

Modality in Branching Time

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14.11.2022

Structure

- 1 Puzzles
- 2 Modal flavours
 - Background
 - Problems
- 3 Tools
 - Branching time
 - Topic indices, situation indices
- 4 Solutions
 - Looking back
 - Looking forward
- 5 Modal weakness
 - Background

Puzzle one: modal flavours and aspect/tense

- (1) sie hat trainieren müssen
“she had to train” (mostly non-epistemic)
- (2) sie muss trainiert haben
 - a. “she must have trained (yesterday)”, epistemic
 - b. “she must have trained/ has to train (by next week)”, mostly non-epistemic

Puzzle two: The weakness of epistemic *must*

- (3) sie muss gestern trainiert haben
“she must have trained yesterday”
- (4) sie hat gestern trainiert
“she trained yesterday”

Modal flavours and modal forces

	Flavour	Force
<i>everyone can join the meeting</i>	deontic	∃
<i>everyone must join the meeting</i>	deontic	∀
<i>hydrangeas can grow here</i>	metaphysical/ realistic/...	∃
<i>trees must shed their leaves in winter</i>	metaphysical/ realistic/...	∀
<i>Danielle can swim</i>	dynamic	∃
<i>Lisa might be the culprit</i>	epistemic	∃
<i>Lisa must be the culprit</i>	epistemic	∀

Epistemic vs. non-epistemic

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Epistemic vs. non-epistemic

- [Kratzer \(1981\)](#) suggests that there is a basic split between epistemic and non-epistemic (root/ circumstantial) modal bases.
- Different non-epistemic flavours are a matter of ordering sources.
- [Rubinstein *et al.* \(2013\)](#) show that experts can distinguish root vs. epistemic modals fairly reliably, but not between more fine-grained modal flavours.

Kratzer: root modals

Modal auxiliaries below aspect (traditionally called “root modals”) are future oriented and are used to talk about propensities and potentials of people, things, and spatiotemporal locations, given their current circumstances.

- (10) a. *The glass can break easily.*
 b. *When you must sneeze, cover your mouth.*
 c. *Hydrangeas can grow there.*

Kratzer (2013: 188)

Kratzer: epistemic modals

Modal auxiliaries above aspect (traditionally called “epistemic modals”) represent assessments of the truth of propositions against a range of possibilities determined by a body of evidence.

- (11) a. *They must have forgotten.*
 b. *He might be around.*
 c. *Hydrangeas might be growing there.*

Kratzer (2013: 189)

Is it something about the syntax?

Different kinds of potential modal anchors become available at different stages of a syntactic derivation, and this explains why there can be a connection between modal flavor and syntactic positions.

Kratzer (2013: 191)

Hacquard: syntactic positions

(31)

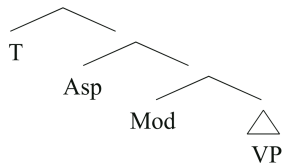
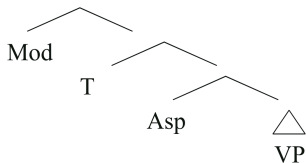


Figure: From Hacquard (2010: 96)

Hacquard: event variables

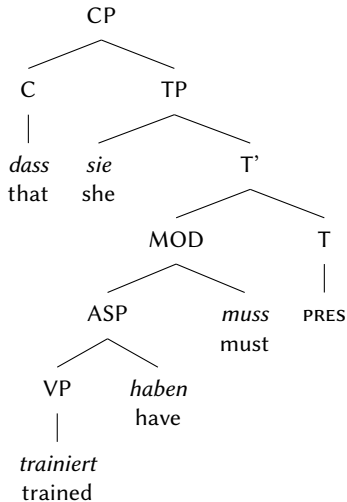
[...] beyond a root/epistemic distinction, modals seem to be relative to one of three kinds of individual/time pairs: speaker/speech time, attitude holder/attitude time, and VP-event participant/VP event time. These, I argued, could be obtained by anchoring the modal to speech, attitude, and VP-events, respectively.

