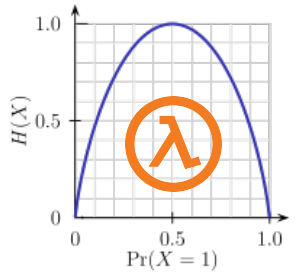


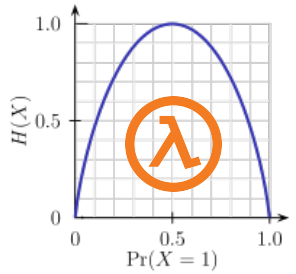
The weakness of *must*: In defense of a Mantra

Daniel Lassiter

Stanford Linguistics

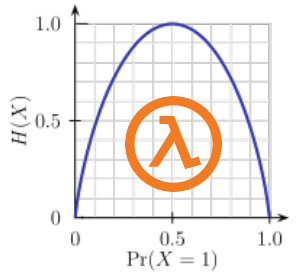
SALT 24 @ NYU 5/30/14

how to download slides



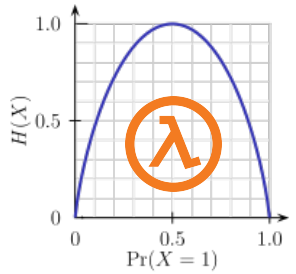
- fonts too small?
  - find my Stanford website on Google,
  - download on right sidebar near top

plan



- "The Mantra": *must p* is weaker than *p*
  - von Fintel & Gillies' arguments against
  - problems
- Inferential, not weak?
  - conceptual problem: induction
  - corpus data
- Inferential **and** weak
  - structured probabilistic models
  - abductive and threshold semantics

"The Mantra"



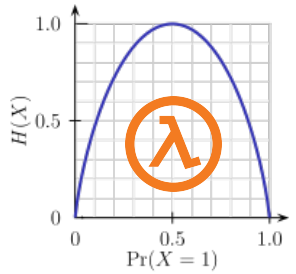
There is a striking difference between the logical necessity operator and words like *must*. … In any of the standard modal logics, *Lp* is a stronger expression than *p*. However, there is an inverse relation between the two sentences

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

Intuitively, (2) makes a stronger claim than (1).

(Our illustrious invited speaker:
"*Possible* and *must*", 1972, pp.11-12)

“The Mantra”



It has often been observed that I make a stronger claim in uttering (3) than (4):

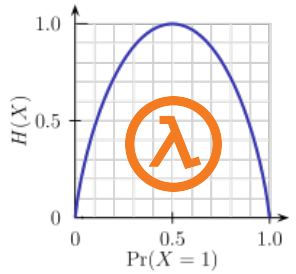
3) She climbed Mount Toby.

4) She must have climbed Mount Toby.

(Kratzer 1991, ‘Modality’)

For Kratzer, *must p* =/=> *p*.

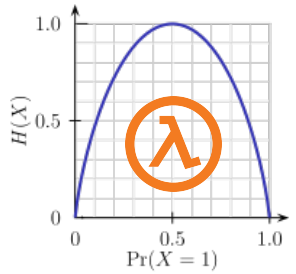
"The Mantra"



Confronted with Karttunen's problem, semanticists have reacted with an overwhelming consensus that the meaning of epistemic *must* needs to be weaker than classically predicted and weaker than the bare prejacent – a consensus that has **mantra** status.

von Fintel & Gillies 2010,
"*Must* … stay … strong!"

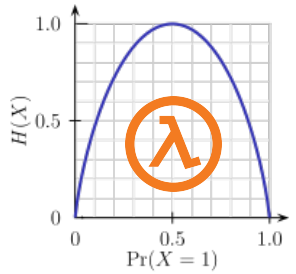
counter-proposal



[I]nstead of having a weak semantics, *must* presupposes the presence of an indirect inference or deduction rather than of a direct observation. This is independent of the strength of the claim being made. Epistemic *must* is therefore quite similar to evidential markers of indirect inference …

von Fintel & Gillies 2010,
"*Must* … stay … strong!"

indirectness ≠ weakness

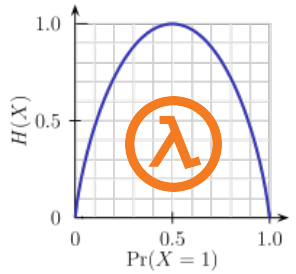


vFG emphasize: logical weakness and indirectness of evidence are orthogonal.

