Don't panic: The inverse reading of *most* conditionals

Sven Lauer and Prerna Nadathur

17th Annual Semantics Fest
Stanford University
March 11, 2016

Quantified Indicative Conditionals (QICs): Sentences whose subject is a nominal quantifier and which are modified by an **if**-clause.

(1) a. Every student passed if he studied hard.
 b. No student failed if he studied hard.

As of yet, **no consensus about a compositional analysis** (or whether one is feasible).

> "The embarrassment had been known for a long time, but nobody dared talk about it. Then Higginbotham (1986) dragged it into the open."
> (Kratzer in press)

1 "Reversed" readings

Kratzer (in press) observes that certain QICs have an unexpected reading:

(2) Most kids asked for calculators if they had to do long divisions.
 a. *Vanilla reading:*
 The majority of kids who had to do long divisions asked for calculators.
 $\#(\text{calculator users} \cap \text{long-divisioners}) > \frac{1}{2}\#(\text{long-divisioners})$
 b. *Reversed reading:*
 The majority of kids who asked for calculators were ones that had to do long divisions.
 $\#(\text{long-divisioners} \cap \text{calulator users}) > \frac{1}{2}\#(\text{calculator users})$

- On the *vanilla reading*, the **if**-clause appears to enter into the *restriction* of **most**, while the matrix clause provides its nuclear scope.
- On the *reversed reading*, it appears as if the matrix clause enters the restriction, while the **if**-clause provides the nuclear scope!

The reversed reading requires some contextual support (backgrounding of the consequent, and focus in the **if**-clause):

(3) You: Did you see kids using calculators when you volunteered in your son's school yesterday? What did they use the calculators for?

Me: *Most kids asked for calculators if they had to do LONG DIVISIONS.* But I am pleased to report that most kids in my son's school do long divisions by hand.

The problem: How do we derive this interpretation compositionally?

- Arguably, past-tense QICs do not involve a modal quantifier (**will, must, may, might**); how is the **if**-clause to be interpreted (cf. Kratzer 1986)?
- The simplest solution (cf. Leslie 2009) is to interpret **if** as restricting **most**.
- But, in combination with a standard generalized-determiner meaning for **most** (4), this only predicts the vanilla interpretation (5)

(4) $MOST[A][B] := |A \cap B| > |A - B|$

(5) $|\text{kids} \cap \text{long division} \cap \text{calculators}| > |\text{kids} \cap \text{long division} - \text{calculators}|$

Kratzer uses the reversed reading to support a startling conclusion about QICs: their perceived interpretation **does not arise compositionally!**

2 Kratzer's analysis

2.1 Good intentions...

- Kratzer starts by ruling out the possibility of interpreting QIC **if**-clauses as entering the quantifier restriction (based on arguments from von Fintel and Iatridou 2002, Leslie 2009, see appendix)

- Instead, QICs embed a (full, binary) conditional operator $\triangleright$ under the quantifier.

(6) (1b) $\equiv No_x[student(x)][\text{studied-hard}(x) \triangleright \text{failed}(x)]$

- Kratzer argues that $\triangleright$ should support the following inferences:

(7) **Modus ponens**
$\phi \triangleright \psi$ and ϕ jointly entail ψ

(8) **Contraposition**
$\phi \triangleright \psi$ entails $\neg\psi \triangleright \neg\phi$

(9) **Conditional excluded middle**
For all ϕ, ψ: either $\phi \triangleright \psi$ or $\phi \triangleright \neg\psi$

(10) **Weak Boethius' Thesis**
$\phi \triangleright \neg\psi$ entails $\neg(\phi \triangleright \psi)$

The result is **Pizzi and Williamson's (2005) "bombshell"**: Given a bivalent background logic, every connective $\triangleright$ that satisfies all four is equivalent to the *material biconditional*!

2.2 Domain restriction *ex machina*

Desperate times call for desperate measures . . .

- (Past-tense) QICs embed a *material conditional* under the nominal quantifier.

$$No_x[\text{student}(x)][\text{studied-hard}(x) \supset \text{failed}(x)]$$

- Nominal quantifier domains are restricted *pragmatically,* via **domain variables** (von Fintel 1994, Stanley and Szabó 2000).

