From Natural Logic to Natural Reasoning

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The goal

- To persuade you that one can do formal reasoning in natural language without translating it into a formal language, perhaps more than you thought possible. That's the Natural Logic part.

- To demonstrate that Natural Logic is not sufficient by itself for practical tasks such as RTE. It needs to be supplemented with pragmatic reasoning.

Outline

- A brief history of Natural Logic
  Monotonicity

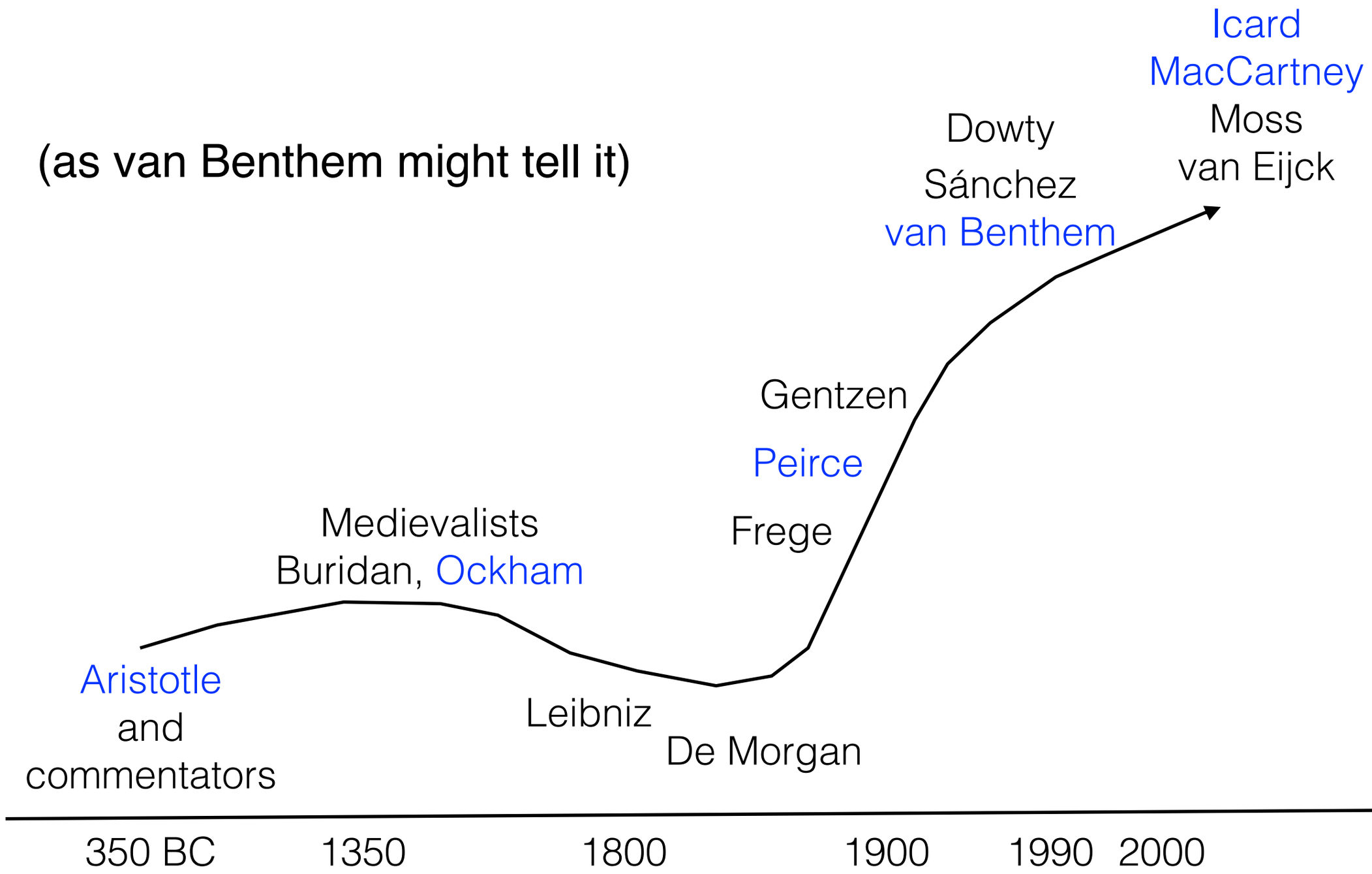
- Beyond monotonicity
  Implicative constructions

- Beyond Natural Logic
  Soft inferences
  Consonance/dissonance effect
  Lucky

- Conclusion
  (you just heard it)

A Brief History of Natural Logic

(as van Benthem might tell it)



Why the nadir at De Morgan?

- De Morgans Laws

  The negation of a conjunction is the disjunction of two negations.

  $\neg(p \wedge q) \equiv \neg p \vee \neg q$

  The negation of a disjunction is the conjunction of two negations.

  $\neg(p \vee q) \equiv \neg p \wedge \neg q$

- What did de Morgan get wrong?

  Every tail of a horse is a tail of an animal.

  is true in our world because every horse is an animal.

  Every tail of an animal is a tail of a horse.

  is false in our world because not every animal is a horse.

Every tail of a horse is a tail of a horse

- Given that every horse is an animal, why is it that substituting animal for first occurrence of horse

  Every tail of an animal is a tail of a horse.

  is an invalid inference but substituting animal for the second

  Every tail of a horse is a tail of an animal.

  is valid?

- Downward monotonic vs. upward monotonic contexts

(Every (tail of a horse)) (is a tail of a horse).

- A term in an upward monotone context can be replaced by a more general term: horse ⊏ animal.

Every tail of an animal is a tail of an animal

- A term in a downward monotonic context can be replaced by a more specific term: horse ⊐ animal

(Every (tail of an animal) (is a tail of an animal)).

(Every (tail of a horse) (is a tail of an animal)).

- Every ↓ ↑: Every is downward monotonic (= antitone) on its first argument, upward monotonic (= monotone) on the second.

De Morgan's error

- De Morgan set up a system for explaining the correct inference

  Every tail of a horse is a tail of a horse.

  ⊨ Every tail of a horse is a tail of an animal.

- But his system also derives the incorrect inference

  Every tail of an animal is a tail of an animal.

  ⊭ Every tail of an animal is a tail of a horse.