- Conclusions derived from indirect sources can be maximally strong.
- Example: mathematical or logical arguments.

This is clearly correct. Could it be that we mistook indirectness for weakness?

vFG against weakness



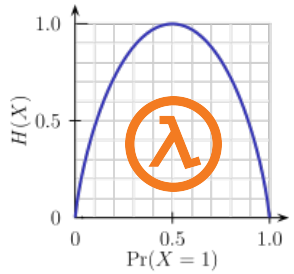
3 kinds of arguments:

- A1) *must* is not always weak
- A2) *must* is never weak
- A3) strong semantics makes available an attractive theory of evidential meaning

Responses:

- A1) only relevant to one class of Weak theories
- A2) corpus examples
- A3) problems with use to report induction

A1) uncertainty implicatures

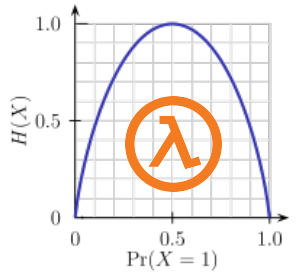


"*must* can be easily be used in contexts where there is no weakness attending the conclusion"

- $x^2 = 81$
- $x < 0$
- So, *x* must equal -9.

If *must p* =/=> *p,* we expect an uncertainty implicature.

A1) uncertainty implicatures



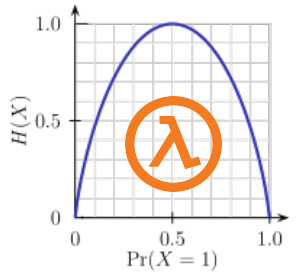
2 kinds of ‘weak’ theories:

a. *must* is weak but silent on direct/indirect
b. *must* is semantically weak **and** indirect

Problem for (a)-type theories, e.g. Kratzer, with a stronger expression entailing *must*.

I’ll push a (b)-theory: □p =/=> *must* p.

A2) *must* is never weak

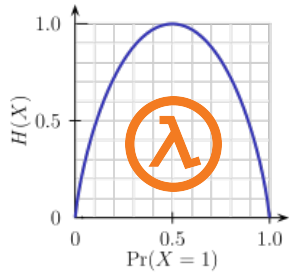


must p but perhaps not-p is contradictory

- problem only if = "true in ≥ 1 world in E"
- predicted if it's **defined** as *not must not*.

Response: "There *are* strong necessity epistemic modals. So pick one and take its dual (e.g., *there is a vanishingly small chance that*). It'll be horrible when paired with *must*, we promise."

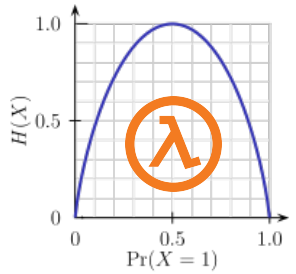
not so horrible after all



There's one missing pepper on the ground a few feet away. A closer look reveals it has been chewed by something. **I wouldn't put it past** that pesky blue jay to have teeth but then **I think it is unlikely** he does. **It must be a squirrel**.

(web)

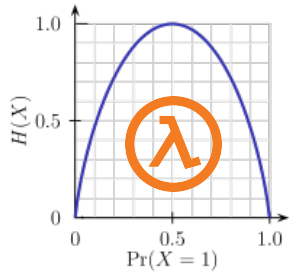
not so horrible after all



I refuse to believe that this one game … is crashing because my overclock is unstable …. **It's not impossible,** granted, but IMO **it is highly unlikely**. There ***must*** be some other cause.

Exx. only make sense if *must* admits uncertainty.

must is never weak, second try



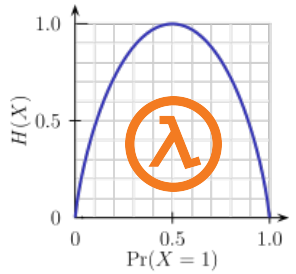
The following argument is intuitively valid.

- *If it's raining, Bill must be sad*
- *It's raining*
- *Therefore, Bill is sad*

But it is not logically valid if *must* is weak.

