

Fragment functional answers^{*}

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Abstract An answer may often be expressed with a full reply and with a fragment reply. We discuss the fact that some fragment replies are unacceptable replies to multiple-*wh* interrogatives, and suggest that the reason for this is that fragment replies are the basic semantic answers while full replies can sometimes be parasitic on them.

Keywords fragments, functional *wh* interrogatives, pair-list *wh* interrogatives

1 Full replies or fragments?

The *wh* string [Which student turned in this paper?] expresses an interrogative that may be answered with the full reply in (1a) or with its fragment in (1b) (here and throughout, a fragment of a string *S* is some sub-string of *S* distinct from *S*).

- (1) Which student turned in this paper?
- a. Marv turned in this paper.
 - b. Marv.

It is a matter of some debate which of these – the full reply in (1a) or its fragment in (1b) – expresses the basic answer. Arguments favoring the view that full replies are basic (as in Morgan 1973) rely on the fact that the unacceptability of some replies follows from independently motivated constraints on clause-level dependencies. For example, the fact that *himself* is an acceptable reply to [Who did John shave?] when John self-shaved, but *him* is not, is easily accounted for if fragment replies are derived from full replies: *John shaved himself* complies with Binding Theory when *John* and the reflexive pronoun *himself* corefer, but *John shaved him* violates Condition B of Binding Theory when *John* and the non-

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reflexive pronoun *him* corefer (see Chomsky 1981). On the other hand, arguments favoring the view that fragment replies are basic (as in Jacobson 2016) rely on the fact that the unacceptability of some replies does not obviously follow from independent constraints on clause-level dependencies. We discuss a puzzle – noted in Kang 2012 – that illustrates the latter fact.

Kang’s observation concerns the unacceptability of certain fragment replies. It is manifested by contrasts between so-called functional replies and so-called pair-list replies to multiple-*wh* strings. Consider the multiple-*wh* string in (2). It may be answered with the full pair-list reply in (2a) (see Baker 1970) and with its “gapped” fragment in (2b) (see Merchant 2004; but see Jacobson 2016).

- (2) Which student turned in which paper?
- a. Marv turned in Binding, Fred turned in Anaphora, (and) Sam turned in Tense.
 - b. Marv, Binding; Fred, Anaphora; (and) Sam, Tense.

Interestingly, while the same string can also be answered with the full “functional” reply in (3a) (see Dayal 1996 and Comorovski 1996), neither the gapped fragment of (3a) in (3b), nor its non-gapped fragment in (3c), is a fully acceptable reply: (3b) is considerably degraded (compared to (3a)), and (3c) is simply unacceptable.

- (3) Which student turned in which paper?
- a. Every student turned in his term paper.
 - b. #Every student, his term paper.
 - c. ##His term paper.

Adopting the hypothesis that semantic answers are expressed by fragments, and full replies can sometimes be parasitic on fragments, we propose (4) regarding the string [Which student turned in which paper?].

- (4) a. *His term paper* ((3c)) is not an acceptable reply because it denotes a function of type $(s, (e, e))$ (i.e., an (e, e) -function concept), while the interrogative seeks a function of type $((s, e), (s, e))$ (i.e., a function from individual concepts to individual concepts).
- b. *Marv, Binding; Fred, Anaphora; Sam, Tense* ((2b)), which denotes a function of type $((s, e), (s, e))$, may be an acceptable reply.
- c. *Every student, his term paper* ((3b)) is a degraded reply because it denotes a function that is, in many cases, unsuitable.
- d. The full replies (2a) and (3a) are acceptable replies only when they are parasitic on *Marv, Binding; Fred, Anaphora; Sam, Tense*.

Section 2 explains why we do not pursue an analysis according to which fragment replies are derived from full replies. Section 3 spells out (4a,b) in detail, accounting for the contrast between the fragments in (2b) and (3c). Section 4 spells out (4c,d) in detail, accounting for the fragment in (3b) and for full replies.