- When the pragmatic restriction *just so happens* to associate with the antecedent of the embedded conditional, we get:

$$No_x[\text{student}(x) \wedge \text{studied-hard}(x)][\text{studied-hard}(x) \supset \text{failed}(x)]$$

- This makes the antecedent redundant in the embedded conditional, so is equivalent to:

$$No_x[\text{student}(x) \wedge \text{studied-hard}(x)][\text{failed}(x)]$$

2.3 Reversing

The "reversed" reading enters the picture at this point:

- If the pragmatic domain restriction happens as above (i.e., with the content of the antecedent of the embedded conditional, we obtain the vanilla reading of (2) (assuming the denotation for **most** in (4) above).

$$Most_x[\text{kid}(x) \wedge \text{long-divisions}(x)][\text{long-divisions}(x) \supset \text{calculator}(x)]$$

- Since the domain variable picks up its associate pragmatically, there should be additional possibilities; Kratzer suggests that this produces the "reversed" reading.

- If the domain variable picks up the conditional *consequent*, we get:

$$Most_x[\text{kid}(x) \wedge \text{calculators}(x)][\text{long-division}(x) \supset \text{calculator}(x)]$$

- This doesn't quite get us to (2b),[1] so Kratzer has to additionally postulate an embedded application of *conditional perfection* (Geis and Zwicky 1971) to get a biconditional from the material conditional:

$$Most_x[\text{kid}(x) \wedge \text{calculators}(x)][\text{long-division}(x) \equiv \text{calculator}(x)]$$
$$Most_x[\text{kid}(x) \wedge \text{calculators}(x)][\text{long-division}(x)]$$

- (Embedded perfection does not change the result in the previous cases.)

[1] In particular, these truth conditions are satisfied (assuming (4)) in the following scenario, contrary to intuition: The class contains twenty childen, 18 of which asked for calculators. Of those, 16 had to do logarithms, and 2 had to do long division. This means that the number of children satisfying kid(x) $\wedge$ calculators(x) $\wedge$ [long-division(x) $\supset$ calculator(x)] is 18, while the number of children satisfying kid(x) $\wedge$ calculators(x) $\wedge$ $\neg$[long-division(x) $\supset$ calculator(x)] is 0.

2.4 The end of the road?

Besides sacrificing compositionality, Kratzer's analysis ...

- ... postulates *embedded* conditional perfection.
  - But: Conditional perfection is generally considered a pragmatic inference.
  - And: In general, conditional perfection yields something weaker than a biconditional (von Fintel 2001)
  - So, instead of relying on a well-known inference, this instance of perfection would need to be derived by new means (embedded EXH?).
- ... predicts 'reversed' readings for *all* quantifiers (not just **most**).
  - But we do not seem to find such readings.

3 Inverse-proportional readings of *many*

3.1 An observation

The quantifiers *many* and *few* are known to have an "inverse proportional" reading that resembles the reversed conditional:

(11) Many Scandinavians have won the Nobel Prize in literature.
  a. *Cardinal:* The number of Scandinavians NP-lit winners is large
  b. *Standard proportional:* The ratio of Scandinavian NP-lit winners to Scandinavians is high
  c. *Inverse proportional:* The ratio of Scandinavian NP-lit winners to NP-lit winners is high (Westerståhl 1985)

Romero (2015), building on Cohen (2001), paraphrases the inverse-proportional reading as in (12); it only surfaces when the quantifier-restriction is focused:

(12) Many Scandinavians$_{foc}$ have won the Nobel Prize in literature.
$\rightsquigarrow$ The ratio of Scandinavian NP-lit winners to Scandinavians is high compared to the ratio of NP-lit winners from other world regions to the population of those regions.

This **many** needs the following truth conditions:

(13) *Many Ps are Q:*
$|P \cap Q| : |P| > \theta(|\textsc{alt}(P) \cap Q| : |\textsc{alt}(P)|)$
where θ determines a high standard by substituting P's alternatives

But, (13) is **non-conservative** ... which is a problem (cf. Barwise and Cooper 1981, Keenan and Stavi 1986, on natural-language quantifiers).