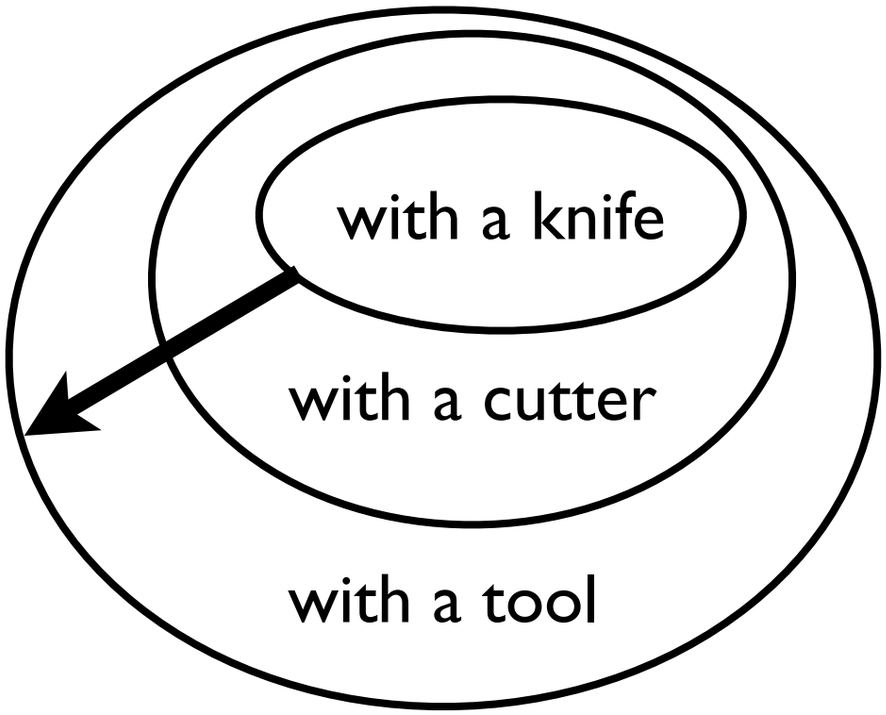
- Charles Sanders Peirce is the first logician in modern times to get a grip on monotonicity inferences.

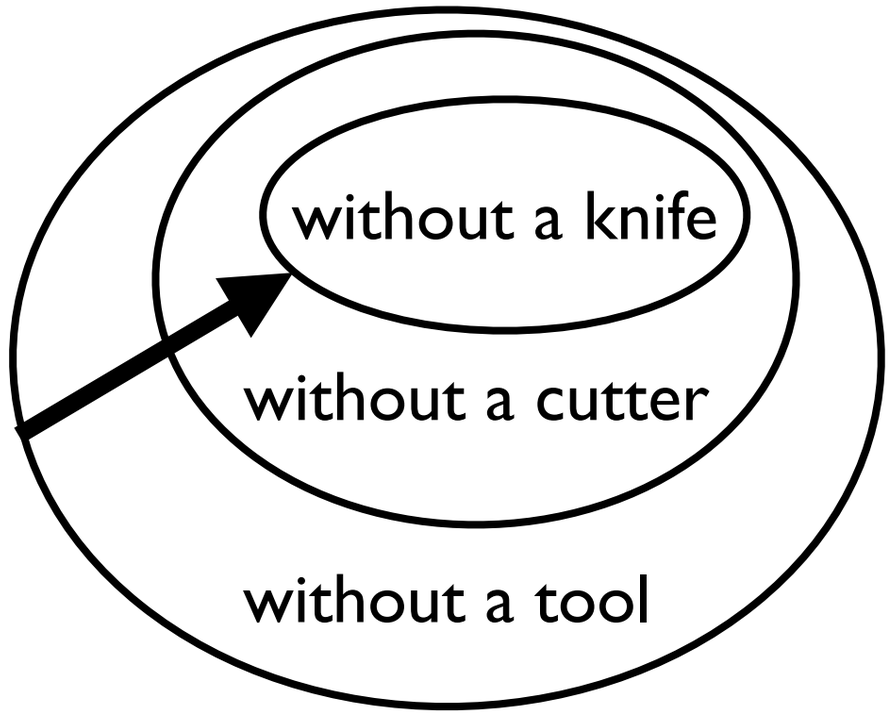
Monotonicity reasoning

- Some ↑ ↑: some small boys sang beautifully
  ⊏ some kids sang
  small boys ⊏ kids
  sang beautifully ⊏ sang
- No ↓ ↓: no tigers attacked people
  ⊏ no dangerous tigers attacked and killed people
  dangerous tigers ⊐ tigers
  attacked and killed ⊐ attacked
- Few = ↓: few students have a car
  ⊏ few students have a fancy car
- Many = ↑: many professors have a fancy car
  ⊏ many professors have a car

With↑ and Without↓

She did it …





Polarity matters

- Some ↑ ↑:

  It is not the case that some houses were damaged.

  ⊏ No small houses were damaged by fire.

  small houses ⊏ houses damaged by fire ⊏ damaged

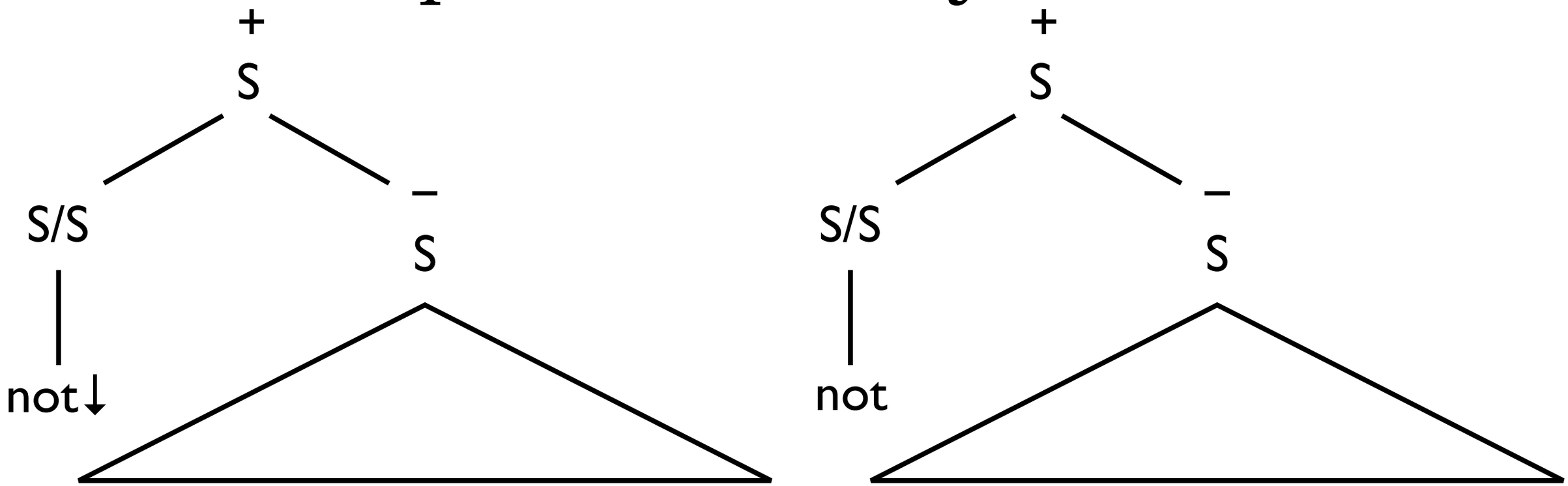
- Every ↓ ↑:

  Not every poor student has a car.

  ⊏ Not every student has a cheap car.

  poor student ⊐ student cheap car ⊏ car

Two-step monotonicity calculation



1. Assign POLARITY based on the operator signatures.

2. Convert polarities to upward/downward MONOTONICITY marks by counting the − signs from the leaf node to the root. If the number is even, turn − into +; if the number is odd turn + into −.

Beyond monotonicity

- James Dean refused to move without blue jeans.

  ⊏ Dean didn't dance without trousers.

(MacCartney & Manning, 2009)

blue jeans ⊏ trousers
dance ⊐ move

For these edits to be correct, move must be in a downward monotonic context and blue jeans in an upward monotonic context. What justifies turning refused to didn't?

\+ + ↓ − ↓ + +

James Dean refused to move without blue jeans.

Implicative constructions

Implicative constructions yield an entailment about the truth or falsity of their complement clause.

Some are simple verbs like *forget to* and *remember to*, some are phrasal constructions like *take the trouble to*.

There are six different kinds of implicative constructions. Each of them has one the six possible implicative signatures:

+/− −/+ +/○ −/○ ○/− ○/+

to be explained shortly. (Adopting MacCartney's notation to replace my ++|−−, +−|−+, ++, +−, −−, −+.)

Simple two-way implicatives

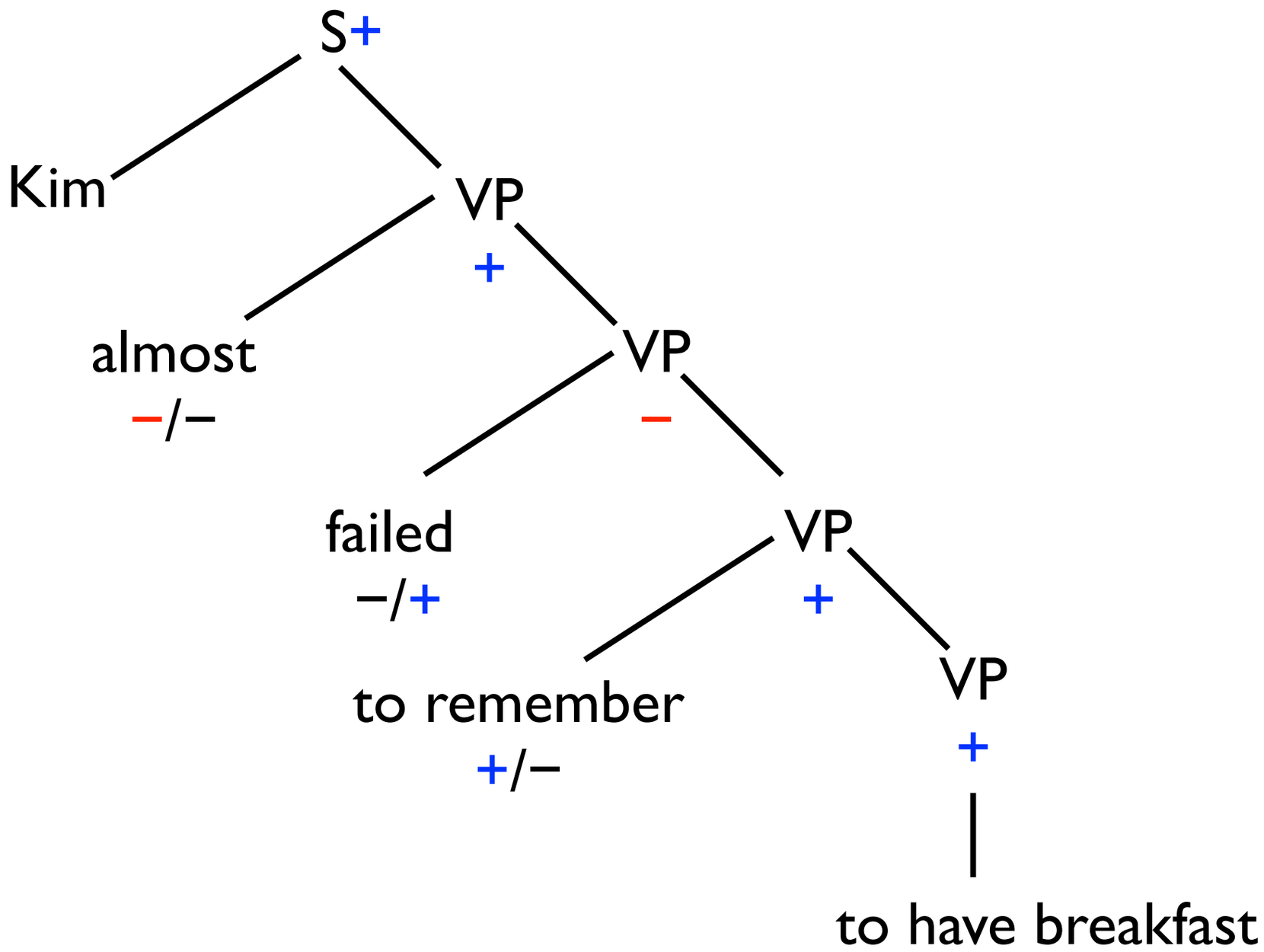
remember to X +/–	forget to X –/+
+ Kim remembered to X	+ Kim forgot to X
entails + Kim Xed	entails - Kim did not X
– Kim did not remember to X	– Kim did not forget to X
entails – Kim did not X	entails + Kim did X

Either way, there is a presupposition that
that Kim intended to or was expected to X.