2 The implications of Kang's observation

We set aside (non-)coreference effects, and focus on the fact that *Every student turned in his term paper* may be an acceptable reply to the multiple-*wh* string in (3), but its relevant fragments are either unacceptable or not fully acceptable (despite the fact that fragment replies are possible in principle, as shown in (1) and (2)). This fact seems to be problematic for the approach that says that fragment replies are derived from full replies, as we now show.

One might conjecture (following Merchant 2004) that the contrast between (2b) and (3c) arises because any and all fragment replies to [Which student turned in which paper?] are derived from the full reply by movement of some of the arguments of *turn in* to a sentence-initial position – the F(ocus)P(rojection) position – and subsequent T(ense)P(rojection)-ellipsis, where the TP in the full reply is elided under identity with the TP in the interrogative antecedent. (Ellipsis is triggered by the E-feature in C(omplementizer).) Accordingly, since TP in (5b) is identical to TP in (5a) but TP in (5c) is not, *Marv ~~turned in~~ Binding*; *Fred ~~turned in~~ Anaphora*; (and) *Sam ~~turned in~~ Tense* is an acceptable reply, but *Every student ~~turned in~~ his term paper* is not.

- (5) a. [CP *which student*₁ *which paper*₂ C [TP *t*₁ *turned in t*₂]]
 b. [FP *Marv*₁ *Binding*₂ [CP C_[E] [TP ~~*t*₁ *turned in t*₂~~]]] [FP *Fred*₁ *Anaphora*₂ [CP C_[E] [TP ~~*t*₁ *turned in t*₂~~]]] [FP *Sam*₁ *Tense*₂ [CP C_[E] [TP ~~*t*₁ *turned in t*₂~~]]]
 c. [FP *his term paper*₂ [CP C_[E] [TP ~~*every student turned in t*₂~~]]]

In addition, since TP in (5c) is identical to TP in (6), *Every student ~~turned in~~ his term paper* is an acceptable reply to the single-*wh* string [Which paper did every student turn in?] (as reported in, for example, Engdahl 1986).

- (6) [CP *which paper*₂ C [TP *every student turned in t*₂]]

The problem is that single-pair gapping and multiple-pair gapping contrast in a way that is not accounted for. Consider [Which paper did Marv turn in?], which has a non-quantificational subject, and [Which paper did every student turn in?], which has a quantificational subject. While the single-pair gapped *Marv ~~turned in~~ Binding* is a degraded reply to the former (compared to both *Marv turned in*

Binding and *Marv turned in Binding*), the multiple-pair gapped *Marv turned in Binding*; *Fred turned in Anaphora*; (and) *Sam turned in Tense* is a fully acceptable reply to the latter. Indeed, TP in (7b) is identical to TP in (7a) and TP in (7c) is not. However, TP in (5b) is not identical to TP in (6).

- (7) a. $[_{CP} \text{which paper}_2 C [_{TP} \text{Marv turn in } t_2]]$
 b. $[_{FP} \text{Binding}_2 [_{CP} C_{[E]} [_{TP} \text{Marv turn in } t_2]]]$
 c. $[_{FP} \text{Marv}_1 \text{Binding}_2 [_{CP} C_{[E]} [_{TP} t_1 \text{turn in } t_2]]]$

On the other hand, if gapping in replies is allowed even without movement-to-FP, the acceptability of *Marv turned in Binding*; *Fred turned in Anaphora*; (and) *Sam turned in Tense* as a reply to |Which paper did every student turn in?| is expected, but the degraded status of *Marv turned in Binding* as a reply to |Which paper did Marv turn in?| is not.

In addition, while the multiple-pair gapped (8) is a fully acceptable reply to the multiple-*wh* string |Which student turned in which paper?|, the single-pair gapped (3b) (*Every student turned in his term paper*) is a considerably degraded reply to the same string (compared to both (3a) and (8)).

- (8) Every syntax student ~~turned in~~ his phonology term paper; (and) every semantics student ~~turned in~~ his syntax term paper.

Since TP in (9), where $(\alpha, \beta) \in \{(_, _), (\text{syntax}, \text{phonology}), (\text{semantics}, \text{syntax})\}$, is identical to TP in (5a), both (3b) and (8) should be fully acceptable replies to |Which student turned in which paper?|.