- Yes, but problematic only if our intuitions of argument strength track logical validity.
- Psychological research shows they don't: high conditional probability of conclusion is enough

plan



"The Mantra": *must p* is weaker than *p*

- von Fintel & Gillies' arguments against
- problems

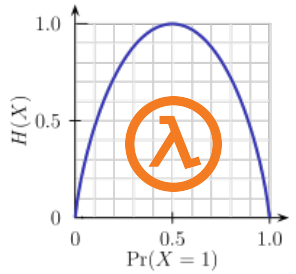
Inferential, not weak?

- conceptual problem: induction
- corpus data

Inferential **and** weak

- structured probabilistic models
- abductive and threshold semantics

vFG proposal



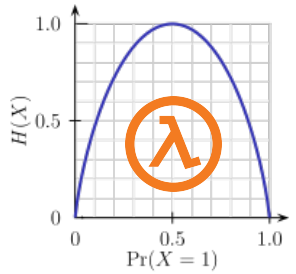
Epistemic states E are structured:

- K is the **kernel** – a set of propositions known from direct experience.
- E is K closed under logical deduction.

must p

- presupposes that neither p not not-p is in K.
- asserts that p is in E.

motivating example



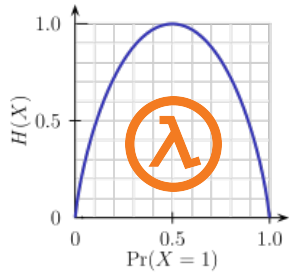
[People enter w/ wet raincoats, umbrellas]

Billy: *It must be raining*.

True and appropriate if K is (e.g.)

{*people are coming into the office with wet raincoats, people only come into the office with wet raincoats when it's raining*}

conceptual problem

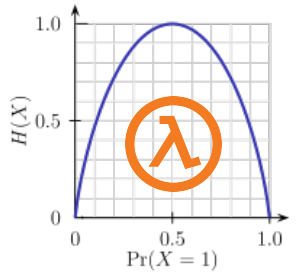


K has to include *People only come into the office with wet raincoats when it's raining.*

- Equiv.: *People never come in with wet raincoats when it's not raining.*
- Billy has **direct experience** of a **negative existential**?
- You can't **observe** non-existence of alternative explanations – that's an **inference** (indirect, usu. uncertain).

Inductive inference crucial in use of *must.*

empirical problems

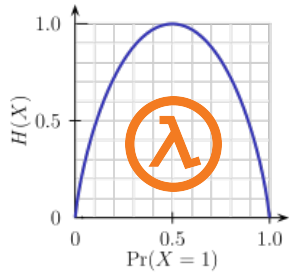


For vFG, s.o. who asserts *must p* either

1) knows *p* by deduction from directly known propositions;
2) doesn't, but believes they do;
3) is flouting conversational norms.

It's easy to find naturalistic examples where none of these options is plausible.

example: genealogy



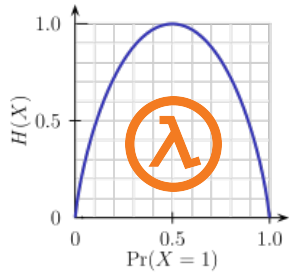
[T]he 1880 census shows her living with mom, two brothers, and her daughter ... So [the father] must have died before 1880.

The 'directly known' proposition:

The only way the father of a family in York County, PA in 1880 could fail to appear in the census is that he was dead.

– Author is presumably not this confused: father's death is presented as **best explanation.**

example: genealogy



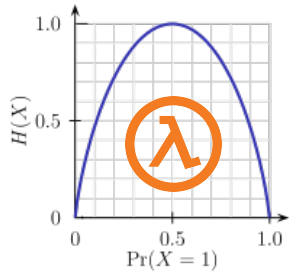
Goodman was still alive in mid-January 1621..., although not in good physical shape.... He is not listed among those who were part of the cattle division of 1627, so he must have died by then.

‘Directly known’ proposition:

The only way that a 17th-century farmer could fail to be in a list of farmers 6 years after an illness is that he died in the meantime.

‘Best explanation’ much more charitable gloss

usage of *must* on ancestry.com

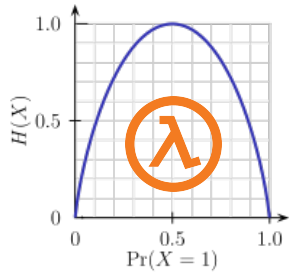


must p frequently used to mark *p* as an inference about activities & mental states of unknown, long-dead persons made using fragmentary information.

