Plurality effects and exhaustive readings of embedded questions

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Plan for today

- Describe similarities between a. Definite descriptions and b. Embedded questions,
- Suggest an analysis which would allow us to extend theories of (a) to (b),
- Show how this is compatible with a theory of strong and intermediate exhaustivity,
- Discuss new predictions, shortcomings and consequences for theories of questions.

1 Plurality effects with definite descriptions and questions

Questions have been shown to behave like (definite) plurals in many aspects. Each of the following phenomena is common to definite plurals (1-3a) and embedded questions (1-3b).

(1) Quantificational Variability Effect (QVE)[1] / Modification by an adverb of quantity (Berman, 1991):
  a. "The students mostly arrived" ≈ "Most students arrived".
  b. "John mostly knows which students arrived" ≈ "For most students who arrived, John knows it".

(2) Semi-distributive / cumulative readings (Lahiri, 2002):
  a. "The boys talked to the girls"
  → OK if each boy talked to some girl and each girl "was talked to" by some boy.
  b. "The witnesses knew which klansmen were present at the lynching".
  → OK if each witness knows a partial answer and each klansman who was present is known to be so by at least one witness.

[1] Berman (1991) makes an analogy with modification of an indefinite by adverbs of frequency, as in "A professor usually likes his students". This led to a theory of questions as free variables lacking a quantificational force. Although I won't pursue such an analysis, I will stick to the widely accepted term 'QVE'.

(3) Homogeneity (Xiang, 2014; Križ, 2015):

a. "The students didn't come to the class" $\rightsquigarrow$ "No student came to the class".

b. "Mary doesn't know which students arrived" $\rightsquigarrow$ "Mary has no idea which students arrived".

A few words on Homogeneity:

- Intuitively: (4a) is true if all students arrived, false if none did, but neither true nor false otherwise.
- The inferences in (3) are not explained by scope of negation: still valid in (5).
- They disappear with adverbs: if some but not all students smoke, (6a) is plain false and (7a) is true.

(4) a. The students arrived.

b. Mary knows which students arrived.

(5) a. No professor$_i$ talked with the students she$_i$ likes.

b. No professor$_i$ knows which of her$_i$ students arrived.

(6) a. The students all smoke.

b. Mary completely knows which students arrived.

(7) a. The students don't all smoke.

b. Mary doesn't completely know which students arrived.

2 Embedded questions as definite plurals in the literature

2.1 Plurals and definite descriptions

Link (1983):

- D_e contains not only *atomic* individuals $(a, b, \dots)$, but also *plural* individuals $(a + b)$
- Order relation on individuals (i-part): $a \preceq a + b$ ('Ann' is a part of 'Ann and Bill')
- $\star$-operator transforms predicates of atomic individuals (*girl*) into plural predicates:

(8) $^\star P(X) = 1 \text{ iff } \forall y \preceq X, Atomic(y) \rightarrow P(y) = 1$

$[\![\text{girls}]\!] = {}^\star[\![\text{girl}]\!]$: 'girls' is true of any plurality which atoms are all girls.

Plural definite articles take a plural predicate and return its maximal element (the biggest plural individuals which satisfies the predicate):

(9) $$[\![\text{the } {}^\star P]\!] = \sigma x. {}^\star P(x) = \iota x. {}^\star P(x) \wedge \forall y [{}^\star P(y) \rightarrow y \preceq x]$$

The can be seen as an overt type-shifter from predicates ($<e,t>$) to individuals (e).

2.2 Some previous theories of plurality in questions

Conjunction and material implication for propositions allow an analogy with sum-formation and part-whole relation for individuals.

Dayal (1996): translate the plural marking on 'which student**s**' (for pair-list readings)
Lahiri (2002): questions map to *Proposition Conjunction Algebras*, which allow QVE and semi-distributive readings.