- (9) $[_{FP} \text{every } \alpha \text{ student}_1 \text{ his } \beta \text{ term paper}_2 [_{CP} C_{[E]} [_{TP} t_1 \text{turned in } t_2]]]$

In view of this, we pursue an alternative theory of replies, along the lines of Jacobson 2016 according to which fragment replies express basic semantic answers (cf. Groenendijk & Stokhof 1984 and Ginzburg & Sag 2000).

3 *Wh* questions and their semantic answers

This section accounts for the contrast between (2b) and (3c). In 3.1 we present our basic assumptions regarding *wh* interrogatives; in 3.2 we discuss the contrast between natural function interrogatives and pair-list interrogatives. We propose that (3c) denotes a natural function – a possible semantic answer to a natural function interrogative; and (2b) denotes a (possibly) random set of ordered pairs – a possible semantic answer to a pair-list interrogative.

3.1 The semantics of *wh* interrogatives

Some fragment-reply approaches treat a *wh* interrogative as denoting a function from entities to $\{\text{True}, \text{False}\}$. According to one implementation of this idea, *[Which student turned in Binding?]* may phonetically realize the interrogative *[which^e student] [Q [turned-in Binding]]*, whose extension in $D_{(e,t)}$ is restricted to salient students, as in (10). K is the set of possible utterance contexts, W is the set of possible worlds and for each $c \in K$, REL_c is the restrictive property of individuals that is salient in w_c (the world of c).

- (10) For any $c \in K$ and $w \in W$:¹
- a. $\llbracket \text{which}^e \rrbracket^{c,w} = \lambda f: f \in D_{(e,t)}. \lambda y: y \in D_e \ \& \ y \in \text{REL}_{c,w}. f(y)$
 - b. $\llbracket \text{student} \rrbracket^{c,w} = \lambda x: x \in D_e. x \in \text{STUDENT}_w$
 - c. $\llbracket \text{turn-in} \rrbracket^{c,w} = \lambda x: x \in D_e. \lambda y: y \in D_e. (y, x) \in \text{TURN-IN}_w$
 - d. $\llbracket \text{Binding} \rrbracket^{c,w} = \mathbf{b}$ (an element of D_e)
 - e. $\llbracket Q \rrbracket^{c,w} = \lambda g: g \in D_{(e,t)}. \lambda f: f \in D_{(e,t)}. \lambda x: x \in D_e \ \& \ f(x) = \text{True} \ \& \ x \in \text{Dom}(g). g(x)$
 - f. $\llbracket [\text{which}^e \text{ student}] [Q [\text{turned in Binding}]] \rrbracket^{c,w} = \lambda x: x \in D_e \ \& \ x \in (\text{REL}_{c,w} \cap \text{STUDENT}_w). (x, \mathbf{b}) \in \text{TURN-IN}_w$

If *which student* is type-flexible, *[Which student turned in Binding?]* may have other denotations. We assume that a *which* phrase is indeed type-flexible, but stipulate that it cannot contribute an element of $D_{(e,t)}$; it contributes an element of $D_{((s,\sigma),t)}$, where $\sigma \in \{e, (e, e), \dots\}$ (the reason for this stipulation will become clear in 3.2). In the current approach, then, *[Which student turned in Binding?]* cannot be interpreted as in (10), but may be interpreted as in (11), phonetically realizing *[which^(s,e) student] [Q [turned-in^{T1} ~Binding]]*, whose extension in $D_{((s,e),t)}$ is restricted to salient student-valued natural functions. NAT_c is the restrictive property of natural functions that is salient in w_c (and for all $w \in W$ and $x \in D_e$, there is an $f \in \text{NAT}_{c,w}$ such that $x = f(w)$ iff $x \in \text{REL}_{c,w}$). The extension of *turn-in^{T1}* is a type-shifted variant of *turn-in*; the extension of *Binding* is a (s, e) -function.