Hacquard (2010:95)

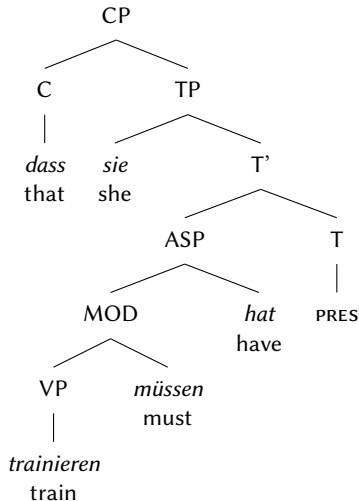
It's not (just) syntax

- (5) sie hat trainieren müssen
“she had to train” (mostly non-epistemic)
- (6) sie muss trainiert haben
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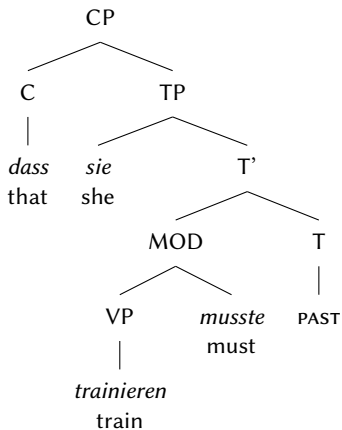
Syntactic projections: *muss trainiert haben*



Syntactic projections: *hat trainieren müssen*



Syntactic projections: *musste trainieren*



Interim: Problems with a syntax-based solution

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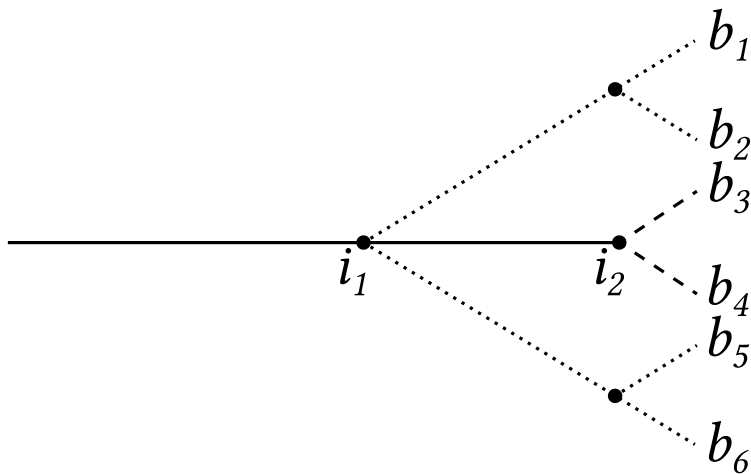
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 - or **after** the actual present

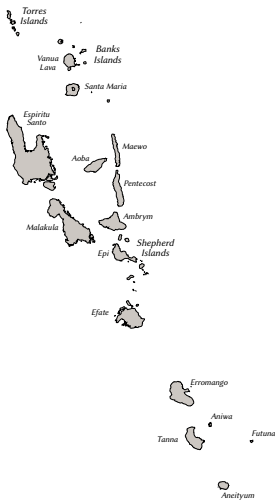
Interim: Problems with a syntax-based solution

- The same form *sie muss trainiert haben* can have an epistemic and a non-epistemic reading, depending on whether
 - the training is supposed to take place before
 - or after the actual present
- In the case of simple past (Präteritum Indikativ), interpretations cannot be derived from syntactic positions at all.