More simple two-way implicatives

+/−	−/+
turn out that X	fail to X
manage to X	neglect to X
succeed in Xing	refrain from Xing
deign to X	avoid Xing
happen to X	
dare to X	

Example of a chain of implicatives



Kim almost failed to remember to have breakfast

⊏ Kim had breakfast.

Positive one-way implicatives

\+ Kim forced Mary to speak up. +/○

entails + Mary spoke up.

– Kim did not force Mary to speak up.

○ no commitment

\+ Kim prevented Mary from speaking up. –/○

entails – Mary did not speak up.

– Kim did not prevent Mary from speaking up.

○ no commitment

Negative one-way implicatives

− Mary was not able speak up. ○/−

entails − Mary did not speak up.

\+ Mary was able to speak up.

○ no commitment

− Mary did not hesitate to speak up. ○/+

entails + Mary spoke up.

\+ Mary hesitated to speak up.

○ no commitment

Simple and phrasal implicatives

Kim did not attempt to hide her feelings.

Kim made no attempt to hide her feelings.

Jim did not dare to speak to her.

Jim did not have the guts to speak to her.

Ed did not bother to come.

Ed did not take the trouble to come.

MacCartney relations

symbol	name	example	definition
x ≡ y	equivalence	couch ≡ sofa	x = y
x ⊏ y	forward entailment	crow ⊏ bird	x ⊂ y
x ⊐ y	reverse entailment	European ⊐ French	x ⊃ y
x ^ y	negation	human ^ nonhuman	x ∩ y = ∅ ∧ x ∪ y = U
x | y	alternation	cat | dog	x ∩ y = ∅ ∧ x ∪ y ≠ U
x ⌣ y	cover	animal ⌣ nonhuman	x ∩ y ≠ ∅ ∧ x ∪ y = U
x # y	independence	hungry # hippo	(all other cases)

MacCartney and Manning 2009

Two-way implicatives

+/− ≡ equivalence

Kim remembered to have breakfast. ≡ Kim had breakfast.

−/+ ^ negation

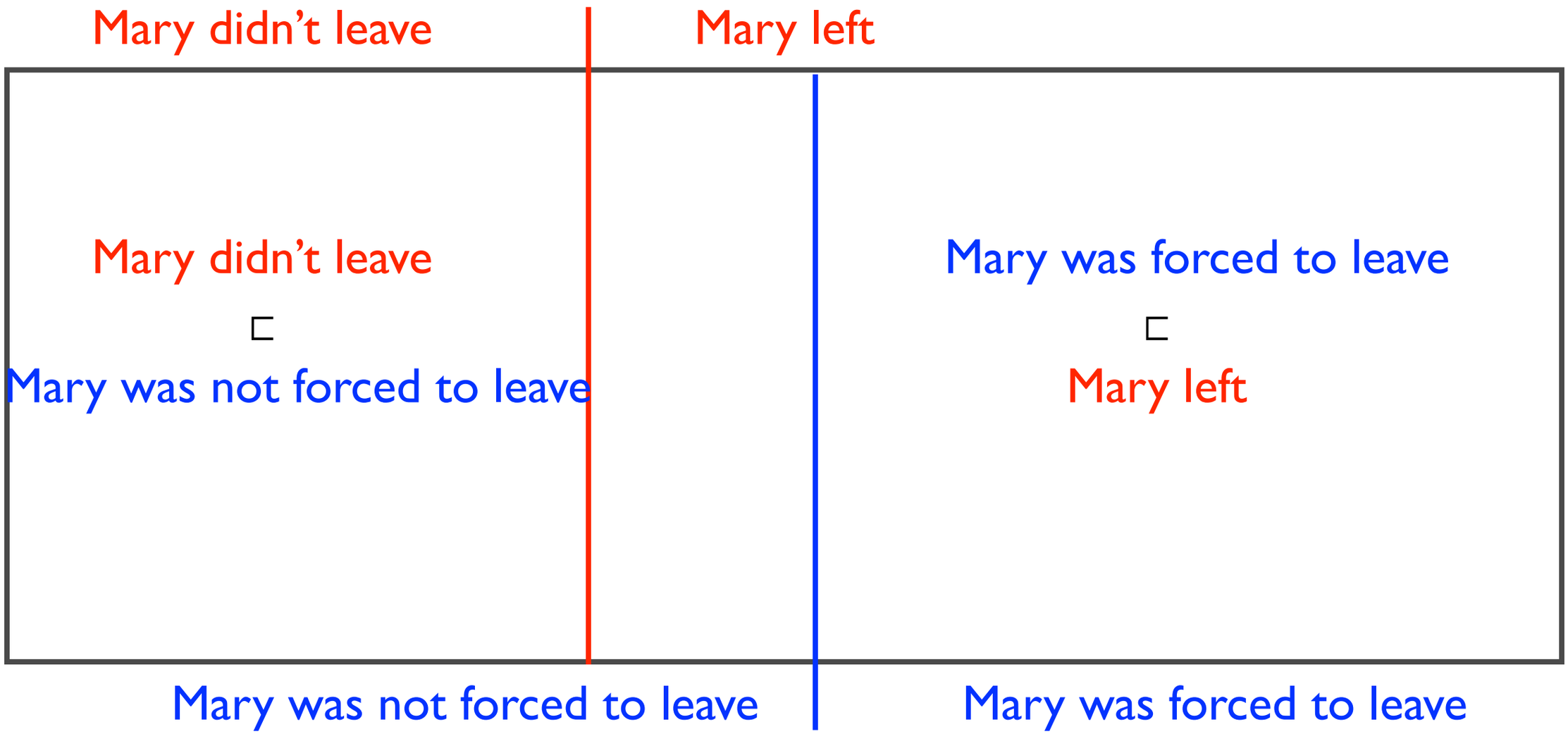
Kim forgot to have breakfast. ^ Kim had breakfast.