3.2 Restoring conservativity (making *many* great again)

Romero's proposal: (building on Hackl 2009, Schwarz 2010) natural-language **many** is the composition of a parametrized conservative determiner MANY (ambiguous between 14a and 14b) with the morpheme POS associated with bare gradable adjectives.[2],[3]

(14) a. $\text{MANY}_{\text{card}} := \lambda d_n \lambda P_{et} \lambda Q_{et}.\exists x : P(x)[Q(x) \ \& \ |x| \geq d]$, where n is the degree-type

b. $\text{MANY}_{\text{prop}} := \lambda d_n \lambda P_{et} \lambda Q_{et}.(|P \cap Q| : |P|) \geq d$

c. $\text{POS} = \lambda \mathbf{C}_{dt,t} \lambda P_{dt}.\exists d[P(d) \wedge d > \theta(\mathbf{C})]$, where $\mathbf{C}$ is a comparison class

Standardly, POS uses focus structure to determine the comparison class **C** against which the standard θ is generated: this comparison class is the set of sentence-level alternatives determined by substituting the focused element for its (relevant) alternatives.

The inverse proportional reading (5) arises when *many* = MANY_{prop} + POS co-occurs with a focus associate in the quantifier restriction, and POS scopes sententially:

(15) Many $\text{Scandinavians}_{foc}$ have won the NP in literature.

a. LF: $\big[[\text{POS } C]\big[1[t_1\text{-MANY}_{prop} \text{ Scandinavians}_{foc} \text{ have won NP-lit}]\big] \sim C\big]$

b. *Alternatives:* {ratio of Scandinavian NP-lit winners to Scandinavians, ratio of East-Asian NP-lit winners to East Asians, ratio of Balkan NP-lit winners to Balkans, ...}

c. (15a) ≡ the ratio of Scandinavian NP-lit winners to Scandinavians > θ(the ratio of E-Asian NP-lit winners to E-Asians, the ratio of Balkan NP-lit winners to Balkans, ...)

d. $\rightsquigarrow$ The ratio of Scandinavian NP-lit winners to Scandinavians is high compared to the ratio of NP-lit winners from other world regions to the population of those regions.

4 Our proposal

The decompositional analysis of **many** is independently motivated by Hackl's (2009) proposal that **most** is the composition of **many** with the focus-sensitive superlative morpheme **-est** (which scopes independently of its host; Heim 1999): [4]

[2]Penka (ms.) argues that $\text{M}\textsc{any}_{\text{prop}}$ can be dispensed with, with the three observed readings—cardinal, proportional and inverse-proportional—arising on the basis of $\text{M}\textsc{any}_{\text{card}}$, in interaction with Pos and focus interpretation.

[3]Hackl (2009) takes Many to uniformly be a gradable modifier with meaning $\lambda P.\lambda d.\lambda x.[P(x)\&|x| \geq d]$, assuming its quantificational force on apparently-quantificational uses is provided by a silent existential quantifier. Romero instead analyzes Many as a 'parametrized quantifier', as in 14. We follow her in this regard for **most** below.

[4]Like Romero (2015) (for POS), we set aside the question whether **-est** is conventionally or non-conventionally focus-sensitive (Beaver and Clark 2008), letting **-est** take a comparison class argument that is partially-determined by focus interpretation.

(16) a. MOST = MANY + *-est*

b. $[\![\text{-est}]\!] = \lambda \mathbf{C}_{dt,t} \lambda P_{dt}.\exists d\big[P(d) \;\&\; \forall C \in \mathbf{C}[C \neq P \rightarrow \neg Q(d)]\big]$ where **C** is a comparison class

- This predicts the existence of "inverse" readings for **most**-statements if they involve focus associates within the quantifier restriction.
- Kratzer's "reversed" (2b) is exactly this case ... if we assume that **if**-clauses directly restrict the domain of a nominal quantifier.