- (11) For any $c \in K$ and $w \in W$:
- a. $\llbracket \text{which}^{(s,e)} \rrbracket^{c,w} = \lambda f: f \in D_{(s,t)}. \lambda h: h \in D_{(s,\sigma)} \ \& \ h(w) \in \text{Dom}(f) \ \& \ h \in \text{NAT}_{c,w}. f(h(w))$

¹ $[\lambda x: \phi. \varphi]$ is the smallest function f that meets the description in (i) or (ii), whichever is applicable (see Heim & Kratzer 1998):

- (i) f maps every x such that ϕ to φ ;
- (ii) f maps every x such that ϕ to True if φ , and to False otherwise.

- b. (10b)
 c. $\llbracket \text{turn-in}^{T1} \rrbracket^{c,w} = \lambda x: x \in D_e. \lambda f: f \in D_{(s,e)} \ \& \ w \in \text{Dom}(f). \llbracket \text{turn-in} \rrbracket^{c,w}(x)(f(w))$
 d. $\llbracket \text{Binding} \rrbracket^{c,w} = \mathbf{B} (= \lambda v: v \in W. \mathbf{b}); \llbracket \sim \text{Binding} \rrbracket^{c,w} = \mathbf{b}$
 e. $\llbracket ? \rrbracket^{c,w} = \lambda g: g \in D_{((s,\sigma),t)}. \lambda k: k \in D_{((s,\sigma),t)}. \lambda f: f \in D_{(s,\sigma)} \ \& \ k(f) = \text{True} \ \& \ f \in \text{Dom}(g). g(f)$
 f. $\llbracket [\text{which}^{(s,e)} \text{ student}] [\text{?} [\text{turned-in}^{T1} \sim \text{Binding}]] \rrbracket^{c,w} = \lambda f: f \in D_{(s,e)} \ \& \ f \in \text{NAT}_{c,w} \ \& \ f(w) \in \text{STUDENT}_w. (f(w), \mathbf{b}) \in \text{TURN-IN}_w$

For all $c \in K$, $w \in W$ and interrogative β , $\llbracket \beta \rrbracket^{c,w}$ is a question.² A question-taker is denoted by, for example, an interrogative-embedding verb such as *know* or *wonder*. A question-taker can also be QU, which takes as its argument the question corresponding to a main clause interrogative yielding a question act (see, for example, Krifka 2001), as in (12a). ANS is an answer-taker; it takes as its argument the entity corresponding to a reply yielding an answer act, as in (12b).

- (12) a. $\lambda c: c \in K \ \& \ \llbracket \beta \rrbracket^{c,w_c} \in \text{Dom}(\text{QU}_{w_c}). \text{QU}_{w_c}(\llbracket \beta \rrbracket^{c,w_c})$
 b. $\lambda c: c \in K \ \& \ \llbracket \alpha \rrbracket^{c,w_c} \in \text{Dom}(\text{ANS}_{w_c}). \text{ANS}_{w_c}(\llbracket \alpha \rrbracket^{c,w_c})$

A main clause interrogative β and a potential reply to β are subject to various congruence conditions (see, for example, Roberts 2012). Let us assume that (β, α) is a congruent interrogative-reply pair in c only if $cs_c \subseteq \{w \in W \mid \llbracket \beta \rrbracket^{c,w}(\llbracket \alpha \rrbracket^{c,w_c}) \text{ is defined}\}$, $\{w \in cs_c \mid \llbracket \beta \rrbracket^{c,w}(\llbracket \alpha \rrbracket^{c,w_c}) = \text{True}\} \neq \emptyset$ and $\{w \in cs_c \mid \llbracket \beta \rrbracket^{c,w}(\llbracket \alpha \rrbracket^{c,w_c}) = \text{False}\} \neq \emptyset$, where cs_c is the context set of c in the sense of Stalnaker 1978 (the set of worlds compatible with what is presupposed in w_c). If (β, α) is congruent in c and α is accepted in c as a reply to β , $\{w \in cs_c \mid \llbracket \beta \rrbracket^{c,w}(\llbracket \alpha \rrbracket^{c,w_c}) = \text{False}\}$ is subsequently removed from cs_c . Since $\llbracket \text{Marv} \rrbracket^{c,w_c} = \mathbf{M} (= [\lambda w: w \in W. \mathbf{m}]; \text{cf. (11d)})$, a (s, e) -function such that for some $c \in K$, for all $w \in cs_c$, \mathbf{M} is student-valued (and also, presumably, an element of $\text{NAT}_{c,w}$), the pair $(\llbracket [\text{which}^{(s,e)} \text{ student}] [\text{?} [\text{turned-in}^{T1} \sim \text{Binding}]] \rrbracket, \text{Marv})$ may sometimes be a congruent interrogative-reply pair (provided, of course, that the full set of congruence conditions is met). Similarly, *the syntax student*, interpreted as in (13), may also form a congruent pair with $[\text{which}^{(s,e)} \text{ student}] [\text{?} [\text{turned-in}^{T1} \sim \text{Binding}]]$.³