In MacCartney's system we can represent the truth-conditional part of the meaning of two-way implicatives, but not the additional component contributed by the main verb or the phrasal implicative construction.

One-way implicatives: +/○

The join of negation and cover is entailment: ^ ⋈ ⌣ = ⊏

Mary was not forced to leave ⌣ Mary left



Tentative conclusion

- You can do formal reasoning in natural language without translating it into a formal language, perhaps more than you thought possible, just using the syntactic structure and monotonicity and implicative properties of lexical items.

- But there are limits to what Natural Logic can do…

Beyond Natural Logic

- Soft inferences

  Inferences that not based on entailment or presupposition but legitimate unless explicitly counter-indicated by the situation or by the speaker.

- The consonance/dissonance effect

  Sentences of the form *NP was not ADJ to VP* can be understood *factively* implying that NP VPed or *implicatively* meaning that NP did not VP. The preferred interpretation is sensitive to the hearer's opinion of whether VPing would be ADJ or not.

- Lucky

  is one of the evaluative adjectives that show a strong consonance/dissonant effect: lucky to win a lottery vs. lucky to get cancer.
  In the future tense NP will be lucky to VP has a fascinating ambiguity between an optimistic 'NP will VP 'and a pessimistic 'NP will probably not VP 'interpretation. What does that depend on?

Soft Inferences

- be able ○/–

  She was able to respond but didn't bother to do so.
  New Zealand called and Kane Williamson was able to deliver.

  ⇝ Kane Williamson delivered.

- prevent –/○

  Her mother did not prevent her from visiting her father, but she never did.
  The language barrier did not prevent us from having a few laughs together.
  ⇝ We had a few laughs together.

- mean ○/○

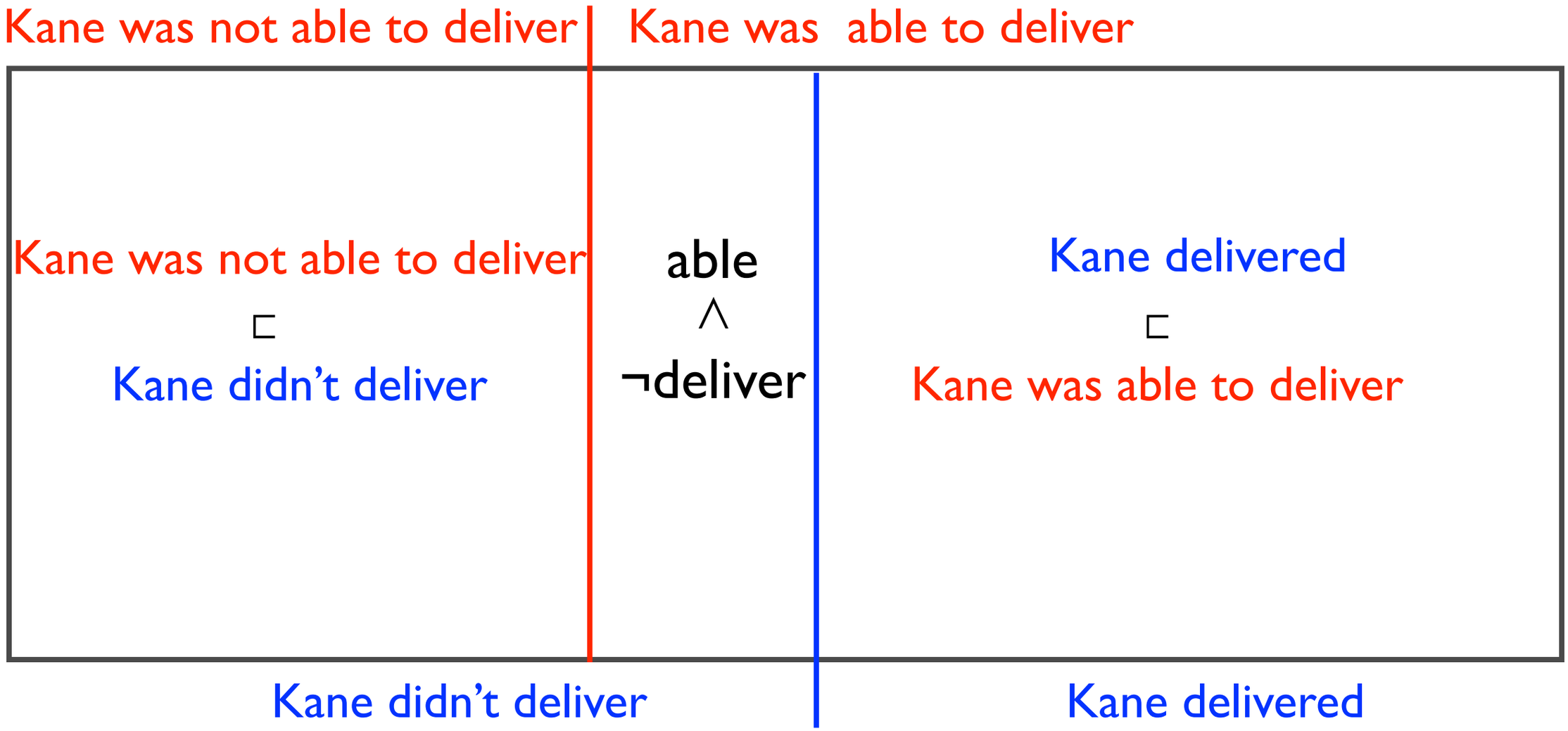
  I meant to answer your email right away. ⇝ I didn't

  I didn't mean to hurt your feelings. ⇝ I did

Pragmatic account?

Kane was able to deliver ⇝ Kane delivered — soft inference

Kane was able to deliver ∪ Kane didn't deliver — semantic relation



Consonance/Dissonance

- Constructions of the form *be ADJ to VP* are CONSONANT if it is generally thought that 'to VP would be ADJ.' *stupid - waste money*

- If it the prevalent opinion is that 'to VP would not be ADJ,' we have a DISSONANT construction. *clever - waste money*

- If there is no prevailing view of whether 'VPing would or would not be ADJ,' the construction is NEUTRAL. *clever - have a cold*

Consonance/Dissonance Effect

- The interpretation of sentences like

  John was not clever to take the best piece. (CONSONANT)

  John was not clever to take the middle piece. (NEUTRAL)

  John was not clever to take the worst piece. (DISSONANT)

  is influenced by the perceived relation between the adjective and the VP. Negation of a consonant relation is biased towards an implicative interpretation, negation of a dissonant relation favors the factive interpretation.