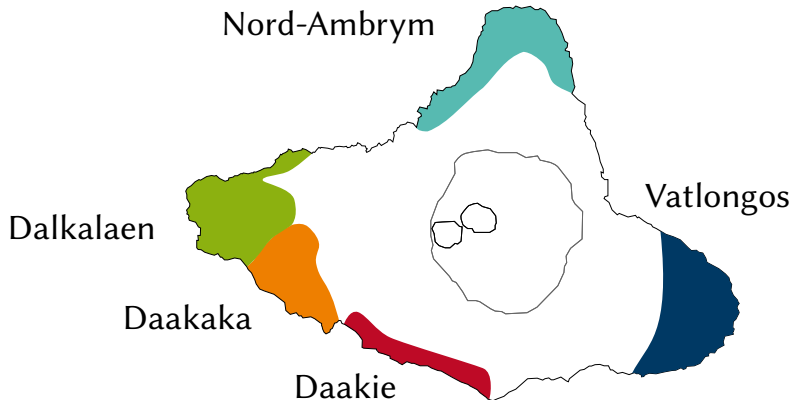
Traditional branching time



Vanuatu



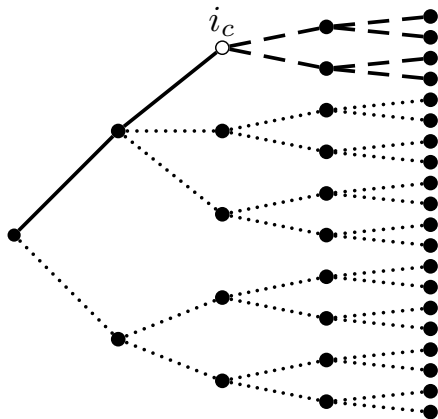
Ambrym languages



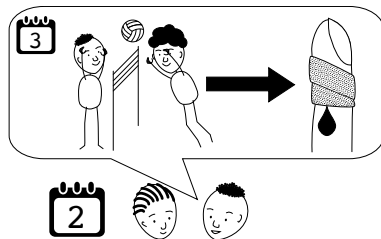
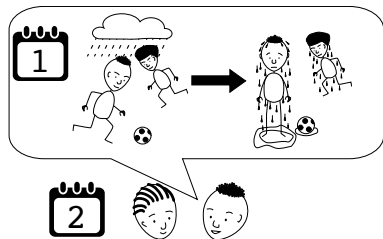
Daakaka TAM

	enclitic	proclitic	monosyllabic
Pos. Realis	<i>=m</i>	<i>mw=</i>	<i>mwe/mV</i>
Neg. Realis			<i>to</i>
Pos. Potential	<i>=p</i>	<i>w=</i>	<i>wV</i>
Negative Potential	<i>=n</i>		<i>nV</i>
Distal	<i>=t</i>	<i>t=</i>	<i>tV</i>
Open Polarity			<i>doo</i>
Change of State			<i>bwet</i>

Tripartite branching time



Mapping irrealty: storyboards



Mapping irrealty (with Krajinović, Ana; Krifka, Manfred; Guérin, Valérie; Franjeh, Michael)

Irrealis is real

 **Irrealis is real**

Kilu von Prince, Ana Krajinović, Manfred Krifka

Language

Linguistic Society of America

Volume 98, Number 2, June 2022

pp. 221-249

10.1353/lan.2022.0009

Article

<https://muse.jhu.edu/article/857153/>

Utterance time, Topic time, Situation Time

Klein (1994)

- Utterance time TU

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- Tense modifies the relation between TT and TU;

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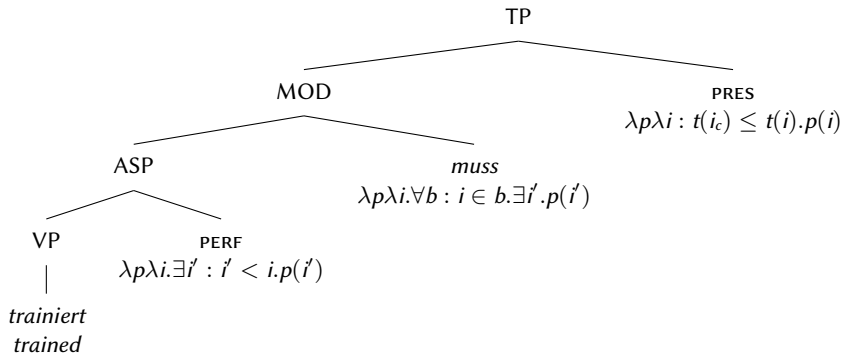
Klein (1994)