Not plausible that users (think they) have direct knowledge of anything that would entail *p*.

Better characterization: 'I can't think of a good explanation for the information that I have except the following: …' (cf. Stone 1994)

more genealogical discussion

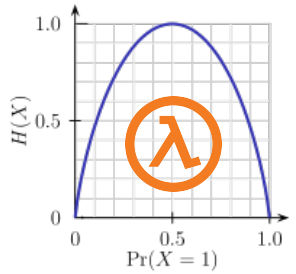


A1: [Y]our man Lazarus **must have sustained injuries** at [Buena Vista] by his death date. ...

B: 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 …

analytical hints



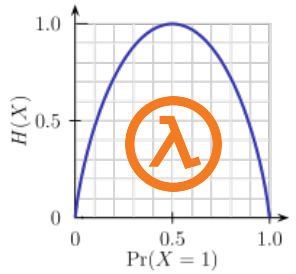
B cont: *[A]s we all know, disease took a heavier toll on the troops than actual enemy fire. [But] when I see a death date that close to the battle date, I tend to think that wounds played a part.*

B describes a statistical inference:

- low P(**wounded**|**died**)
- high P(**wounded**|**died & battle**)

wounded is best explanation of **died & battle**.

plan

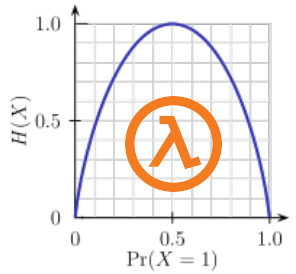


"The Mantra": *must p* is weaker than *p*
- – von Fintel & Gillies' arguments against
- – problems

Inferential, not weak?
- – conceptual problem: induction
- – corpus data

Inferential **and** weak
- – structured probabilistic models
- – abductive and threshold semantics

structured Bayesian model



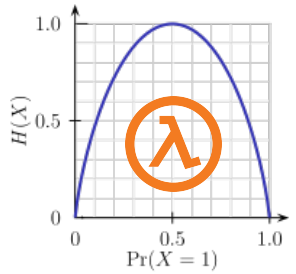
Agents represent uncertainty using probability distributions over sets of worlds.

1. $P : \wp(W) \rightarrow [0, 1]$
2. $P(W) = 1$
3. $A \cap B = \emptyset \Rightarrow P(A \cup B) = P(A) + P(B)$

These states are internally structured by partitions, aka **random variables**.

(AI: Pearl, 1988; psych: Tenenbaum et al., 2011)

