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Reciprocals with quantified antecedents

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The problem

Question

Under what conditions is (1) true?

(1) Most members of this club know each other.

Three options from Kamp & Reyle (1993, 468–9):

a. the largest set *A* of club members such that for any two distinct elements *a* and *b* of *A*, *a* knows *b* and *b* knows *a*, consists of more than half of the members of the club;
b. the set of club members *a* for which there is some other member *b* such that *a* knows *b* and *b* knows *a* consists of more than half of the members of the club;
c. the set of pairs of distinct club members *a* and *b* such that *a* knows *b* and *b* knows *a* consists of more than half of the total number of pairs of distinct club members.

Problems

a. too strong. (1) is "arguably true" in a situation where there is one cluster of five people and seven clusters of four people such that all and only the people within one and the same cluster know each other.
b too weak? But hard to tell.
c. too strong. Assume there are ten members and that a subset of six all know each other but there is otherwise no knowing. Then there are 30 pairs in the know relation and 60 pairs not in the know relation. But the sentence is (definitely) true.

Conclusion

"it is not certain that the matter could ever be settled, no matter how many sentences and scenarios we look at. It may well be that sentences of the type exemplified in (4.258) [=(1)] do not have well-defined truth conditions, which apply to all situations in which the sentence can be used - that all that can be ascertained of them is that they are true in some situations and false in certain others, but that there are many other situations in which their truth values are not determined." (Kamp & Reyle, 1993, 469)

This is surpising because (1) is made up from well-understood components:

(2) a. The members of this club know each other.
b. More than half of the members of this club know the chairman.
c. More than half of the members of this club know each other.

Downward entailing quantifiers

(3) Its members are so class conscious that *few have spoken to each other*, lest they accidentally commit a social faux pas.

As Dalrymple et al. (1998) observe, this sentence "claims that few members have spoken to another one; it is clearly not a statement about the size of the largest group of members such that each pair of them have spoken."

Global Strongest Meaning Hypothesis? But not replicated in other downward entailing contexts (Sauerland, 2012):

(4) If the team members knew each other in advance, they won.

(5) No team whose members knew each other in advance lost.

⇒ the weak reciprocal reading in (3) is due to the quantificational structure, not the downward entailing environment.

The idea

Similar uncertainty with donkey anaphora

"Consider *Most farmers who own a donkey beat it*: does it mean that most farmers who own a donkey beat all of the donkeys they own, that most farmers who own a donkey beat most of the donkeys they own, or that most farmers who own a donkey beat some of the donkeys they own? I am simply not sure, and informants I have consulted have not expressed strong or consistent opinions." (Rooth, 1987, 256)

Champollion et al. (2019) (based on Križ (2015) on plurals):

- Two precisifications: the ∀ and the ∃ readings
- **True** iff true on both readings, **False** iff false on both, otherwise **Neither**.

(6) Most farmers who own a donkey beat it
a. **True** iff a majority of donkey-owning farmers beat all their donkeys
b. **False** iff a majority of donkey-owning farmers beat none of their donkeys
c. **Neither** otherwise

Neither "counts as true" in worlds that resolve the current question under discussion in the same way as a world in which the sentence is true.

The ambiguity

In plural dynamic semantics, generalized quantifiers introduce two discourse referents for anaphoric uptake (Nouwen, 2003):

- the maximal set (the whole restrictor set)
- the reference set (the intersection of the restrictor and the scope)

(7) Few senators admire Kennedy. Most of them prefer Carter. (*them* = maximal set)

(8) Few senators admire Kennedy and they are very junior. (*they* = reference set)

Similar ambiguity with reciprocals:

(9) Most club members know each other.

each other ranges over the **maximal set** (all club members) or the **reference set** (all club members who participate in the reciprocal relation) and the sentence is **True** if true on both readings, **False** if false on both; and otherwise **Neither**.

The framework

Plural CDRT (Brasoveanu 2007, following van den Berg 1996):

(10) a. Two cats ate three mice.

b. $[x_1\ x_2 \mid cat(x_1),\ 2\text{-}atoms(\cup x_1),\ mouse(x_2),\ 3\text{-}atoms(\cup x_2),\ eat(x_1, x_2)]$

c. $\lambda I.\lambda O.I[x_1\ x_2]O \wedge \forall o \in O.cat(\nu(o)(x_1)) \wedge 2\text{-}atoms(\bigcup_{o\in O}\nu(o)(x_1))$
$\wedge\ mouse(\nu(o)(x_2)) \wedge 3\text{-}atoms(\bigcup_{o\in O}\nu(o)(x_2))$
$\wedge eat(\nu(o)(x_1), \nu(o)(x_2))$

- *I* and *O* are plural information states differing in the values of x_1 and x_2 so that each state in *I* is "continued" in some state in *O* and vice versa
- Conditions like $cat(x_1)$ are *pointwise* satisfied in each assignment in *O*
- Conditions like $2\text{-}atoms(\cup x_1)$ are collectively satisfied by the sum over the assignments in *O*

Reciprocity + quantification

Reciprocity in Plural CDRT

(11) Contribution of *each other*, Dotlačil (2013):

$[\![each\ other^{u_n}_{u_m}]\!] = \lambda P.\ [u_n \mid \cup u_m = \cup u_n,\ u_m \neq u_n]\ ; P(u_n)$