² $\llbracket \alpha \rrbracket^{c,w} = \lambda v: v \in W \ \& \ \llbracket \alpha \rrbracket^{c,v}$ is defined. $\llbracket \alpha \rrbracket^{c,v}$

³ It is worth noting that ‘de dicto’ readings of *wh* strings with intensional verbs (discussed in Rullmann & Beck 1998) such as *[Which student does John think turned in Binding?]* suggest that $\llbracket [\text{which}^{(s,e)} \text{ student}] \rrbracket^{c,w} = [\lambda f: f \in D_{(s,t)}. \lambda h: h \in D_{(s,\sigma)} \ \& \ h \in \text{NAT}_{c,w} \ \& \ \text{Dom}(h) \supseteq \mathbf{F}_{c,w}. \text{for all } v \in \text{Dom}(h), f(h(v)) = \text{True}]$ (where $\mathbf{F}_{c,w}$ is a c -relevant subset of W ; e.g., the set of John’s belief worlds in w). Since the examples discussed here do not contain intensional verbs, adopting (11a) is harmless.

- (13) $\lambda v: v \in W \ \& \ \text{CARD}(\{x \in D_e \mid x \in (\text{REL}_{c,v} \cap \text{SYNTAX-STUDENT}_v)\}) = 1.$
the element of $\{x \in D_e \mid x \in (\text{REL}_{c,v} \cap \text{SYNTAX-STUDENT}_v)\}$

By assumption, NAT_c in (11) is a property of natural functions (the reason for this, too, will become clear in 3.2). Let us briefly elaborate on the distinction between natural functions and pair-lists – functions that are (possibly) random sets of ordered pairs. The following (from Jacobson 1999, Fn. 23) describes this distinction informally:

‘The term “natural function” is perhaps not the most felicitous one – a better one would be a “procedurally defined function”. I will not attempt to precisely pin this down here ... but the basic intuition is fairly obvious. A procedurally defined function is an intensional one: its value can be computed for any new individual added to the world ... A random list of ordered pairs – while extensionally equivalent to a procedurally defined function for a given domain – is not a recipe in the same sense.’

We rely on this informal and intuitive understanding of what a natural function is, and do not attempt to provide a more rigorous or precise definition.

Natural functions are often referred to by definite noun phrases such as *Binding* ((11d)), *the syntax student* ((13)) and *his term paper* ((14a); cf. Jacobson 1999). Pair-lists are often referred to by strings of pairs of definite noun phrases. A name-name string phonetically realizes several expressions ((14b) provides the extensions of some of the possible expressions realized by such a string).

