Epistemic ‘must’
is an inferential evidential

Giuseppe Ricciardi¹, Rachel A. Ryskin² & Edward Gibson³

¹Harvard University, ²UC Merced, ³MIT

ELM 1
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The epistemic use of ‘must’

“Carole picked up the phone and called Amy’s number to tell her that she was on the way. Amy must have been sitting right by the phone, because she picked up the receiver on the first ring”


What is the meaning of ‘must’ when used epistemically?
Preview

• Three hypotheses about the meaning of epistemic ‘must’

• Lassiter (2016, L16)’s TVJT experiment and our replication (E1)

• Extending L16 by manipulating the number of sentences per participant (E2)

• Extending L16 by manipulating the number of sentences per participant + the contextual information (E3)

• General discussion and conclusions
Three hypotheses

Presupposing that the speaker has inferential evidence for ‘p’,

STRONG MUST:
‘must p’ = ‘it is necessary that p’  
(Von Fintel & Gillies, 2010, 2020)

WEAK MUST:
‘must p’ = ‘it is highly probable that p’  

EVIDENTIAL/PERFORMATIVE MUST (EVID MUST):
‘must p’ = ‘p, I infer/suppose/guess/bet’  
Recent experimental works

Lassiter (2016, L16)
Del Pinal & Waldon (2019)
Degen et al. (2019)

⇒ all these findings suggest that WEAK MUST is supported over STRONG MUST
L16: ‘must p’ in a context where ‘p’ is highly probable

Please read the following description, and then answer the question at the bottom of the page.

Yesterday, Bill bought a single ticket in a raffle with 1000 total tickets. There were also 999 other people who bought one ticket each. That is, the tickets were distributed like this:

- People holding one ticket: Bill, Mary, Jane, ... [997 more]

The drawing was held last night, and the winner will be announced this evening.

After reading this, do you agree with the following statement?

"Bill must not have won the raffle."

○ Agree ○ Disagree
L16: predictions

- L16 had each participant see one sentence out of a list of nine including
  - ‘Bill must not have won the lottery’ (must not)
  - ‘It is certain that Bill did not win the lottery’ (certain not)
  - ‘We know that Bill did not win the lottery’ (know not)

- Given the lottery context where ‘p’ is highly probable,

  STRONG MUST (‘must p’ = ‘it is necessary that p’) predicts this endorsement pattern:  
  must not = certain not = know not  
  WEAK MUST (‘must p’ = ‘it is highly probable that p’) predicts this endorsement pattern:  
  ‘must not’ > ‘certain not’ or ‘know not’

(L16 didn’t assess EVID MUST)
L16: results

Sentence (between-subjects)

**did:** Bill won the raffle

**know not:** We know that Bill did not win the raffle

**certain not:** It is certain that Bill did not win the raffle

**certainly not:** Bill certainly did not win the raffle

**must not:** Bill must not have won the raffle

**did not:** Bill did not win the raffle

**possibly:** Bill possibly won the raffle

**might:** Bill might have won the raffle

**possible:** It is possible that Bill won the raffle
L16: interpretation of the results

In a context where ‘p’ is highly probable,

- ‘must p’ is more endorsed than ‘it is certain p’ or ‘know p’
- also, most participants (58%) endorsed ‘must p’

⇒  X STRONG MUST ✓ WEAK MUST

Here, we assess this conclusion and bring EVID MUST into the discussion
E1: Replication of L16

Instructions

Please read the context and the sentence, state whether you agree or disagree with the sentence in the context and then answer the question immediately following.

Please note that there is a correct answer for the question.

Context: Yesterday, Bill bought a single ticket in a raffle with 1000 total tickets. There were also 999 other people who bought one ticket each. That is, the tickets were distributed like this: People holding one ticket: Bill, Mary, Jane, ... [997 more]. The drawing was held last night, and the winner will be announced this evening.

Target sentence: Bill must not have won the raffle.

☐ Agree  ☐ Disagree

Question: Is there anyone other than Bill who bought a ticket?