Translating the plural morphology with Link's (1983) $\star$-operator in a Hamblin (1973) style denotation:

(10) $$[\![\text{Which students arrived}]\!] = \lambda p.\exists X[{}^{\star}\text{student}(X) \wedge p = \lambda w.{}^{\star}\text{arrived}(w)(X)]$$
$$= \{\text{Mary arrived, Peter arrived, Peter and Mary arrived}\ldots\}$$

A common feature of most theories of embedded questions: Answer operator.

(11) a. Heim (1994): $ans_1(Q,w) = \cap(Q(w))$
b. Dayal (1996): $Ans(Q,w) = \iota p.[p \in Q \wedge p(w) \wedge \forall p' \in Q, [p'(w) \rightarrow p \subset p']]$
c. Beck and Rullmann (1999): $answer_1(w)(Q) = \cap\{p : Q(w)(p) \wedge p(w)\}$

Some common properties of these operators:

1. Restrict the set of answers to true answers (if not done already),
2. Type-shift the question from a set of propositions to a proposition,
3. Usually: select/build the most informative proposition among the true answers.

Some versions of the *Ans* operator are transpositions of *the* (in particular, Dayal, 1996), and *Ans* can be seen as a (covert) definite article for questions (explicit in Fox, 2012: $Ans =$ "*The True*").

3 A possible implementation

3.1 Hypotheses

Building on Dayal (1996), Lahiri (2002) and Fox (2012):

(12) $[\![\text{Which students arrived}]\!] = \lambda p.\exists X[{}^{\star}\text{student}(X) \wedge p = \lambda w.{}^{\star}\text{arrived}(w)(X)]$

(13) $Ans(Q) = \iota p.[Q(p) \wedge [\forall p', Q(p') \rightarrow p \subseteq p']]$

Concretely, Q will only be fed to Ans after being intersected with C, a restrictor provided by the embedding verb: $Ans(C \cap Q)$ = "The C p in Q"

For veridical responsive verbs, C is simply the set of all true propositions, and we recover Fox's Ans.

- QVE derived as in Lahiri (2002), for the most part,
- Cumulative readings can be explained by extending any good theory of cumulative readings with definite plurals (predictions do not differ on simple examples),
- Homogeneity can be implemented with supervaluationist theories (Spector, 2013; Križ and Spector, 2015), although other options are available.

One asymmetry between definite descriptions and questions: we can always retrieve the atoms from a plural individual, but we cannot do so from an arbitrary proposition. In order to define the atomic answers, we need the algebra of answers, Q.

We will simply assume that some information about the algebra of answers is preserved after application of Ans. As it stands, the second line of (15) is ill-defined, but hopefully this can be done in a fully compositional way.[2]

We will define atoms for both sets and pluralities of individuals/propositions:

(14) $At_e(P) = \lambda x.[P(x) \wedge \forall y.[(P(y) \wedge y \preceq x) \rightarrow y = x]]$
$At_e(X) = At_e(\lambda x_e.x \preceq X)$

(15) $At_{st}(Q) = \lambda p_{st}.\left[p \in Q \wedge \forall p' \in Q, [(p \subseteq p') \rightarrow (p = p')]\right]^3$
$At_{st}(Ans(Q_{<st,t>})) = At_{st}(Q)$

3.2 Consequences

3.2.1 QVE

(1) a. The students mostly arrived.
b. John mostly knows which students arrived.

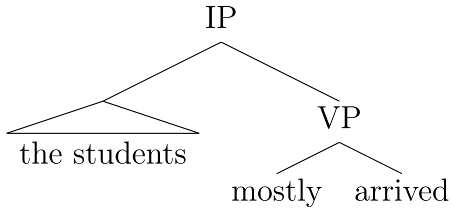
(16) Adapting Lahiri's (2002) structure:

[2] One possibility would be to have more structure in what we take to be the translation of a sentence. Nevertheless, there may be cases where the atoms must be retrieved from the context anyway, as in "John mostly knew Beethoven's 5th symphony".