- (14) For any $c \in K$ and $w \in W$:
- a. (i) $\llbracket \text{his} \rrbracket^{c,w} = \lambda P: P \in D_{(s,(e,t))}. \lambda v: v \in W. \lambda x: x \in D_e \ \& \ \text{CARD}(\{z \in D_e \mid z \in \text{REL}_{c,v} \ \& \ P(v)(z) = \text{True} \ \& \ (z, x) \in \text{OF}_v\}) = 1.$
the element of $\{z \in D_e \mid z \in \text{REL}_{c,v} \ \& \ P(v)(z) = \text{True} \ \& \ (z, x) \in \text{OF}_v\}$
 - (ii) $\llbracket \text{his term paper} \rrbracket^{c,w} = \llbracket \text{his} \rrbracket^{c,w}(\lambda v: v \in W. \llbracket \text{term paper} \rrbracket^{c,v}) = \text{TRMPPR} (= \lambda v: v \in W. \lambda x: x \in D_e \ \& \ \text{CARD}(\{z \in D_e \mid z \in (\text{REL}_{c,v} \cap \text{TERM-PAPER}_v) \ \& \ (z, x) \in \text{OF}_v\}) = 1.$
the element of $\{z \in D_e \mid z \in (\text{REL}_{c,v} \cap \text{TERM-PAPER}_v) \ \& \ (z, x) \in \text{OF}_v\}$
 - b. (i) $\llbracket \text{Marv, Binding; Fred, Anaphora; Sam, Tense} \rrbracket^{c,w} = \{(\mathbf{M}, \mathbf{B}), (\mathbf{F}, \mathbf{A}), (\mathbf{S}, \mathbf{T})\}$, which is an element of $D_{((s,e),(s,e))}$.
 - (ii) $\llbracket \text{Marv, } \sim \text{Binding; } \sim \text{Fred, } \sim \text{Anaphora; } \sim \text{Sam, } \sim \text{Tense} \rrbracket^{c,w} = \{(\mathbf{m}, \mathbf{b}), (\mathbf{f}, \mathbf{a}), (\mathbf{s}, \mathbf{t})\}$, which is an element of $D_{(e,e)}$.
 - (iii) $\llbracket \text{Marv, Binding; } \sim \text{Fred, Anaphora; } \sim \text{Sam, Tense} \rrbracket^{c,w} = \{(\mathbf{m}, \mathbf{B}), (\mathbf{f}, \mathbf{A}), (\mathbf{s}, \mathbf{T})\}$, which is an element of $D_{(e,(s,e))}$.

We assume, crucially, that for all $c \in K$ and $w \in W$, only **B**, $\llbracket \text{Marv's term paper} \rrbracket^{c,w_c}$, **TRMPPR** and the like can be in $\text{NAT}_{c,w}$; $\llbracket \sim \text{Marv}, \sim \text{Binding}; \sim \text{Fred}, \sim \text{Anaphora}; \sim \text{Sam}, \sim \text{Tense} \rrbracket^{c,w_c}$ and the like are not in $\text{NAT}_{c,w}$ (even if **b** is – accidentally – **m**'s term paper in w , **a** is **f**'s and **t** is **s**'s). Neither is $\llbracket [\sim \text{Marv}, \sim \text{Binding}; \sim \text{Fred}, \sim \text{Anaphora}; \sim \text{Sam}, \sim \text{Tense}] \rrbracket^{c,w_c}$, although it is – like **TRMPPR** – of type $(s, (e, e))$. The value of **TRMPPR** can be computed for any $w \in W$ and “any new individual added to” $\text{Dom}(\text{TRMPPR}(w))$, but the value of $\llbracket [\sim \text{Marv}, \sim \text{Binding}; \sim \text{Fred}, \sim \text{Anaphora}; \sim \text{Sam}, \sim \text{Tense}] \rrbracket^{c,w_c}$ cannot be computed for any $w \in W$ and “any new individual added to” $\{\mathbf{m}, \mathbf{f}, \mathbf{s}\}$.

There is evidence that the grammar of natural language is sensitive to the natural function/pair-list distinction. The contrast between *wh* gaps and resumptive pronouns in Modern Hebrew regarding anaphora illustrates this (see Sharvit 1999a, responding to Doron 1982). In (15a,b) (where OM stands for “object marker”), ‘every man’ may “bind” the pronoun ‘he’ in the main verb phrase despite the fact that on the surface, the scope of ‘every man’ is limited to the relative clause embedded in the subject. Accordingly, both (15a) (with ‘the woman every man hates’ in subject position) and (15b) (with ‘the woman every man hates her’ in subject position) have a reading that implies that for each man x , the woman that x hates is x 's biggest female enemy.