structured Bayesian model



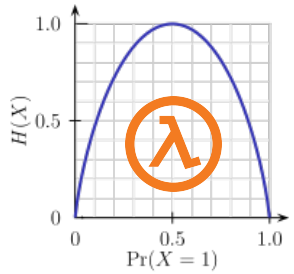
Random variable: a partition on W

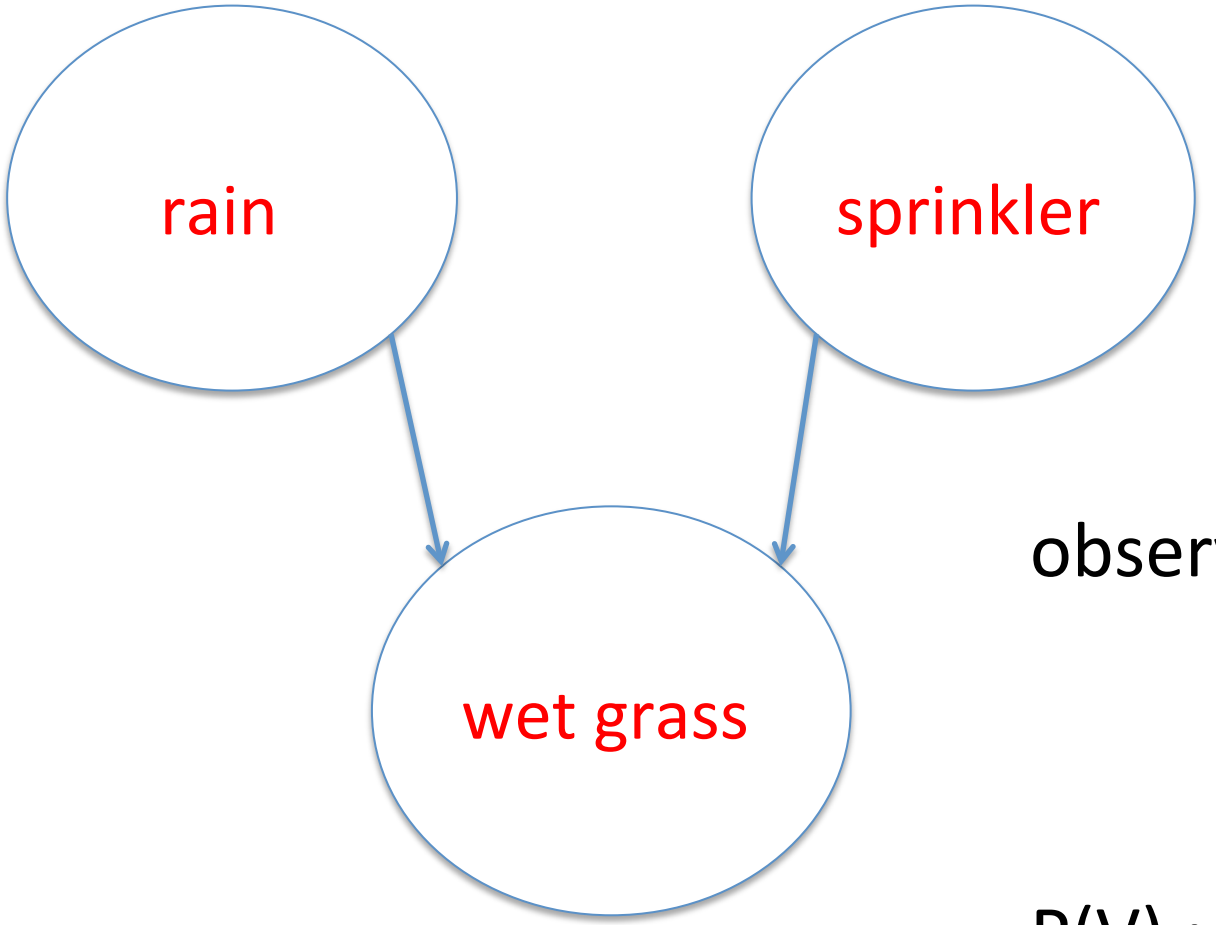
– equiv.: a G&S '84 question meaning.

$$\mathbf{rain}? = [|is\ \ it\ \ raining?|]$$
$$= \{\{w|\mathbf{rain}(w)\}, \{w|\neg\mathbf{rain}(w)\}\}$$

$$\mathbf{Dan\text{-}hunger} = [|How\ \ hungry\ \ is\ \ Dan?|]$$
$$= \{\{w|\neg\mathbf{hungry}(w)(\mathbf{d})\},$$
$$\{w|\mathbf{sorta\text{-}hungry}(w)(\mathbf{d})\},$$
$$\{w|\mathbf{very\text{-}hungry}(w)(\mathbf{d})\}\}$$

classic 3-RV structured model





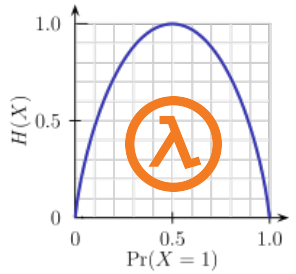
observe **wet grass** = 1:

update

P(V) := P(V | **wet grass** = 1)

(Pearl, 1988)

representing (in)direct info



V = variables represented in E.

(equiv: questions under consideration)

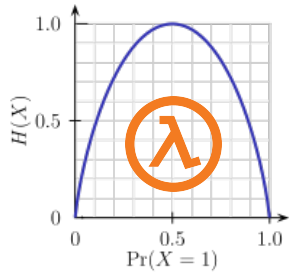
partitioned into V_D (directly observed) and V_I

Key Bayesian assumptions:

If Q in V_D, $P(Q = q) = 1$ for one cell

For Q in V_I, $P(Q = q) := P(Q = q \mid V_D)$

example



rain

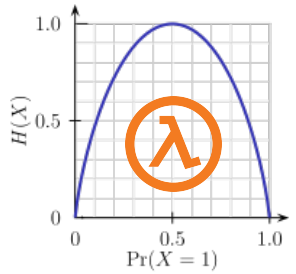
sprinkler

wet grass

conditioned on answers to Q in V_D

V_D: One answer has prob. 1, others 0

first pass: abductive semantics



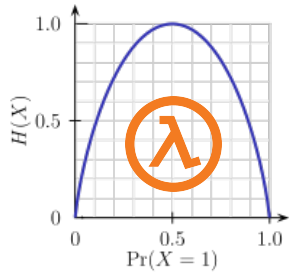
Formalizing best explanation + indirectness:

Let *q* be an answer to Q.