4.1 The derivation

- We represent **most** as MOST = $\text{MANY}_{\text{card}}$ + **-est**[5]
  - $\text{MANY}_{\text{card}}$ is concerned with measuring the number of elements that satisfy both property (P and Q) arguments.

    (14a) $[\![\text{MANY}_{\text{card}}]\!] = \lambda d_n \lambda P_{et} \lambda Q_{et}.\exists x : P(x)[Q(x) \;\&\; |x| \geq d]$
  - **-est** checks that its argument set has larger cardinality than any alternative's argument set.

    (16b) $[\![\text{-est}]\!] = \lambda \mathbf{C}_{dt,t} \lambda P_{dt}.\exists d\big[P(d) \;\&\; \forall C \in \mathbf{C}[C \neq P \rightarrow \neg Q(d)]\big]$
- As in (15), the focus-sensitive morpheme takes sentential scope: the comparison class alternatives are $\text{MANY}_{\text{card}}$-statements which substitute for *long divisions*
- **if** signals that its complement should be interpreted as the restriction of the determiner (in this case MANY)

(17) Most students asked for calculators$_{top}$ if they had to do long divisions$_{foc}$.

a. LF: $\big[[\text{-est } C]\big[1[t_1\text{-MANY}_{card}$ kids [asked-for-calcs if they had long-div$_F$]$\big] \sim C\big]$

b. *Alternatives:* $[\![\mathbb{C}]\!] \subseteq \{\lambda d'.d'$-many kids asked for calcs if they had long-div,
$\lambda d'.d'$-many kids asked for calcs if they had multiplications,
$\lambda d'.d'$-many kids asked for calcs if they had decimals, ...$\}$

c. $(17a) \equiv \exists d\big[\exists x : (\text{kid}(x) \;\&\; \text{long-div}(x))[\text{calc}(x) \;\&\; |x| \geq d] \;\&$
$\forall C \in [\![\mathbb{C}]\!][C \neq \lambda d'.\exists x : (\text{kid}(x) \;\&\; \text{long-div}(x))$
$[\text{calc}(x) \;\&\; |x| \geq d'] \rightarrow \neg C(d)]\big]$

d. $\rightsquigarrow$ the number of calculator-using long-div kids > the number of calculator-using kids doing other problem types

[5]Following Hackl (2009), but as Romero (2015), we assume $\text{MANY}_{\text{card}}$ has a quantificational-determiner meaning with an extra (degree) argument. Hackl instead takes MANY to be a gradable NP-modifier.

4.2 Consequences, questions, etc.

- The interpretation we come to in (17d) differs from the paraphrase in (2b):
  - Kratzer (seems to) suggest that the right interpretation is that more than half of the calculator-users were kids doing long-division
  - We derive a reading that might be paraphrased with *the most* instead of *the majority* – specifically, that grouping the calculator-users by problem type gives us the single largest group as kids who had to do long divisions
  - Is this the right interpretation? (We think so . . .)
- The inverse reading is dependent on focus structure and the inclusion of a focus-sensitive component in the surface-level determiner:
  - this predicts that inverse conditional readings should be possible for determiners like *many*, *few*, *least/the least*, but NOT for *every* and *no*
- Ultimately, we are proposing that the restrictor-model for *if* be extended to allow *if* to restrict nominal quantifiers.
  - If this is right, it might help to solve the QIC "embarrassment" (Higginbotham 1986, Kratzer 2013):

4.3 *If*-clauses vs regular restrictions

So far so good, but . . .

- Problem: Since we take the **if**-clause to restrict the quantifier, we *prima facie* predict that the same set of readings should arise if the quantifier is instead restricted by a relative clause, as in (18)

(18) Most kids who had to do long divisions asked for calculators. (#I am pleased to report that most kids in my son's class do long divisions by hand.)

- But (18) only seems to have the vanilla reading.
- Relatedly, **most** does not give rise to the 'inverse-proportional' reading in sentences without **if**-clauses:

(19) Most Scandinavians$_{foc}$ have won the NP in literature.
$\not\rightsquigarrow$ *The number of Scandinavian NP-lit winners > the number of NP-lit winners from any other world region*

- Independent generalization drawn by Pancheva and Tomaszewicz (2012): In English, the focus associate of **-est** cannot be within the DP where **-est** originates.