Generalized (Non-Distributive) Quantification in Plural CDRT

(12) $\mathbf{max}^x P(x); \mathbf{max}^{y \sqsubseteq x} Q(y); DET(x, y)$ (following Brasoveanu 2007)

- Quantifiers are externally dynamic and introduce two drefs
  - *x* (= Nouwen's maximal set)
  - *y* (= Nouwen's reference set)
- Introduced through special DRSs $\mathbf{max}^x P(x)$ where

(13) $\mathbf{max}^x(K) =_{def} \lambda I.\lambda O.\big([x \mid\ ]\ ;\ K\big)(I)(O) \wedge$
$\forall J.\big([x \mid\ ]\ ;\ K\big)(I)(J) \rightarrow \nu(J)(x) \subseteq \nu(O)(x)$

Combining reciprocals and quantifiers

Combining (11) and (12) we get (14) where the antecedent '?' can be either *x* or *y*

(14) a. $\mathcal{Q}$ people know each other.

b. $\mathbf{max}^x\ [\ \mid people(x)]\ ;\ \mathbf{max}^{y \sqsubseteq x}\ [z \mid \cup z = \cup ?,\ z \neq ?,\ know(y, z)]\ ;\ \mathcal{Q}(x, y)$

For independent reasons, predicates like *know* require strong reciprocity, i.e. $\cup z = \cup ?$ must relate every inhabitant of *z* to every inhabitant of the antecedent.

Reference set binding

(15) a. $\mathbf{max}^x\ [\ \mid people(x)]\ ;\ \mathbf{max}^{y \sqsubseteq x}\ [z \mid \cup z = \cup y,\ z \neq y,\ know(y, z)]\ ;\ \mathcal{Q}(x, y)$

b.

x	y	z
$person_1$	$person_1$	$person_2$
$person_1$	$person_1$	$person_3$
$person_2$	$person_2$	$person_1$
$person_2$	$person_2$	$person_3$
$person_3$	$person_3$	$person_1$
$person_3$	$person_3$	$person_2$
$person_4$	•	•
$person_5$	•	•

Strong reciprocity holds over the whole reference set

Maximal set binding

(16) a. $\mathbf{max}^x\ [\ \mid people(x)]\ ;\ \mathbf{max}^{y \sqsubseteq x}\ [z \mid \cup z = \cup x,\ z \neq x,\ know(y, z)]\ ;\ \mathcal{Q}(x, y)$

b.

	x	z	y
o_1	$person_1$	$person_2$	$person_1$
o_2	$person_1$	$person_3$	•
o_3	$person_1$	$person_4$	•
o_4	$person_1$	$person_5$	•
o_5	$person_2$	$person_1$	•
o_6	$person_2$	$person_3$	$person_2$
o_7	$person_2$	$person_4$	•
o_8	$person_2$	$person_5$	•
o_9	$person_3$	$person_1$	•
o_{10}	$person_3$	$person_2$	•

	x	z	y
o_{11}	$person_3$	$person_4$	$person_3$
o_{12}	$person_3$	$person_5$	•
o_{13}	$person_4$	$person_1$	•
o_{14}	$person_4$	$person_2$	•
o_{15}	$person_4$	$person_3$	•
o_{16}	$person_4$	$person_5$	•
o_{17}	$person_5$	$person_1$	•
o_{18}	$person_5$	$person_2$	•
o_{19}	$person_5$	$person_3$	•
o_{20}	$person_5$	$person_4$	•

The reference set contains everyone who knows some other person

Predictions

Upward entailing quantifiers

The reference set reading entails the maximal set reading and so determines truth.

(17) Most members know each other
a. **True** if the maximal subset *X* of members such that *know-each-other*(*X*) contains a majority of the club members.
b. **False** if the set of members who know at least one other member contains less than half of the club members
c. **Neither** otherwise

True in exactly Kamp and Reyle's scenario a. which they consider "definitely true", **Neither** in exactly the scenarios they consider murky. These can clearly be judged true in relevant contexts.

(18) He added that current radio stations have unimaginative programming, and *most stations copy each other* and use basic programming formulas. [NOW]

(19) As recently as the 1990s, *most scientists found each other's work* by cracking open a journal that their university subscribed to and reading the articles in print. [NOW]

(20) 36-year-old Kimberley revealed: "Cheryl comes to me for advice – *all mums ask each other for advice* and share stories about their babies." [NOW]

Downward entailing quantifiers The maximal set reading determines truth.

(21) Few members have spoken to each other.
a. **True** if the maximal subset *X* of members who have spoken to at least one other member contains less than half of the members
b. **False** if the maximal subset of members such that *speak-to-each-other*(*X*) contains more than half of the members
c. **Neither** otherwise

(21-a) are the truth conditions that Dalrymple et al. (1998, 207) assign to (3). **Neither** sentences can be judged true.

(22) Imagine a cocktail party, there are multiple friends and couples who want to talk to each other in a small single room. If they all talk at the same time, the room will be too noisy and *no one can hear each other*. [Google]

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Conclusions

- Much simpler than analyses based on Bounded Composition (Dalrymple et al., 1998) or Ramsey quantifiers (Szymanik, 2016)
- No need to manipulate reciprocal strength in quantified structures
- Does justice to uncertain truth value judgements