- **felicity:** *must q* infelicitous if Q is in V_D
- **truth:** *must p* is true iff

$$\text{for all } r \neq q \in Q : P(q) > P(r).$$

genealogical example

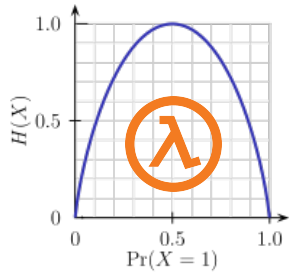


[The father] must have died before 1880.

- V_D = {[|*What is in the census record?*|]}
- V_I = {[|*Did David die before 1880?*|]}
- **felicity condition:** *q=David died before 1880* does not answer any question in V_D
- **truth condition:** given V_D,

P(*q*) > P(*not-q*)

too weak!

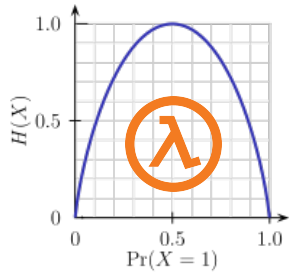


On the abductive semantics,

- for polar Q, *must q* requires P(q) > .5
- even weaker with large |Q|

Doesn't *must* at least entail *probably*?

threshold semantics



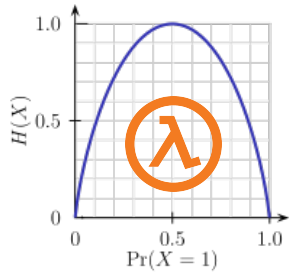
- **felicity:** *must q* infelicitous if *Q* is in V_D
- **truth:** *must q* is true iff

$$P(q) > \theta$$

where θ is a context-sensitive threshold.

Stronger as long as $\theta > .5$.

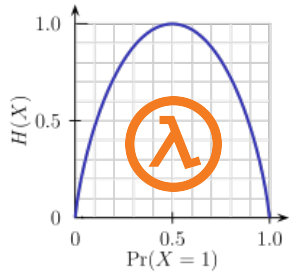
genealogical example



Your man Lazarus must have sustained injuries at Buena Vista by his death date….

- V_D = historical records available to author
- V_I = {[|*What was the cause of L's death?*|]}
- **felicity**: the record does not state whether L. was injured at Buena Vista.
- **truth**: P(**injury**) > θ
  - so, P(**injury**) > P(**illness**), P(**starvation**) …

what determines θ ?

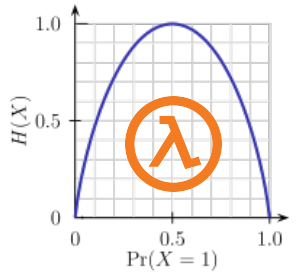


Context-sensitivity motivated by varying force; but how is it resolved?

- Bayesian inference (Lassiter & Goodman '13)
- inputs might include, e.g.,
  - lexical (*probably* : *must* :: *warm* : *hot*)
  - conversational stakes (Lewis 1979)
  - alternatives (*certainly, probably, …*)

corpora only tell so much: need experiments

must q vs. *certainly q* vs. *q*



must q does not entail *q* or *certainly q*

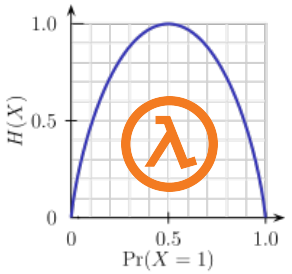
all 3 are compatible and may compete.

- In logical arguments, choose *must* to mark indirectness explicitly.
- Independent of strength, as vFG observe.

Is *must q* always (ever?) determinately true or false?