- Utterance time TU
- Topic time TT
- Situation time TSit
- Tense modifies the relation between TT and TU;
- Aspect modifies the relation between TSit and TT;

Aspect, Tense, and Modality

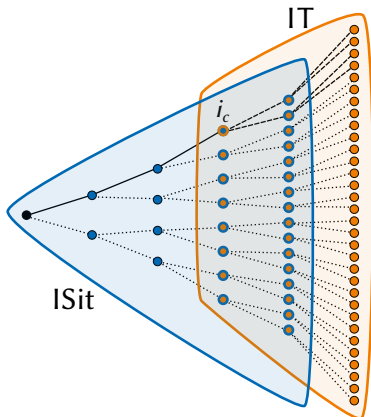
PRES IND	IT is simultaneous with or later than the actual present	$t(i_c) \leq t(i)$
<i>müssen</i>	in all branches through IT, there is an index ISit such that p is true	$\forall b : i \in b. \exists i'. p(i')$
PERFECT	ISit is a predecessor of IT	$i' < i$

muss trainiert haben (“must have trained”)



$$\lambda i : t(i_c) \leq t(i) . \forall b : i \in b . \exists i' \in b : \exists i'' : i'' < i' . \varphi(i'')$$

muss trainiert haben

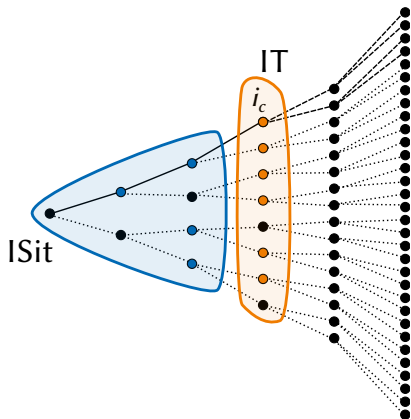


(7) Sie muss trainiert haben

- a. “She must have trained yesterday” (epistemic)
- b. “She must have trained (by the end of the week)” (not necessarily epistemic)

$$\lambda i : t(i_c) \leq t(i). \forall b : i \in b. \exists i' \in b : \exists i'' : i'' < i'. \varphi(i'')$$

Epistemic interpretations



- (8) Sie muss trainiert haben
“She must have trained
(in the past)” (epistemic)

Topic Time= Utterance Time;
TSit is temporally before TT,
includes counterfactual and
actual indices

$$\lambda i : t(i_c) \leq t(i). \forall b : i \in b. \exists i' \in b : \exists i'' : i'' < i'. \varphi(i'')$$

Deriving epistemic interpretations

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Deriving epistemic interpretations

- $TT = TU$, the topic time is simultaneous with the utterance time;
- $TSit < TU$, the situation time is prior to the utterance time;
- ISit includes both actual and counterfactual indices;
- We are generally not interested in counterfactual indices;
- If we include them nonetheless, we usually get an ignorance inference.

Non-epistemic interpretations of past-oriented modals

- Even when we quantify over both actual and counterfactual indices from a present perspective, we might get a non-epistemic interpretation:

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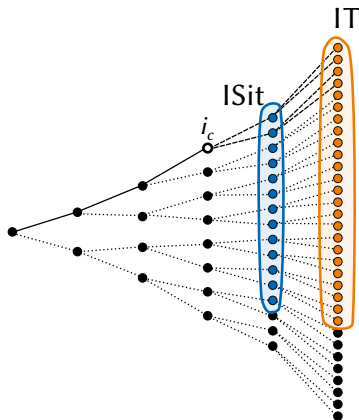
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- One way to think about this example is that somehow, quantification ends up ranging over individuals rather than indices, but don't ask me how.
- Ultimately, the interpretation of modals is pragmatic, all the way down.