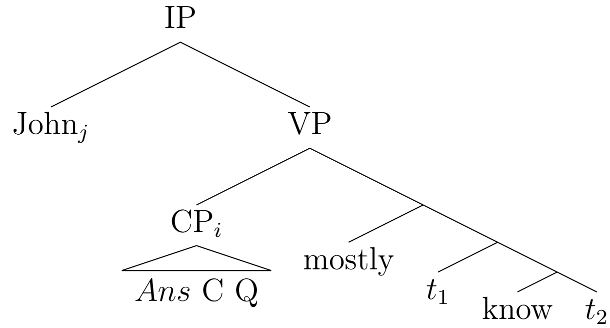
[3] The definition of At must be refined if we want to consider multiple *wh*-questions. In order to get rid of propositions of the form "$a \oplus b$ love $c \oplus d$", the final definition would be (see Lahiri, 2002, p.202):

$$\lambda p_{st}.\left[p \in Q \wedge \forall r \in Q, [(p \subseteq r) \rightarrow (p = r)] \wedge \bigwedge \left\{q \in Q | q \neq p \wedge \forall r \in Q, [(q \subseteq r) \rightarrow (q = r)]\right\} \not\subseteq p\right]$$

a. Structure for (1a)



b. Structure for (1b)



$[\![\text{IP}]\!] = \text{mostly}_{DD}(\lambda x.\text{arrived}(x))(s_1 + \dots)$ $\quad$ $[\![\text{IP}]\!] = \text{mostly}_{EQ}(\lambda p.K(j)(p))(Ans(C \cap Q))$

Our semantics for *mostly* relies on a function *card* which takes a set (of propositions or individuals) and returns the cardinality of its atoms.

(17) $[\![\text{mostly}_\tau]\!] = \lambda P_{<\tau,t>}.\lambda X_\tau.[card(At_\tau(X) \cap P) > \frac{1}{2}.card(At_\tau(X))]$ $\quad$ $(\tau = e/st)$

3.2.2 Cumulative readings

Cumulative readings arise when a transitive verb takes two pluralities as its arguments.

Usual case: two pluralities of individuals (see 2a). The same happens when some responsive verbs take a plural individual and a plural question (see 2b).

Many theories of (2a) (Kratzer, 2008; Champollion, 2010; Scha and Winter, 2014; Champollion, 2014, among many others), but their predictions should not differ much on the basic cases we are interested in.

Not all responsive verbs allow cumulative readings: For instance, non-veridical predicates don't (Lahiri, 2002), possibly because their lexical restrictor is dependent on the subject:

(18) Lahiri (2002): John is certain about Q = John is certain about every answer to Q that he considers possible.
More formally: $C_{john} = \lambda p_{st}.(Dox(john) \cap p \neq \emptyset)$

(19) The witnesses were certain about which klansmen were present at the lynching
Available distributive reading: Each witness was certain about which klansmen were present at the lynching (different witnesses may not agree)
Possibly available reading: All witnesses were certain about the same set of klansmen, and they were all certain that any other klansman was absent.[4]
Unavailable cumulative reading: For each klansman that some/all witnesses considered to be possibly present, at least one witness was certain that he was present, and

[4] Whether this is a different reading or just a specific case of distributive reading is unclear, because it entails the previous one. If we were to derive it, we would probably need the question to take scope over the subject.

each witness was certain about the presence of at least one klansman. (compatible with each witness being uncertain about some klansmen).

3.2.3 Homogeneity

We can implement a simple supervaluationist theory of homogeneity. It may not derive the correct predictions for some complex cases of projection, but I refer to Križ and Spector (2015) for further details.

The idea:

(20) Given a distributive predicate $P_{<\tau,t>}$ applied to a plurality X_τ ($\tau = e/st$):
- P is (super)true of X if P is true of all atoms of X
- P is (super)false of X if P is false of all atoms of X
- P is a truth-value gap otherwise.

For a theory of homogeneity with questions, see Križ (2015). He shows that, provided some reasonable hypotheses on the projection of these truth-value gaps, the homogeneity of questions derives immediately from the fact that answers which involve plural individuals are trivalent themselves.

Note that the complex predicate of propositions which combines with the question in (16b) is not distributive: $\lambda p.[mostly_{st}(\lambda p'.K(j)(p'))(p)]$. This may be sufficient to explain why we don't see homogeneity in the presence of an adverb.

