments (posterior $P(\Delta > 0) \approx .98$) and provided little evidence for an interaction with preamble type ($p_{Bayes} \approx .78$). MUSTxWILL: Participants overwhelmingly chose `must` in all conditions. Across inference types and experiments, `will` never exceeded about 20–23% of responses (Fig2), and the Bayesian GLM estimated high `must` probabilities in every cell (all posterior means $\geq .85$), indicating that `will` was consistently dispreferred. MUSTxHAVETO: In deductive contexts without conditional framing, `haveto` gained some ground against `must`. In Exp2, `haveto` was chosen about 29% of the time in deductive contexts (vs. 7% in abductive), and the GLM (with deductive as the baseline inference) suggests a higher rate of `haveto` in deductive
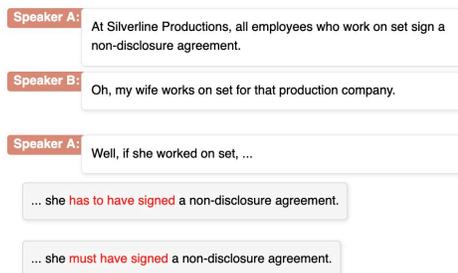
than abductive contexts in this experiment (posterior $P(\beta_{\text{ded}} > \beta_{\text{abd}}) \approx .9$), while still maintaining an overall preference for `must`. Under conditional framing, by contrast, participants continued to choose `must` over the unmodalized form on roughly 90% of trials. In inductive contexts, `must` was still chosen on the majority of trials (about 70% in Exp1; Fig. 2), and the model places most posterior mass on $p(\text{must}) > .5$, suggesting that `haveto` remains comparatively dispreferred. <u>MUSTxBARE</u>: When `must` competed with a bare conclusion, participants generally preferred `must`, but bare completions gained noticeable ground in the older "well, then…" version. In Exp1 and Exp3 (both with conditional "if" framings), bare conclusions were chosen on roughly 10–30% of trials across inference types, with `must` taking the remaining majority; in Exp2, bare responses rose to about 22% in abductive contexts, 31% in the inference-based condition, and nearly half of responses in deductive contexts (47%; Fig. 2). The Bayesian GLM again indicated an overall preference for `must` (positive intercept) and suggested increased bare responding specifically in Exp2 deductive contexts, although the corresponding credible intervals were wide. **TAKEN TOGETHER**, Our central finding is that `must` faces competition exactly where the warrant is, in principle, strongest. This is unexpected if `must` p entails p. On such accounts, `must` should be preferred in deductive contexts. Instead, speakers shift toward bare forms (47%) and `haveto` (29%) precisely there. We believe this pattern supports non-veridical accounts of `must`. When p is guaranteed, speakers who wish to commit to p will consider forms that do: bare forms or `haveto`. The divergence between `must` and `haveto` reinforces this: `haveto` clusters with deductive contexts while `must`, but not `haveto`, tolerates inductive ones suggesting `haveto` requires the warrant to logically guarantee p, whereas `must` does not. `Will` shows a pattern consistent with Winans (2016): it is dispreferred most strongly in abductive contexts (under 5%) and shows its largest share in deductive contexts (~22%). But even where `will` is semantically acceptable, `must` still dominates. Finally, the preference for bare forms over `must` in deductive contexts suggests that `must` may function less to mark certainty than to mark the inferential act itself: signalling that the speaker is drawing an inference, based on a salient set of premises, rather than simply expressing their level of commitment to p.

In sum, `Must` faces competition from bare forms and `haveto` where the warrant is strongest, and from `probably` where it is weakest. `Have to` patterns with deductive contexts; `must` tolerates inductive ones. This distribution supports accounts on which `must` p does not logically entail p, but `haveto` p might.
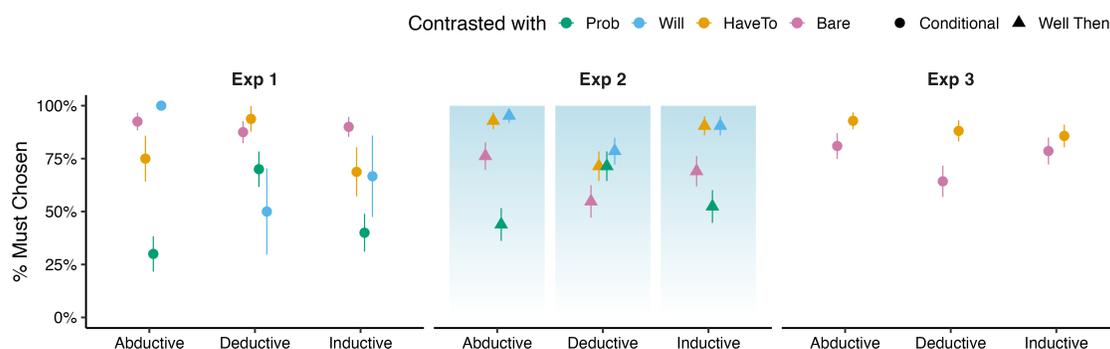

Fig2: Preference for must contrasted with alternative modals. Blue highlighting, along with point-shape, denotes the 'Well, then...' context, compared to conditionals (white). Error bars represent ± 1 SE.

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