Consonance/Dissonance Effect

stimulus	adjective - complement relation	answers	Interpretation	%
R. was not clever to choose the best piece.	choosing the best piece is clever CONSONANT	R. chose the best piece.	**F**	25
		R. did not choose the best piece.	**I**	**64.2**
		undecided		10.7
R. was not clever to choose the worst piece.	choosing the worst piece is not clever DISSONANT	**R. chose the worst piece.**	**F**	**80**
		R. did not choose the worst piece.	**I**	10
		undecided		10
K. was not stupid to save money.	saving money is not stupid DISSONANT	**K. saved money.**	**F**	**78.6**
		K. did not save money.	**I**	14.2
		undecided		7.1
K. was not stupid to waste money.	wasting money is stupid CONSONANT	K. wasted money.	**F**	28.6
		K. did not waste money.	**I**	**66.7**
		undecided		4.8

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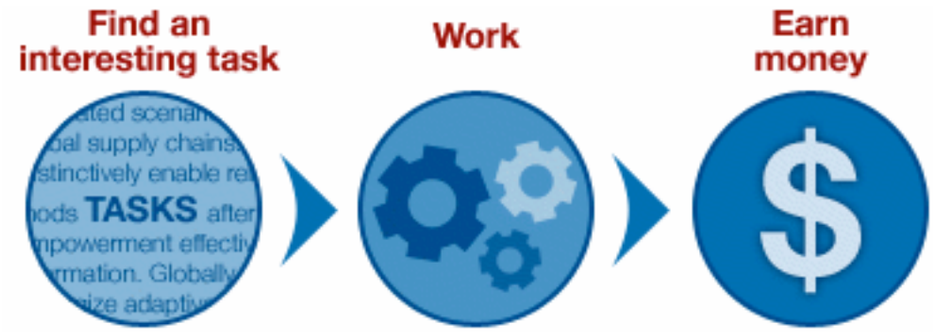

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Get Started

Experimental setup

Statement: Kim was not lucky to have a well-paying job.

Question: Does the author believe A or B?

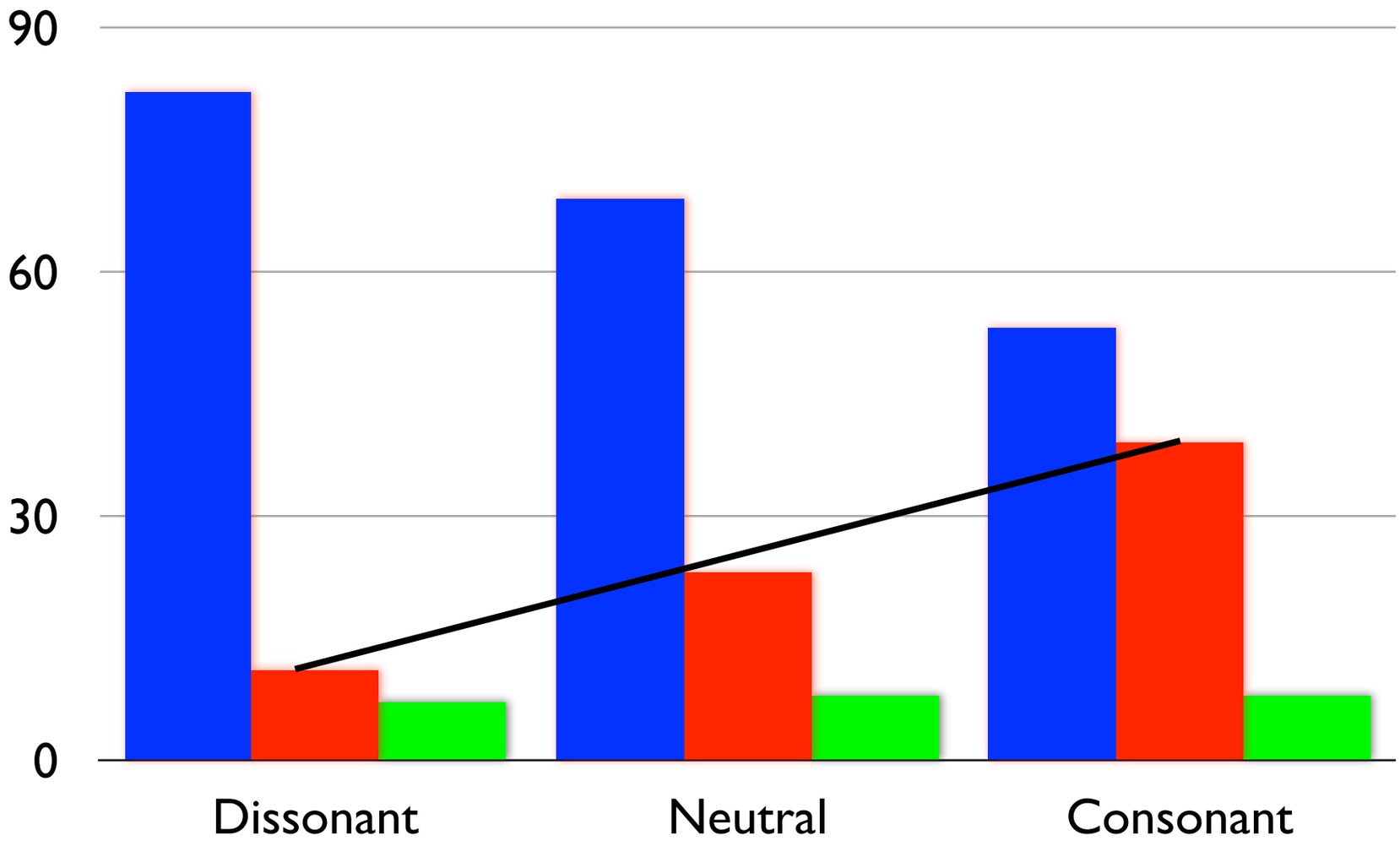
A: Kim did have a well-paying job.

B: Kim did not have a well-paying job.

Choose one answer based only on the given sentence.