4 Incorporating stronger exhaustivity

4.1 Facts

Weak (WE), Intermediate (IE) and Strong (SE) exhaustive readings (Heim, 1994; Spector, 2005):

(21) John knows which students arrived

(22) WE: For all students who arrived, John knows that they did.
IE: For all students who arrived, John knows that they did, and he does not believe that any other student arrived.
SE: For all students who arrived, John knows that they did, and he knows that no other student arrived.

Klinedinst and Rothschild (2011): Possible to derive IE and SE from WE for non-factive predicates, using an EXH operator and some well-chosen alternatives.

Quantitative data from Cremers and Chemla (2014) confirms the availability of these 3 readings for adults. Cremers et al. (2015) shows that 5-year-olds favor the WE reading, while adults mostly access the IE reading. This supports a parallel with scalar implicatures, which are known to cause difficulty in children.

4.2 Klinedinst and Rothschild (2011)

(23) John predicted which students arrived

(24) WE: For all students who arrived, John predicted that they did.
IE: For all students who arrived, John predicted that they did, and he did not predict that any other student arrived.
SE: For all students who arrived, John predicted that they did, and he predicted that no other student arrived.

The theory:

(25) $Q(w)$ is the true (weak) complete answer in w.
Example: $Q(w) =$ Ann arrived and Bill arrived

(26) Any potential complete answer to the question is an alternative:
$Alt(Q(w)) = \{Q(w')|w' \in W\}$
$Alt(Q(w) = \{\text{Ann arrived}, \text{Bill arrived}, \text{Celena arrived}, \dots \text{A, B and C arrived}, \}$

Crucially, $Alt(Q(w)$ includes false answers.

- WE reading obtained by simply combining $Q(w)$ with the verb.
- IE reading derived through global (matrix) exhaustification:
$\textsc{exh}[\text{predict}(j)(Q(w))] = \text{predict}(j)(\text{A arrived and B arrived}) \wedge \neg \text{predict}(j)(\text{A, B and C arrived})$
- SE reading derived through local exhaustification:
$\text{predict}(j)(\textsc{exh}[Q(w)]) = \text{predict}(j)(\text{A arrived and B arrived and } \neg(\text{A, B and C arrived}))$

5 An exhaustification theory for plural questions

5.1 Hypotheses

Goal: Retrieve the alternatives of K&R with minimal stipulations in the theory we sketched in section 3 (the rest will follow).

Three main hypotheses:[5]

(27) The set of alternatives to a set of propositions Q consists of all the subsets of Q which are closed under conjunction: $Alt(Q) = \{Q'|Q' \subseteq Q \wedge [\forall X \subseteq Q', (\wedge X) \in Q']\}$
→ *Required to get all possible answers as alternatives to the complete answer.*

[5](27) and (28) can be reformulated as a single hypothesis on C: Any subset of C closed under conjunction is an alternative to C. However, this would make the system more obscure and further reduce the little hope I have that these alternatives may one day be derived as structural alternatives...

(28) Alternatives can be derived by deletion of the restrictor C: $\mathit{Alt}(Q) \subseteq \mathit{Alt}([C\, Q])$
$\rightarrow$ *Crucial to allow false answers in the set of alternatives.*

(29) *believe* is an alternative to *know* (Percus, 2006; Sauerland, 2008)
$\rightarrow$ *Allows derivation of IE readings for* know.

What are the predicted alternatives for a complete answer?

(30) $\mathit{Alt}(\mathit{Ans}(C \cap Q)) = \{\mathit{Ans}(C \cap Q') | Q' \in \mathit{Alt}(Q)\} \cup \{\mathit{Ans}(Q') | Q' \in \mathit{Alt}(Q)\} = Q$

The result ends up equal to Q, which means that any answer is an alternative to a given answer (crucially including false answers).[6]

We'll use a version of Fox's (2007) EXH operator to derive (secondary) implicatures. The most important property we are after is the possibility to negate not only stronger alternatives, but also non-weaker ones. We will also need to make a few assumptions about how EXH interacts with presuppositions and vagueness.