☐ Yes  ☐ No
We focused on ‘must’, ‘know’, ‘it is certain’

‘must’ higher than ‘know’ and ‘certain’ replicated

But overall, lower agreement in E1 vs L16 (only 28% for ‘must p’ in E1)
Hypothesis motivating E2

- **Our reasoning**: L16 and E1 show that it is more acceptable to produce ‘must p’ than ‘certain p’ or ‘know p’ in a context c of high probability for ‘p’, although they are all universal expressions, hence literally false in c (See Waldon & Degen, 2020 on TVJT's as generally targeting production rather than semantic judgments)

- **E2’s goal**: To test the hypothesis that in L16’s context ‘must’ is endorsed as much as ‘know’ and ‘certain’ once you make sure through clear baselines that participants understand the task as about the literal meanings
## E2: methods

**Within-subjects (9 sentences per participant)**

<table>
<thead>
<tr>
<th>Exactly one:</th>
<th>Bill bought exactly one ticket in the raffle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two tickets:</td>
<td>Mary bought two tickets in the raffle</td>
</tr>
<tr>
<td>Know:</td>
<td>We know that Bill did not win the raffle</td>
</tr>
<tr>
<td>Must:</td>
<td>Bill must not have won the raffle.</td>
</tr>
<tr>
<td>Probable:</td>
<td>It is highly probable that Bill did not win the raffle.</td>
</tr>
<tr>
<td>1000 people:</td>
<td>1000 different people bought one lottery ticket each in the raffle</td>
</tr>
<tr>
<td>Winner tomorrow:</td>
<td>The winner will be announced tomorrow.</td>
</tr>
<tr>
<td>Certain:</td>
<td>It is certain that Bill did not win the raffle.</td>
</tr>
<tr>
<td>Slight chance:</td>
<td>There is a slight chance that Bill won the raffle.</td>
</tr>
</tbody>
</table>

⇒ see discussion about single vs joint presentation in Marty et al. 2020
In E2, ‘must’ = ‘certain’ = ‘know’ as predicted by STRONG MUST

described above. The graphs show that the response rates for ‘must’, ‘certain’, and ‘know’ are all close to zero.

It’s certain that Bill didn’t win the lottery
We know that Bill didn’t win the lottery
Bill must not have won the lottery
E2: results for all sentences

Experiment 2: all statements

‘must’ close to floor

‘probable’ and ‘chance’ close to ceiling

It is highly probable that Bill didn’t win the lottery

There is a slight chance that Bill won the lottery
E1 vs E2: assessing STRONG and WEAK MUST

- **E1 vs E2: main effect of design**
  - E1 (must alone): ‘must’ > ‘certain’ or ‘know’
  - E2 (must with clear baselines): ‘must’ = ‘certain’ = ‘know’
    ('must’ < ‘probable’)

- **WEAK MUST: ruled out by E2**

- **STRONG MUST:**
  - explains E2
  - independently assuming that ‘must’ is more likely to be used hyperbolically than ‘certain’ / ‘know’ one can explain E1 (i.e. people are more willing to exaggerate when they say ‘it is necessary that p’ than when they say ‘it is certain p’ / ‘I know p’)

16
E1 vs E2: EVID MUST’s perspective

• Recall EVID MUST: ‘must p’ = ‘p, I infer/suppose/guess’)

• EVID MUST can explain the E1 vs E2 main effect of design as follows:

  In a context where ‘p’ is very likely but not certain, if the task design induces to be more accurate and careful, people are less willing to commit themselves to the conclusion/supposition that ‘p’

• EVID MUST is a more parsimonious explanation than STRONG MUST + hyperbolic assumption
Hypothesis motivating E3

- **Our reasoning**: people’s endorsement of ‘must p’ in a context c is correlated to their willingness to conclude/suppose ‘p’ in c

- **E3’s goal**: To test the hypothesis that the endorsement of ‘must p’ can be modulated by manipulating the accuracy level of the task (like in E1 vs E2) and the type of supporting evidence for ‘p’ provided by the contextual information
Induction vs best explanation

**L16’s context**: Yesterday, Bill bought a single ticket in a raffle with 1000 total tickets. There were also 999 other people who bought one ticket each. That is, the tickets were distributed like this: People holding one ticket: Bill, Mary, Jane, … [997 more]. The drawing was held last night, and the winner will be announced this evening

⇒ ‘Bill did not win the lottery’ is a very likely but not explanatory conclusion based on explicit statistical reasoning (inductive inference)

**L16’s context modified**: … The drawing was held last night. Today, you meet Bill and he looks a little bit disappointed.