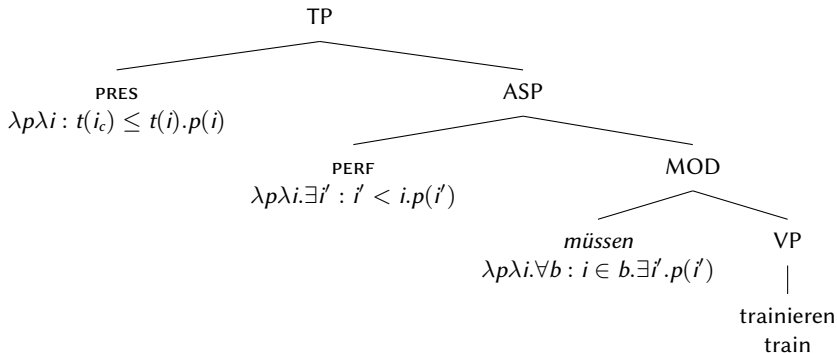
Non-epistemic present/future perfect



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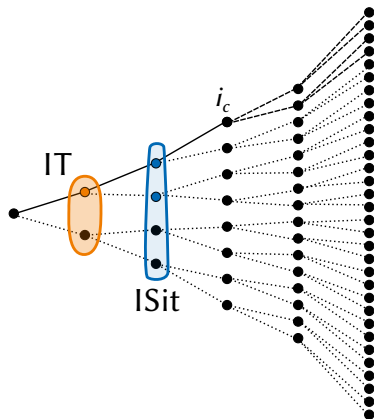
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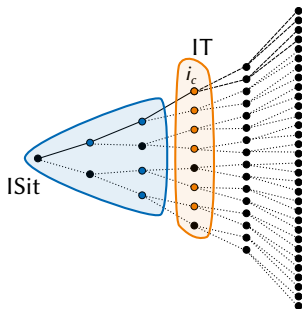
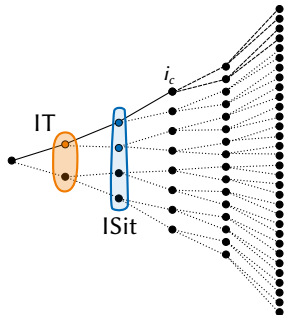
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Topic Time before Utterance
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TSit is after TT

In most contexts, IT will be re-
stricted to actual indices.

$$\lambda i : t(i_c) \leq t(i). \exists i' < i. \forall b : i' \in b. \exists i'' \in b. \varphi(i'')$$

Figure: *muss haben*, epistemicFigure: *hat müssen*, non-epistemic

- *muss haben*, epistemic:
 $\lambda i : t(i_c) \leq t(i). \forall b : i \in b. \exists i' \in b : \exists i'' : i'' < i'. \varphi(i'')$
- *hat müssen*, non-epistemic:
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- Quantifying forward will generally produce the inference that a specific set of rules, goals or circumstances conditions the possibility or necessity of an event.

The puzzle: the weakness of *must*

(12) Esra muss gestern trainiert haben
“Esra must have trained yesterday”

(13) ⊢ Esra hat gestern trainiert
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- The sentence in (13) gets an interpretation of **epistemic necessity**.

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- This means traditionally, that in all worlds that are compatible with the speaker’s knowledge, the Esra trained yesterday.
- But the commitment by the speaker to Esra’s being in her office seems significantly weaker than its implication.

Previous solutions

- von Fintel & Gillies (2010): *must* carries an evidential signal.
- Lassiter (2016): proposes “a new model that embeds an existing scalar theory into a probabilistic model of informational dynamics structured around questions and answers”.

Epistemic modality as ignorance inference

- (14) Q: Did Georgia smoke after dinner yesterday?
A: Georgia ALWAYS smokes after dinner.