- In our cases, that would be the DP headed by **most**.
- This would rule out the 'reversed' reading for the relative clause version in (18) and for (19).
- For QICs with most, we would have to maintain that the **if**-clause, even though it restricts the quantifier, is not 'part of the DP' in the relevant sense.
- This seems plausible.

- However: Pancheva and Tomaszewicz (2012)'s generalization is really about superlatives in definite DPs (**John owns the most/best albums by U2**).
  - And their analysis makes the presence of **the** responsible for the constraint.
  - So is this the same constraint?

A Some arguments against a restrictor view

- Various arguments have been given against the view that **if**-clauses restrict nominal quantifiers.
- All of them involve perceived contrasts between a QIC and the corresponding sentence with a relative clause.
- These examples are a bit of a mixed bag: In every case, there is something else going on.
- What these examples show is that **if**-clauses are not (extraposed) relative clauses.
- But we don't think they clearly show that **if**-clauses do not restrict quantifier domains.

A.1 Possible vs. actual witnesses

Leslie (2009) asks us to consider a student named Meadow.

- **Meadow**'s father has bribed the teacher. Whatever she does, she will pass. But Meadow knows nothing about this, and she is a very conscientious student: She does not goof off. That is, *Meadow is a non-goofer, and she will pass; but even if she goofed off, she would pass.*

Intuitively, Meadow is a counterexample to 20a and 20b.

(20) a. Every student will fail if they goof off.
b. No student will pass if they goof off.

But Meadow is not a counterexample to 21a and 21b.

(21) a. Every student who goofs off will fail.

b. No student who goofs off will pass.

- This suggests that while the relative-clause versions in (21) only care about who *actually* goofs off, the QICs in (20) also are sensitive to what would happen if non-actual goofings took place.
- But: This contrast goes away if we put the sentences in the past tense:

(22) a. Every student failed if they goofed off.
b. No student passed if they goofed off.

(23) a. Every student who goofed off failed.
b. No student who goofed off passed.

This suggests that what makes us take into account non-actual goofers in QICs is the fact that it is not settled, at the time of evaluation, who will goof off.

- Meadow will not actually goof off, but she *could*. When we talk about the past, we know that she did not
- Note: Simply assuming that the (20) examples involve a **will**-conditional under the quantifiers gives very weak truth-conditions to 20b.
  - 20b would be true if there is no goofer who is *guaranteed* to pass.
- We get something closer to intuition if we assume that (modal) **will** takes scope over a restricted nominal quantifer (à la Leslie 2009).
  - $\forall w : No_x(\text{goof-off}(x, w))(\text{pass}(x, w))$
  - Why does **will** have to take wide scope in (20), but not in (21)?

A.2 Iffiness

von Fintel and Iatridou (2002) point out the following contrast:

(24) a. Every coin that is in my pocket is silver.
b. Every coin is silver if it is in my pocket.

- (24b) seems to suggest a non-accidental connection between being in the speakers pocket and being silver.
- (24a) does not.
- A Leslie-style analysis that involves a wide-scope quantfier over worlds for (24b) but not (24a) would go some way to make sense of this contrast.
- But note that in this case, the contrast does not go away in the past tense:

(25) a. Every coin that was in my pocket was silver.
b. Every coin was silver if it was in my pocket.

A.3 Partitives

Also from von Fintel and Iatridou (2002):

(26) Nine of the students will succeed if they work hard.

(27) Nine of the students who work hard will succeed.

- (27) implies/presupposes that there are more than nine students who work hard (but only nine will succeed).
- (26) has no such implication.
- Clearly, this implication is due to the presence of the partitive. (29) does not have the implication, either.

(28) Nine students will succeed if they work hard.

(29) Nine students who work hard will succeed.

- Does not show that **if**-clauses do not restrict nominal quantifiers, but only that the presupposition of the partitive is only sensitive to material in its complement.

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