- (15) a.

| | | | | | |
|-----------|---------------|-------|---------|-------|--|
| ha-ifa | je | kol | gever | sone | |
| the-woman | that | every | man | hates | |
| | | | | | |
| hi | ha-oyev-et | haxi | gdol-a | jel-o | |
| is | the-enemy-FEM | most | big-FEM | of-he | |
- b.

| | | | | | |
|-----------|---------------|-------|---------|-------|-------------|
| ha-ifa | je | kol | gever | sone | ot-a |
| the-woman | that | every | man | hates | OM-she |
| | | | | | |
| hi | ha-oyev-et | haxi | gdol-a | jel-o | |
| is | the-enemy-FEM | most | big-FEM | of-he | |

Yet (15a) and (15b) do not have quite the same meaning, as suggested by the fact that they do not have the same discourse anaphora options. The sequence formed of (16) followed by (15a), the sequence formed of (17) followed by (15a) and the sequence formed of (16) followed by (15b) are all felicitous discourses. But the sequence formed of (17) followed by (15b) is odd.

- (16)

| | | | | |
|-------|-------|-------|-------|-----------|
| kol | gever | sone | ifa | mesuyemet |
| every | man | hates | woman | certain |

 ‘Every man hates a certain woman’

- (17) dan sone et mira, david sone et sara, ve ram sone et rina
 Dan hates OM Mira, David hates OM Sarah, and Ram hates OM Rina
 ‘Dan hates Mira, David hates Sarah, and Ram hates Rina’

Here is a partial explanation. The subject of (15a) (‘the woman every man hates’) may denote a function – a woman-valued function that maps each man to a woman he hates – of two varieties. It may refer back to the function introduced by (16) (along the lines of Jacobson 1994); that function is asserted to be $\llbracket \text{his biggest female enemy} \rrbracket^{f,w_c}$ in all w in cs_c . It may also refer back to the set of ordered pairs introduced by (17) (along the lines of Sharvit 1999a,b); that set of pairs is asserted to (accidentally) be $\llbracket \text{his biggest female enemy} \rrbracket^{f,w_c(w)}$ in all w in cs_c . The subject of (15b) (‘the woman every man hates her’), on the other hand, has only one “functional” interpretation: it may refer back to the natural function introduced by (16), but not to the set of ordered pairs introduced by (17) because, presumably, the resumptive pronoun ‘she/her’ cannot associate with a function that is not procedurally-defined (to borrow Jacobson’s term).

One more remark regarding NAT_c . On the current proposal we expect *the syntax student and Marv* to sometimes be an acceptable reply to [Which students turned in Binding?] when a single individual meets both descriptions. This may seem counter-intuitive (see Rullmann & Beck 1998 for a similar concern within a different approach). However, in a situation where we are trying to determine whether students’ research interests affect their timeliness, *the syntax student and the semantics student* seems a felicitous reply to [Which students turned in their paper on time?] even when a single individual qualifies as both. We therefore maintain that a *which* phrase contributes a property of (s, σ) -functions constrained by NAT_c , and assume that NAT_c itself is constrained in ways – not discussed here – that often boil down to requiring *(the) X and (the) Y* to “pick out” a plurality of two distinct individuals.

3.2 Natural function vs. pair-list interrogatives

That the grammar of natural language is indeed sensitive to the natural function / pair-list distinction is further corroborated by the fact that some *wh* strings (e.g., single-*wh* strings with *every* in subject position) have a natural function reading as well as a pair-list reading, while others (e.g., single-*wh* strings with *no* in subject position) have a natural function reading but no pair-list reading, and multiple-*wh* strings have a pair-list reading but no natural function reading. We discuss the principles that govern the distribution of these readings borrowing insights from Engdahl 1986, Krifka 2001, Dayal 1996, 2002 and others (with the adjustments needed to comply with the assumptions in 3.1).

(18) I1: Which paper did every student turn in?
 R1: Binding. R2: His term paper.
 I2: Which paper did no student turn in?
 R1: Binding. R2: His term paper.
 I3: Which paper did most students turn in?
 R1: Binding. R2: Their term paper.

