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Scope asymmetry, QUDs, and exhaustification

1 Data

***Two/every-not* scope ambiguities**

(1) **Every horse** did**n't** jump over the fence.

a. **every > not** **(surface scope)**
None of the horses jumped over the fence.

b. **not > every** **(inverse scope)**
Not all of the horses jumped over the fence.

(2) **Two horses** did**n't** jump over the fence.

a. **two > not** **(surface scope)**
There are two horses that didn't jump.

b. **not > two** **(inverse scope)**
It is not the case that there are two horses that jumped.

Inverse scope endorsed for *every-not* but not for *two-not* A series of experiments by Musolino and Lidz (2003) found the following:

⋆ In a context where only the inverse scope reading is true, adults typically endorse the ambiguous every-not utterance, (3), but not the ambiguous two-not utterance, (4).

(3) *Context: Two out of three horses jump over a fence.*
Every horse didn't jump over the fence. $\boxed{\text{endorsed ✓}}$

a. every > not (surface scope, F)

b. not > every (inverse scope, T)

(4) *Context: One out of two horses jumps over a fence.*
Two horses didn't jump over the fence. $\boxed{\text{not endorsed ✗}}$

a. two > not (surface scope, F)

b. not > two (inverse scope, T)

Quantifying scope endorsement for ambiguous *two-not* utterance

⋆ In contexts where **both surface and inverse scope were true**:
- Strong surface scope bias (75% surface, 7.5% inverse, 17.5% unclear) for the ambiguous *two-not* utterance.

(5) *Context:* Cookie Monster ate 1/3 pizza slices.
Cookie Monster didn't eat two pizza slices. $\boxed{\text{75\% surface, 7.5\% inverse}}$

a. two > not (surface scope, T)
b. not > two (inverse scope, T)

⋆ In contexts where **only the surface scope was true**:
- 100% endorsement for the ambiguous *two-not* utterance.

(6) *Context: 2/4 horses jump over a fence.*
Two horses didn't jump over the fence. $\boxed{\text{endorsement 100\%}}$
a. two > not (surface scope, T)
b. not > two (inverse scope, F)

⋆ In contexts where **only the inverse scope was true, without explicit linguistic contrast**:
- 27.5% endorsement for the ambiguous *two-not* utterance.

(7) *Context: 1/2 horses jump over a fence.*
Two horses didn't jump over the fence. $\boxed{\text{endorsement 27.5\%}}$
a. two > not (surface scope, F)
b. not > two (inverse scope, T)

⋆ In contexts where **only the inverse scope was true, with explicit linguistic contrast**:
- 92.5% endorsement for the ambiguous *two-not* utterance.

(8) *Context: 1/2 horses jump over a fence.*
Two horses jumped over the rock but two horses didn't jump over the fence.
$\boxed{\text{endorsement 92.5\%}}$
a. two > not (surface scope, F)
b. not > two (inverse scope, T)

Three puzzles

P1 ***Two-not* true surface vs. *two-not* true inverse:**

Why does the ambiguous *two-not* utterance get endorsement at ceiling (100%) in the (only surface true) 2/4 context but low endorsement (27.5%) in the (only inverse true) 1/2 context?

P2 ***Two-not* true inverse without contrast vs. *two-not* true inverse with contrast:**

Why does explicit contrast cause endorsement to increase so dramatically (from 27.5% to 92.5%) in the (only inverse true) 1/2 context?

P3 **(*Two-not* surface vs. inverse) vs. (*every-not* surface vs. inverse):**

In default contexts, why is there surface scope bias for the two-not utterance but not the every-not utterance?

2 Proposal

2.1 The meaning of numerals / ambiguity based on exhaustification

⋆ Horn (1972): a bare numeral such as *two* comes with a basic *at least* meaning and then derives its *exactly* meaning via implicature:

(9) Two horses jumped.
$\rightarrow$ At least two horses jumped. (entailment)
$\rightsquigarrow \neg$ At least three horses jumped. (implicature)
Exactly two horses jumped.

⋆ Chierchia et al. (2012): that this whole process unfolds via a silent grammatical exhaustivity operator *O* (named so because of its affinity to a silent *only*):

(10) O(Two ($\geq$ 2) horses jumped) = Exactly two horses jumped.

⋆ The addition of this new operator means that our ambiguous two-not utterances are ambiguous not only with respect to the relative scope of the numeral/negation, but also with respect to whether *O* is or isn't present. For our purposes this translates into whether the numeral is interpreted as *at least* or *exactly*.