- ○ A
- ○ B
- ◉ Cannot decide

Factive vs. Implicative

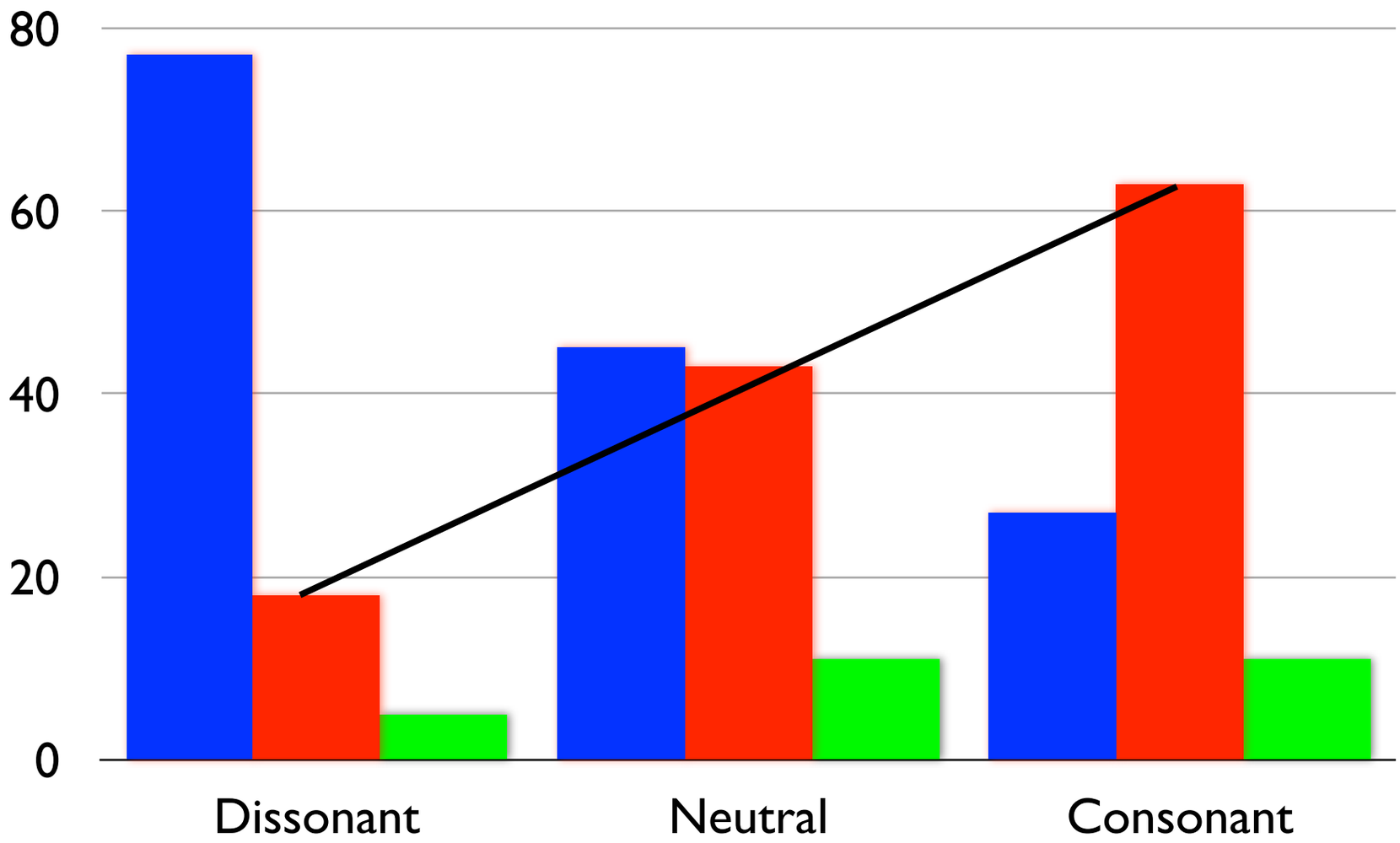


NP was not Adj to VP.

Did NP VP?

YES NO NEITHER

Results for *lucky*



NP was not lucky to VP.

Did NP VP? YES NO NEITHER

lucky or not?

- Pessimistic:

He will be lucky to get away with it. Even if he does, it is a formula for the Italianization of Spain.

`http://www.economist.com/node/14130653`

- Optimistic:

Half of you will be lucky to get away as winners while half of you will go home empty-handed.

`http://jimmakos.com/2013/08/make-money-fast-gambling/`

Necessary structural conditions for the pessimistic reading

- Future tense, future in the past, or generic

  You will be lucky to break even.

  We were going to be lucky to make it home before dark.

  Just a hundert years ago a man was lucky to live to be 40.

- Declarative

  Will she be lucky to survive? — No pessimistic reading, a genuine question.

- Affirmative

  She will not be lucky to survive. — No pessimistic reading, she will not survive.

Biases

- Negative polarity item in the VP favors the pessimistic reading

  I will be lucky to get any sleep this weekend.

  Motorola will be lucky to get another dime from me ever again.

- Existential adverb favors the optimistic reading

  You will be lucky to find an editor who can also typeset your completed book.

  You will sometimes be lucky to find an editor who can also typeset your completed book.

- Minimal vs. substantial benefit

  When staying in a hotel room you will often be lucky to have some sort of balcony, let alone a view.

  If you are there during the summer months, you will often be lucky to enjoy some great live music in the band shell they have on the site!

A message of hope

A promise

My future boyfriend will be so lucky to have me cooking yummy food like this every day ;)

http://twitpic.com/photos/Haleysadler

Variations

My future boyfriend will be so lucky to have me cooking yummy food like this for him every day.