5.2 Putting everything together

(21) John knows which students arrived.

(31) Simplified LF for each reading:
  a. WE reading: $K(j)(\mathit{Ans}(C \cap Q))$
  b. SE reading: $K(j)(\textsc{exh}[\mathit{Ans}(C \cap Q)])$
  c. IE reading: $\textsc{exh}[K(j)(\mathit{Ans}(C \cap Q))]$

Let us imagine a situation where Ann and Bill are the students who arrived, while Celena is a student who didn't arrive. We'll write A for the proposition 'Ann arrived', $A + B$ for 'Ann and Bill arrived', and so on.

In (31b), the only source of alternatives for EXH is the question. Everything goes as in Klinedinst and Rothschild (2011):

$$\mathit{Ans}(C \cap Q) = A + B$$

$$\mathit{Alt}(\mathit{Ans}(C \cap Q)) = \{A, B, C, A + B, B + C, C + A, A + B + C\}$$

The alternatives A and B are entailed by the prejacent. The alternatives C, $A + C$, $B + C$, $A + B + C$ are all non-weaker and innocently excludable. Therefore:

$$\textsc{exh}[\mathit{Ans}(C \cap Q)] = A + B \wedge \neg C$$

[6]Proof: The second set in the union is derived by deletion of C. Since for any $Q' \in \mathit{Alt}(Q)$, $Q' \cap C \in \mathit{Alt}(Q)$, the first set is included in the second. For any $Q' \in \mathit{Alt}(Q)$, Q' is closed under conjunction, hence $\mathit{Ans}(Q')$ is defined, and $\mathit{Ans}(Q') \in Q' \subseteq Q$. Conversely, if $p \in Q$, $\{p\} \in \mathit{Alt}(Q)$, hence: $p = \mathit{Ans}(\{p\}) \in \mathit{Alt}(\mathit{Ans}(Q \cap C))$ QED.

$$K(j)(\textsc{exh}[Ans(C \cap Q)]) = K(j)(A \wedge B \wedge \neg C)$$

(31b) does correspond to the SE reading.

In (31c), the sources of alternatives for EXH are the question and the verb (see 29). (32) contains a subset of the alternatives of 'know($A + B$)'.

(32)

know(A)	$\leftarrow$	know($A+B$)	$\leftarrow$	~~know(C)~~	$\leftarrow$	~~know($A+B+C$)~~
$\downarrow$		$\downarrow$		$\downarrow$		$\downarrow$
believe(A)	$\leftarrow$	believe($A+B$)	$\leftarrow$	believe(C)	$\leftarrow$	believe($A+B+C$)

Importantly:

- 'know(A)', 'believe(A)', 'believe($A + B$)' are entailed.
- 'know($A + B + C$)' is a presupposition failure, because C is false.
- 'believe(C)', 'believe($A + B + C$)' are non-weaker and excludable.

Conclusion:

$$\textsc{exh}[K(j)(Ans(C \cap Q))] = K(j)(A + B) \wedge \neg B(j)(C)$$

(31c) does correspond to the IE reading.

6 Applying the theory to new cases

6.1 QVE

(1b) John mostly knows which students arrived.

3 potential positions for EXH in (16b). However, the lowest one is vacuous and the atoms of $\textsc{exh}[Ans(Q \cap C)]$ are undefined so it cannot be fed to *mostly*. This leaves matrix exhaustification as the only option.