- dunno. Proposal is neutral between contextualism, relativism, expressivism.

embeddings and combinations

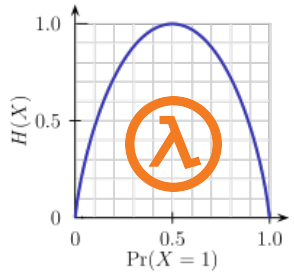


must appears with some frequency

- embedded in weak epistemic attitudes
- in combination with weak epistemics

The threshold semantics may give us a new line on these surprising combinations.

in weaker epistemic attitudes

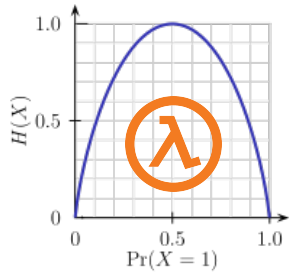


If the handgun was engraved or had some sort of fancier finish then **I figured he must be** a "pistolero." **I might have been wrong** but those were my initial impressions.

– Still signals indirect inference

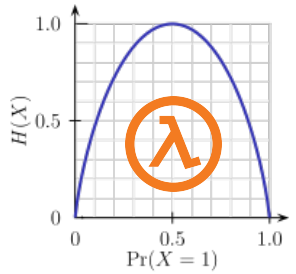
– reduced commitment associated with *figured*

in weaker epistemic attitudes



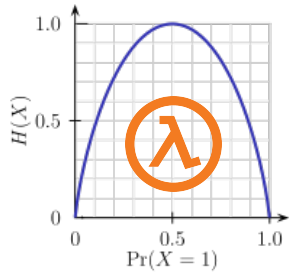
Last August, when they called me and asked whether I'd speak at The Global Leadership Summit held by the Willow Creek Associations, **I thought maybe** there **must** have been a mix up.

with weaker epistemics



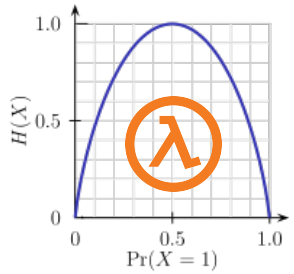
Almost certainly the site **must** have been inhabited well before that time, but in a place where virtually every square inch of land has been built and rebuilt upon many times over the centuries, **positive evidence is most difficult to uncover** ...

with weaker epistemics



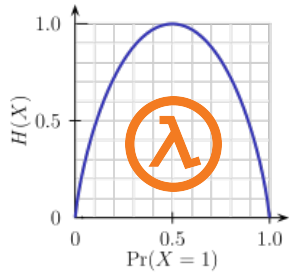
[I]n fact, the words we hear as ‘pity’ can also be translated to mean that when Jesus looked at the man, he ‘snorted like a war horse.’ Now that’s some kind of anger. It’s deeply rooted, instinctive even. As **perhaps** it **must** have been.

with weaker epistemics



Probably this **must** have been done before, but **I couldn't find enough information** on this in the ISIS doc & ISIS/GIS community forums.

sketch of analysis



perhaps q is true iff P(*q*) > $\theta_{perhaps}$

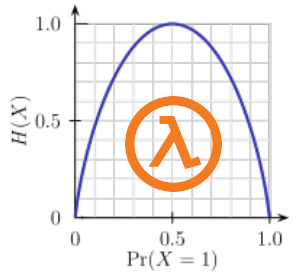
Other operators can bind *must*'s free θ:

perhaps must q

- has felicity condition of *must q*
- is true iff P(*q*) > $\theta_{perhaps}$

connection with 'modal concord' ?

summary



– vFG make a valuable contribution by drawing attention to *must*'s evidential signal

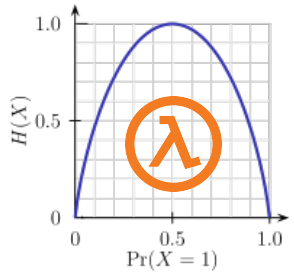
– but they're wrong that this is the entire source of the 'weakness' feeling:

The Mantra is correct.

– These ideas combine neatly in structured Bayesian models used in psychology, AI

– threshold semantics may help make sense of puzzling combinations with other epistemics

conclusion



Must is weak!
Must is weak!
Must is weak!
Must is weak!
Must is weak!
Must is weak!
Must is weak!
Must is weak!
Must is weak!
Must is weak!
…