2.2 The generation of QUDs (see tables on last page)

⋆ I propose that utterances come with certain implicit QUDs for each possible parse.
⋆ For scopally unambiguous utterances there can still be multiple parses based on possibilities for exhaustification.

(11) Two horses jumped over the fence.
- a. At least two horses jumped over the fence. QUD: Did at least two?
- b. Exactly two horses jumped over the fence. QUD: Did exactly two?

(12) Every horse jumped over the fence. QUD: Did every horse jump?

⋆ For scopally ambiguous utterances parses come from possibilities for exhaustification plus possible scope configurations.

(13) Two horses didn't jump over the fence.
- a. two > not
  - (i) At least two horses didn't jump over the fence. QUD: Did at least two not?
  - (ii) Exactly two horses didn't jump over the fence. QUD: Did exactly two not?
- b. not > two
  - (i) It is not the case that at least two did. QUD: Did at least two?
  - (ii) It is not the case that exactly two did. QUD: Did exactly two?

(14) Every horse didn't jump over the fence.
- a. every > not QUD: Did all not?
- b. not > every
  - (i) Not every horse jumped over the fence. QUD: Did all?

(ii) Not every horse jumped, but some did. QUD: Did some but not all?

2.3 Endorsement model (part 1)

⋆ A pragmatic speaker reasoning about a pragmatic listener will endorse an ambiguous utterance in proportion to how likely a pragmatic speaker is to extract from it the true state of the world (Savinelli et al. 2018).

Pragmatic listener strategy #1:
Upon hearing an ambiguous utterance, a pragmatic listener is most likely to extract from it the parse that is logically the strongest.

⇒ **Endorsement criterion #1**:
Endorse the ambiguous utterance if your intended parse is logically the strongest.

2.4 Solving puzzles 1 and 2

P1 ***Two-not* true surface vs. *two-not* true inverse:**

Why does the ambiguous *two-not* utterance get endorsement at ceiling (100%) in the (only surface true) 2/4 context but low endorsement (27.5%) in the (only inverse true) 1/2 context?

For an ambiguous *two-not* utterance the parse that is always logically the strongest is the *Exactly two horses didn't jump* parse. The fact that this parse is a surface scope parse explains both (1) the high endorsement of the ambiguous utterance in the 2/4 context where the surface scope reading was true and (2) the low endorsement of the ambiguous utterance in the 1/2 context where the surface scope reading was false.

P2 ***Two-not* true inverse without contrast vs. *two-not* true inverse with contrast:**

Why does explicit contrast cause endorsement to increase so dramatically (from 27.5% to 92.5%) in the (only inverse true) 1/2 context?

The explicit contrast clause is a scopally unambiguous numeral clause with QUDs *Did at least two horses jump?* and *Did exactly two horses jump?*. Note that these are precisely the QUDs associated with the inverse scope reading of the ambiguous *two-not* utterance that follows. I argue thus that the effect of the explicit contrast clause is to prime the inverse scope QUDs, and implicitly bias towards an inverse scope parse. This explains the high endorsement for true inverse scope in this context.

But the strongest parse is a surface parse not just in the *two-not* case but also in the *every-not* case. How can we explain puzzle 3 (scope endorsement asymmetry for *two-not* but not for *every-not*)?

3 Endorsement model (part 2)

Pragmatic listener strategy #2:
Upon hearing an ambiguous utterance, a pragmatic listener is also likely to extract from it the parse that can settle the largest number of QUDs raised by the ambiguous utterance.

⇒ **Endorsement criterion #2**:
Endorse the ambiguous utterance if your intended parse is a parse that can settle the most of the QUDs raised by the ambiguous utterance.

3.1 Solving puzzle 3

P3 **(*Two-not* surface vs. inverse) vs. (*every-not* surface vs. inverse):**

In default contexts, why is there surface scope bias for the two-not utterance but not the every-not utterance?

For the *two-not* ambiguous utterance there is a unique parse that can settle all the QUDs associated with all the other parses. This is the *Exactly two didn't* parse which was also the logically strongest parse). No other parse can do that.

For the *every-not* ambiguous utterance all the parses can do that to an equal degree (both the surface and the inverse scope parses can settle all the QUDs equally), hence the endorsement for both the surface and the inverse scope.

4 Making sense of additional puzzles

⋆ Lots of experimental data (see Savinelli et al. 2018 and references therein) show that, while adults typically endorse the ambiguous *every-not* utterance in the 2/3 context with only inverse scope reading true, children often do not. We could capture this by saying that children don't care about Endorsement criterion #2 so they only endorse if the intended parse is logically the strongest.