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- The answer in (14) logically implies that Georgia did smoke after dinner that day.
- Yet, even though the assertion is stronger than the simple sentence *Georgia smoked after dinner yesterday*, the speaker commitment appears weaker.
- Violation of Grice's maxim of relation: The QUD is specifically about yesterday. The answer is not. So even though the answer **implies** an actual answer to the question, it does not represent one itself.

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- The other one is a deictic identification of the actual world.

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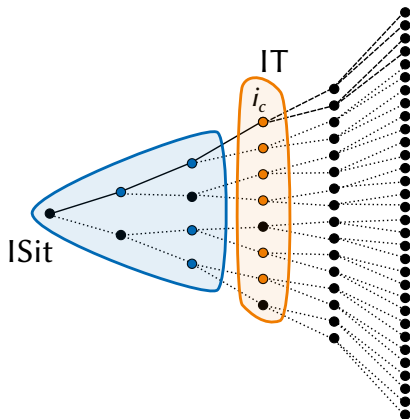
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Deictic vs. epistemic

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- The reasoning behind this is that the actual world is epistemically indistinguishable from many other worlds.
- However, I suggest we identify the actual world not through knowledge the entirety of its properties, but by pointing to it.
- We can say *in the actual world* the same way we can say *here* even when we don't know where we are, or *today*, even when we don't know what day it is.

Epistemic interpretations



- (15) Sie muss trainiert haben
 “She must have trained
 (in the past)” (epistemic)

$$\lambda i : t(i_c) \leq t(i). \forall b : i \in b. \exists i' \in b : \exists i'' : i'' < i'. \varphi(i'')$$

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Summary

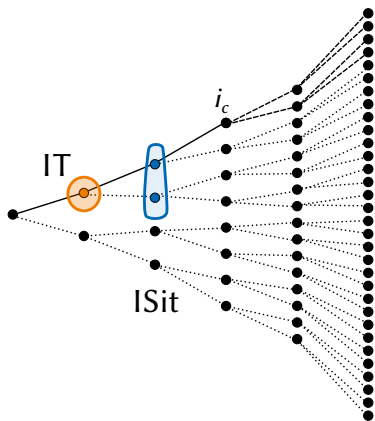
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Summary

- Differences in modal flavours derive in part from the domain of indices that is being quantified over, and from the temporal relation between i_c , IT and ISit.
- Epistemic interpretations are preferred in cases where ISit is prior to IT and contains both actual and counterfactual indices.
- Epistemic modality can be analysed as an ignorance inference: instead of answering a QUD about the actual world, we quantify over both actual and counterfactual worlds.
- This creates an inference of indirect evidence.

Thank you!

musste trainieren



(16) Sie musste trainieren
 “She had to train”
 (non-epistemic)

Topic Time before Utterance
 Time;
 TSit is after TT



References I

- Hacquard, Valentine. 2010. On the event relativity of modal auxiliaries. *Natural Language Semantics*, **18**, 79–114.
- Klein, Wolfgang. 1994. *Time in language*. London, Berlin: Routledge.
- Kratzer, A. 1981. The notional category of modality. *Pages 38–74 of: Words, worlds, and contexts. New approaches in word semantics*. Walter de Gruyter.
- Kratzer, Angelika. 2013. Modality for the 21st century. *Pages 181–201 of: 19th international congress of linguists*.
- Lassiter, Daniel. 2016. *Must*, knowledge, and (in)directness. *Natural Language Semantics*, **24**, 117–163.



References II

- Rubinstein, Aynat, Harner, Hillary, Krawczyk, Elizabeth, Simonson, Daniel, Katz, Graham, & Portner, Paul. 2013. Toward fine-grained annotation of modality in text. *In: Proceedings of the 10th international conference on computational semantics (IWCS), workshop on annotation of modal meanings.*
- von Fintel, Kai, & Gillies, Anthony S. 2010. *Must...stay...strong!* *Natural Language Semantics*, **18**, 351–383.