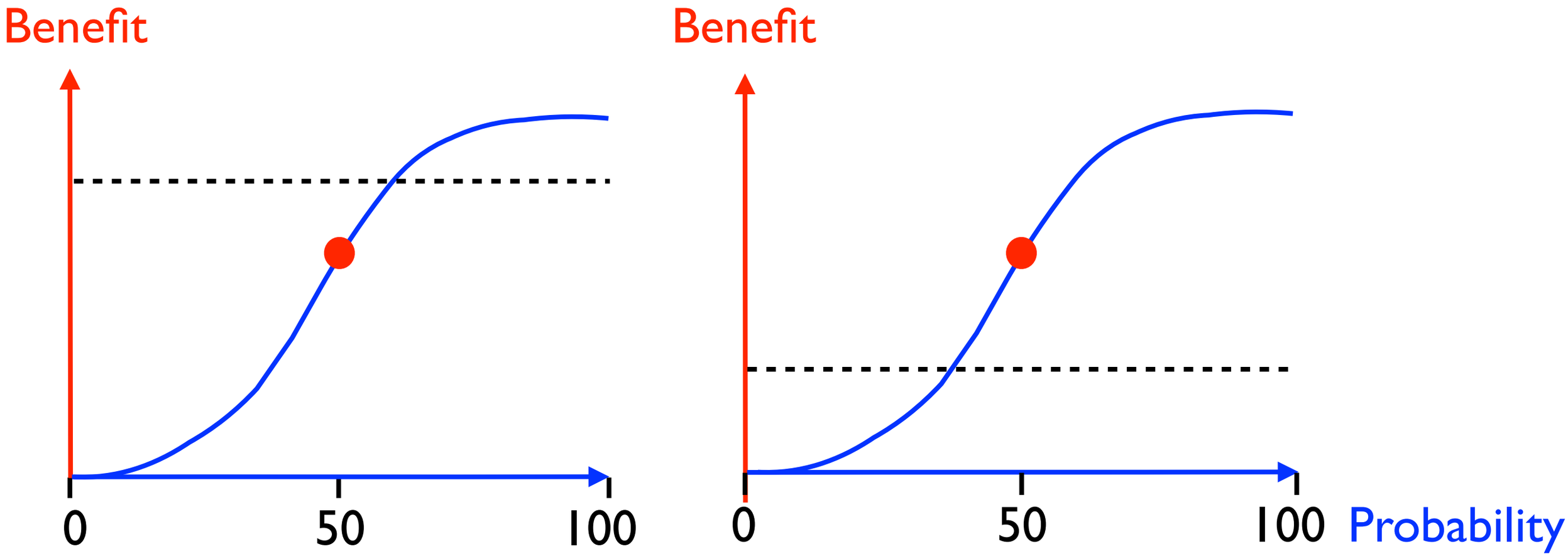
My future boyfriend will be so lucky to have me cooking yummy food for him every day.

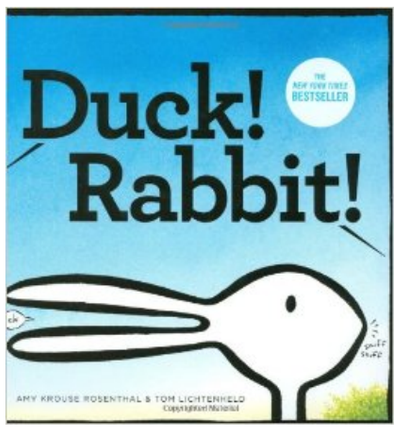
My future boyfriend will be lucky to have me cooking yummy food for him every day.

My future boyfriend will be lucky to have me cooking for him every day.

My future boyfriend will be lucky to have me cooking for him.
(Probably not)

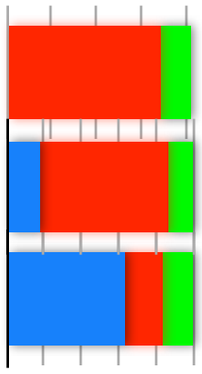
From maximal to minimal benefit
≈ from nearly certain to very unlikely





Positive threshold shifters

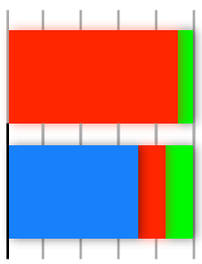
YES PROBABLY NOT NEITHER



You will be lucky to get a response within a reasonable time.

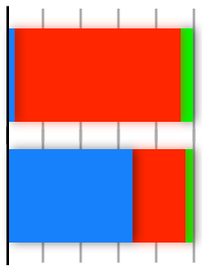
No doubt you will be lucky to get a response within a reasonable time.

At least you will be lucky to get a response within a reasonable time.



You will be lucky to find a buyer for your old car.

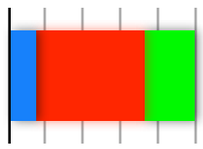
Perhaps you will be lucky to find a buyer for your old car.

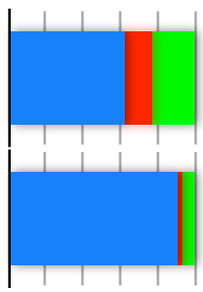


You will be lucky to find a good substitute.

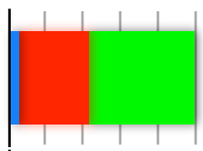
You will *sometimes* be lucky to find a good substitute.

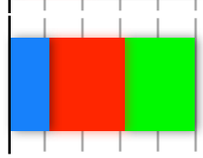
Propositional attitudes


She will be lucky to die instantly.


I wish that she would be lucky to die instantly.

I hope that she will be lucky to die instantly.


I think that she will be lucky to die instantly.


I am afraid the she will be lucky to die instantly

Alignment of preferences

She will be lucky to die instantly.

hope for the best, fear the worst

All her friends hope that she will be lucky to die instantly.

All her friends fear that she will be lucky to die instantly.

hope for the worst, fear the best

The cruel executioner hopes that she will be lucky to die instantly.

The cruel executioner fears that she will be lucky to die instantly.

Yet to be verified…

Conclusion

- One can do formal reasoning in Natural Logic without translating into a formal language,

- But Natural Logic needs to be supplemented with principles of pragmatic reasoning. It is not evident that switching to a formal logic would be the solution to the problems we have discussed.

- Opinions about the world and beliefs of the speaker's intentions have an effect on the interpretations and inferences we make.

Credits

The discussion of monotonicity comes from the course Annie and I taught on Natural Logic at Stanford.

The investigation of the consonance/dissonance effect is joint work with Cleo Condoravdi, Stanley Peters and Annie Zaenen. See our paper:

Karttunen, L., Peters, S., Zaenen, A., Condoravdi, C.: The chameleon-like nature of evaluative adjectives. In: *Empirical Issues in Syntax and Semantics 10*, pp. 233–250. CSSP, Paris (2014)

We are continuing the investigation of *lucky*.

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