5 Conclusion and outlook

Things I've tried to show:
⋆ We can account for the a number of puzzles related to scope endorsement if we adopt a certain view of QUDs and assume that endorsement is affected by both the logical strength of the intended parse relative to the relevant set of QUDs (all or just a subset) and by how well the intended parse can settle the QUDs raised associated with the ambiguous utterance.

Things I'm wondering about:
⋆ Endorsement criterion #1 corresponds to a fairly natural (and traditional) notion of maximizing strength. Is there a way to state Endorsement criterion #2 that would be more intuitive/natural?
⋆ Adults typically endorse both the surface and the inverse scope readings of *every-not* ambiguous utterances. I've argued that happens because, while Endorsement criterion #1 boosts the surface scope reading, Endorsement criterion #2 boosts both the surface scope reading and the inverse scope readings equally. This should results in good endorsement for both scope readings *but with a preference for surface scope*. Alternatively, it is possible that there is an additional factor at play, e.g., Endorsement criterion #3: Endorse unambiguous / most economical utterances. This would penalizes the ambiguous *Every horse didn't jump* on the every > not parse because it would be more economical to say *No horse jumped over the fence*. This should result in good endorsement for both scope readings *and no preference for surface scope*. It would be interesting to get some percentages for endorsement the way our starting data gave us for *two-not*. I don't know if they are already available.

References

Chierchia, G., Fox, D., and Spector, B. (2012). Scalar implicature as a grammatical phenomenon. In *Semantics: An international handbook of natural language meaning*, volume 3, pages 2297–2331. Berlin & Boston: de Gruyter.

Horn, L. R. (1972). *On the semantic properties of logical operators in English*. University Linguistics Club.

Musolino, J. and Lidz, J. (2003). The scope of isomorphism: Turning adults into children. *Language Acquisition*, 11(4):277–291.

Savinelli, K. J., Scontras, G., and Pearl, L. (2018). Exactly two things to learn from modeling scope ambiguity resolution: Developmental continuity and numeral semantics. *Cognitive Modeling and Computational Linguistics*.

Context: 1/2 horses jump over a fence. *Utterance:* Two horses didn't jump over the fence.			
Surface scope (two > not		Inverse scope (not > two)	
Parse	State	Parse	State
$\lvert P \cap \neg Q \rvert \geq 2$ 2 or more did not QUD: Did ≥ 2 not?	0	$\neg(\lvert P \cap Q \rvert \geq 2)$ not 2 or more did QUD: Did ≥ 2?	$0 \vee 1$
$O(\lvert P \cap \neg Q \rvert \geq 2)$ exactly 2 did not QUD: Did $= 2$ not?	0	$\neg O(\lvert P \cap Q \rvert \geq 2)$ not exactly 2 did QUD: Did $= 2$?	$0 \vee 1$
		$*O\neg(\lvert P \cap Q \rvert \geq 2)$ exactly 1 did	*1

Table 1: Parses, states, and QUDs for ambiguous *two-not* utterance in 1/2 context

Context: 2/4 horses jump over a fence. *Utterance:* Two horses didn't jump over the fence.			
Surface scope (two > not)		Inverse scope (not > two)	
Parse	State	Parse	State
$\lvert P \cap \neg Q \rvert \geq 2$ 2 or more did not QUD: Did ≥ 2 not?	$0 \vee 1 \vee 2$	$\neg(\lvert P \cap Q \rvert \geq 2)$ not 2 or more did QUD: Did ≥ 2?	$0 \vee 1$
$O(\lvert P \cap \neg Q \rvert \geq 2)$ exactly 2 did not QUD: Did $= 2$ not?	2	$\neg O(\lvert P \cap Q \rvert \geq 2)$ not exactly 2 did QUD: Did $= 2$?	$0 \vee 1 \vee 3 \vee 4$
		$*O\neg(\lvert P \cap Q \rvert \geq 2)$ exactly 1 did	*1

Table 2: Parses, states, and QUDs for ambiguous *two-not* utterance in 2/4 context

Context: 2/3 horses jump over a fence. *Utterance:* Every horse didn't jump over the fence.			
Surface scope (every > not)		Inverse scope (not > every)	
Parse	State	Parse	State
$\forall\neg$ all did not QUD: Did all not?	0	$\neg > \forall$ not all did QUD: Did all?	$0 \vee 1 \vee 2$
$O(\forall\neg)$ (O vacuous)	0	$\neg O(\forall)$ (O vacuous)	$0 \vee 1 \vee 2$
		$O(\neg\forall)$ some but not all QUD: Did some but not all?	$1 \vee 2$

Table 3: Parses, states, and QUDs for ambiguous *every-not* utterance in 2/3 context