If we take *completely* as a scalar competitor of *mostly*, there are 3 sources of alternatives for 'mostly($\lambda p.K(j)(p)$)($Ans(C \cap Q)$)'. Let us characterize these alternatives:

(33) a. 'completely($\lambda p.K(j)(p)$)($Ans(C \cap Q)$)' is stronger and innocently-excludable.

b. If $X \preceq Ans(C \cap Q)$, 'mostly($\lambda p.K(j)(p)$)(X)' is a non-weaker alternative. However, these alternatives are not innocently-excludable.

c. If $X \not\preceq Ans(C \cap Q)$, 'mostly($\lambda p.K(j)(p)$)($X$)' is a presupposition failure.

d. If $X \succeq (C \cap Q)$, 'mostly($\lambda p.B(j)(p)$)(X)' is a non-weaker alternative. These alternatives are somehow problematic, but we will assume that they are not innocently-excludable.[7]

[7]Consider all Y's which add one atomic answer to $X_0 = Ans(C \cap Q)$. If X_0 is mostly P, but no such Y is mostly P, this means that X_0 is just at the threshold for *mostly*, which we arbitrary fixed at $\frac{1}{2}$. However,

e. If $X \perp Ans(C \cap Q)$ (i.e., no common atoms), 'mostly$(\lambda p.B(j)(p))(X)$' is a non-weaker alternative, and is excludable.

f. Other alternatives play no role (either entailed, or their negation entailed).

(33a) leads to the inference that John does not completely know which student arrived. (33e) implicates that he has no false beliefs about students who did not arrive.

As a conclusion, the exhaustified (1b) will have the following truth conditions:

- John knows of most, but not all, students who arrived that they did.
- John has no false beliefs regarding students who did not arrive.

→ Preuss (2001, p145–155)'s strongly exhaustive reading for QVE sentences:

(269) a. John uncovered to a large extent who took bribes.
b. John confessed to a large extent who he had cheated in poker.
c. John found out to a large extend who had cheated on the exam.

6.2 Mention-some questions

Mention-some questions have no clear equivalent in definite plurals[8], but they received a lot of attention in the recent literature on questions.

(34) Mary knows where John can get gas.
⇝ Mary knows at least one place that sells gas, but not necessarily all of them.

Fox (2013): Mention-some questions involve a distributivity operator (silent *each*) in the scope of an existential modal.

(35) Who can chair this committee?

(36)
$$Q = [\text{who } \lambda X[\Diamond\, each(X)([\text{chair this committee}])]]$$
$$= \{\Diamond(x_1 \text{ chair this committee}), \Diamond(x_2 \text{ chair this committee})\}$$

All answers are now independent → All answers are maximally informative.
Solution: quantify existentially over maximally informative answers.[9]

George (2013); Xiang (2014) show that mention-some questions also display false-answers sensitivity. If we adopt a theory à la Fox (2013), we can account for this immediately.

mostly is probably a vague predicate, and if X_0 is a borderline case, 'X_0 is mostly P' is not completely true. Therefore, we will assume that sets of alternatives which negation would make the prejacent 'untrue' are not innocently excludable.

[8] A few differences may explain this asymmetry: definite articles compete with indefinites. Mention-some usually require number-neutral wh-words (not *which*-phrases), which are somehow equivalent to pronouns, but pronouns do not take complements which would embed a modal.

[9] As it stands, if we adopt this solution for mention-some questions, we lose the uniqueness presupposition of singular *which*-phrases. See Fox (2013) for discussion.

(37) EXH[Janna knows where she can buy an Italian newspaper] = Janna knows at least one place where she can buy an Italian newspaper, and she does not falsely believe that she can buy one in a place that actually does not sell Italian newspaper.

→ George (2013) argued from this example that knowledge-*wh* is not reducible to knowledge-*that*. We gave a reducible account, using lexical competition between *know* and *believe*.

6.3 *Forget*

Let us assume a semantics as (38) for *forget*.

(38) John forgot p: $\underline{p \text{ and John used to know } p}$, it's not the case that John believes p.

Not all propositions in the restrictor satisfy the presupposition, hence we need some hypotheses on the interaction between homogeneity and presupposition. Let us simply assume that if a predicate P with a presupposition ρ applies to a plurality X, $P(X)$ presupposes that each atom of X satisfies ρ.

(39) John forgot which students arrived.
WE: John used to know which students arrived (weakly), and for each student who arrived, John forgot that (s)he arrived.
SE: John used to know which students arrived (strongly), and for at least one student, John forgot whether (s)he arrived.