⇒ ‘Bill did not win the lottery’ is a very likely conclusion but also a very good explanation for the fact that Bill looks disappointed (inference to the best explanation)

Intuition: the ‘best explanation’ context invites to infer ‘p’ with higher confidence than the ‘inductive’ context
E3: methods

2x2x3:

- **context**: ‘inductive’ vs ‘explanatory’
- **Accuracy induced by the task**: ‘between’ vs ‘within’
- **sentence type**: ‘must’ vs ‘certain’ vs ‘know’
E3: predictions

EVID MUST (‘must p’ = ‘p, I infer/suppose/guess’) predicts this endorsement pattern:

explanatory-must > inductive-must

The other hypotheses don’t predict this.

Instead,

WEAK MUST (‘must p’ = ‘it is highly probable p’) predicts

must > certain/know, no matter the design and the inference type

STRONG MUST (‘must p’ = ‘it is necessary p’) + hyperbolic assumption predicts

‘must > certain’ or ‘know’ in the between design but ‘must = certain’ or ‘know’ in the within design, no matter the inference type
Exp 3: results for ‘must’ ‘certain’ ‘know’

E1 and E2 replicated

explanatory > inductive

‘must’ = ‘certain’ = ‘know’
in inductive-within but
‘must’ > ‘certain’ or ‘know’
in explanatory-within

It’s certain that Bill didn’t win the lottery
We know that Bill didn’t win the lottery
Bill must not have won the lottery
Exp 3: results for all nine sentences (Within-subjects)

‘must’ < ‘probable’ across contexts

Bill must not have won the lottery
It is highly probable that Bill didn’t win
E3: assessing the hypotheses

Main effect of context:
For all sentences, explanatory > inductive

Interaction sentence/context:
'Must’ = ‘certain’ or ‘know’ in inductive-within but
'Must’ > ‘certain’ or ‘know’ in explanatory-within

‘must’ < ‘probable’ across contexts

So, the confidence in ‘p’ is overall boosted in the explanatory context,
Yet in the explanatory-within: ‘it is certain p’ < ‘must p’ < ‘it is probable p’

✓ EVID MUST  ❌ STRONG MUST  ❌ WEAK MUST
p, I infer/suppose/guess it is necessary p it is highly probable
Conclusions

The findings reported here suggest that given two very similar contexts where ‘p’ is judged highly probable, the endorsement of ‘must p’ can be affected by

- **Degree of accuracy induced by the task** (see E1 vs E2, and E3)
- **Type of support for ‘p’ provided by the context** (see E3)

We conclude that

- **the debate STRONG vs WEAK MUST is ill-defined**
- **the endorsement of ‘must p’ is not a matter of “objective” probability of ‘p’** but expresses the **speaker’s own assessment about whether to perform the act of inferring ‘p’**, which can be affected by speaker’s accuracy and type of inference suggested by the available information
- **the epistemic use of ‘must’ is the use of ‘must’ as a pure inferential marker**

How to account for the polysemy of the word ‘must’ is another story
Future steps

- Explore the role of contextual info more systematically
- Compare directly ‘must’ to established inferential markers, predicates of conjecturing and certainty
- Connect the linguistic study of ‘must’ to studies in psychology of reasoning
References


von Fintel, K., & Gillies, A. S. (2010). Must... stay... strong!. Natural language semantics, 18(4), 351-383.


References

Goodhue, Daniel. (2017). Must $\phi$ is felicitous only if $\phi$ is not known. Semantics & Pragmatics 10(14). 1–27


References