Homogeneity ensures that John had exhaustive knowledge in the past, and exhaustive oblivion now. Note that these truth conditions cannot be reduced to 'John forgot that p', with p an atomic proposition.

The availability of local exhaustification is an empirical question.

Matrix exhaustification is vacuous here. We cannot derive FA-sensitivity for *forget* unless we postulate a non-factive alternative.

6.4 Some remaining issues

6.4.1 Negative sentences

(3b) Mary doesn't know which students arrived.

If we allow alternatives of the form "Mary doesn't believe $Ans(X)$" with X consisting of false answers, we get the following truth-conditions for (3b):

- For all students who arrived, Mary doesn't know that they did (homogeneity)
- For all students who didn't arrive, Mary (falsely) believes that they did.

This reading is clearly unattested.[10]

6.4.2 *Surprise*

A few puzzles with *surprise* (and possibly other emotive factives):

- It does not trigger homogeneity (but it is not a distributive predicate over propositions).
- Matrix exhaustification yields super-strong (unattested) reading.

Still predicts SE readings with *surprise* (see data in Cremers, 2014, 2015).

6.4.3 Factive verbs beyond *know*

The theory derives IE reading for *know* by competition with *believe*. What about other factives?

(40) **Prediction:** A factive verb receives a 'false answers' sensitive reading if and only if it has a non-factive alternative.

→ An open empirical question...

Conclusion

- Embedded questions must be treated as definite descriptions of their answers in order to account for plurality effects.
- False-answer sensitive readings (strong and intermediate exhaustive) can be implemented in such a framework.
- Some unresolved issues (*surprise*, negative sentences, multiple-*wh* questions)
- Many new predictions, derives readings which had been conjectured for QVE and mention-some questions.

Note: Most theories of plural effects can be extended to questions, but not all theories of questions are compatible with plurality effects. Hamblin's (1973) denotation for questions is crucial because (a) we need weak atomic answers and (b) we need false answers.

Future research: Collect data on FA-sensitive readings of QVE structures, study a wider variety of responsive verbs, and maybe one day understand *surprise*.

[10] The problem would be solved if we accept alternatives obtained by deletion of the negation. This should in principle be possible if we follow Fox and Katzir, 2011, but then we lose all indirect implicatures!

Appendices

A Lexical restrictor

Why do we need lexical restrictor?

Berman (1991); Lahiri (1991): Intermediate accommodation of the verb's presuppositions. Counter-arguments:

- Communication verbs are veridical but not factive (but see Spector and Egré, 2015)
- Complex factive verbs are only veridical (*forget, remember, discover...*)

(41) John forgot which students arrived.
Presuppositions accommodation: $C = \lambda p.\big[p(w) \wedge \exists t < t_0 : K(j)(t)(p)\big]$
$\rightsquigarrow$For each student x who arrived and such that John used to know that x arrived, John doesn't remember that x arrived.
Simply veridical: $C = \lambda p.p(w)$
$\rightsquigarrow$For each student x who arrived, John used to know that x arrived and John doesn't remember that x arrived.

Non-veridical predicates require stipulation of a restrictor, but get a stronger meaning than mere existential:

(42) John told me which students arrived.
Usually assumed: $\approx$ John told me some answer to the question.
Without restrictor: $\rightsquigarrow$John told me that every student arrived.
Doxastic restrictor: $C = \lambda p.B(j)(p)$
$\rightsquigarrow$ John told me what he believes to be the complete answer to "which students arrived".

A new possible explanation for why *believe* does not embed questions:

- Two conceivable restrictors for *believe*: Doxastic and Veridical
- Doxastic restrictor leads to tautology (John believes what he believes).
- Veridical restrictor: ruled out by competition with *know*.[11]

[11] A question-embedding, veridical entry of *believe* exists (Egré, 2008), but it is very restricted and has the semantics of an emotive factive (i). Note that it is also factive when embedding declaratives (ii).

(i) You'll never believe who was at the party!

(ii) Sue can't believe that John was at the party.

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