Each of the strings I1-I3 may phonetically realize more than one interrogative. The R1-readings arise from $[which^{(s,e)} paper]$ [$? [[\text{Subject} \dots] turn-in^{T2Q}]]$, as in (19); the R2-readings arise from $[which^{(s,(e,e))} paper^S]$ [$? [[\text{Subject} \dots] turn-in^{T3Q}]]$, with the subject binding a variable in the verb phrase (cf. Groenendijk & Stokhof 1984, Engdahl 1986 and Chierchia 1993), as in (20).^{4,5} Since *Binding* denotes **B** (see (11d)), a (s, e)-function that is a paper-valued element of $\mathbf{NAT}_{c,w}$ in all $w \in cs_c$ of some $c \in K$, *Binding*_(s,e) may form a congruent pair with $[which^{(s,e)} paper]$ [$? [[\text{Subject} \dots] turn-in^{T2Q}]]$. Since *his/their term paper* denotes **TRMPPR** (see (14a)), a (s, (e, e))-function that is a paper-valued element of $\mathbf{NAT}_{c,w}$ defined for all relevant students in all $w \in cs_c$ of some $c \in K$, *his/their term paper* may form a congruent pair with $[which^{(s,(e,e))} paper^S]$ [$? [[\text{Subject} \dots] turn-in^{T3Q}]]$.

- (19) a. $\lambda c: c \in K. \text{QU}_{w_c}(\lambda w: w \in W. \lambda f: f \in D_{(s,e)} \ \& \ f \in \text{NAT}_{c,w} \ \& \ f(w) \in \text{PAPER}_w.$
 $\text{ALL/NO/MOST } y \in (\text{REL}_{c,w} \cap \text{STUDENT}_w) [(y, f(w)) \in \text{TURN-IN}_w]$
 b. $\lambda c: c \in K. \text{ANS}_{w_c}(\mathbf{B})$
- (20) a. $\lambda c: c \in K. \text{QU}_{w_c}(\lambda w: w \in W. \lambda f: f \in D_{(s,(e,e))} \ \& \ f \in \text{NAT}_{c,w} \ \& \ (\text{REL}_{c,w} \cap \text{STUDENT}_w) \subseteq \text{Dom}(f(w)) \ \& \ \text{Ran}(f(w)) \subseteq \text{PAPER}_w.$
 $\text{ALL/NO/MOST } y \in (\text{REL}_{c,w} \cap \text{STUDENT}_w) [(y, f(w)(y)) \in \text{TURN-IN}_w]$
 b. $\lambda c: c \in K. \text{ANS}_{w_c}(\mathbf{TRMPPR})$

⁵ Some definedness conditions (e.g., ‘ $\llbracket \beta \rrbracket^{f, w_c} \in \text{Dom}(\text{QU}_{w_c})$ ’; see (12a)) are omitted for simplicity.

As is well known, only one of the strings I1-I3 has a pair-list “bound object” reading in addition to its natural function “bound object” reading. This is shown in (21): I1 may be answered with the fragment reply R3, but I2 and I3 cannot be answered with similar fragment replies (cf. Groenendijk & Stokhof 1984, Engdahl 1986 and Chierchia 1993).

- (21) I1: Which paper did every student turn in?
 R3: Marv, Binding; Fred, Anaphora; (and) Sam, Tense.
 I2: Which paper did no student turn in?
 R3: #Marv, Binding; Fred, Anaphora; (and) Sam, Tense.
 I3: Which paper did most students turn in?
 R3: #Marv, Binding; Fred, Anaphora; (and) Sam, Tense.

If R3 could denote a function that has the property NAT_c , I1, I2 and I3 would all have a pair-list “bound object” reading (because of (20a)). But by assumption, it cannot (see discussion of (14)). Why, then, is R3 an acceptable reply to I1?

We propose that I1 also phonetically realizes [*which*^(s,e) *paper*] [*? [[every student][%] turn-in^{t2}]]*], whose meaning results from [*every student*][%] scoping over QU, as in (22a).^{6,7} We obtain a question act that is the conjunction of all the question acts that introduce ‘Which paper did *z* turn in’ for some relevant student *z* (see Krifka 2001). To admit the answer act in (22b), we redefine congruence.

- (22) a. $\lambda c: c \in K.$
 $\mathcal{AL} \mathcal{L} z \in (\text{REL}_{c,w_c} \cap \text{STUDENT}_{w_c}) [\text{QU}_{w_c}(\lambda w: w \in W. \lambda f: f \in D_{(s,e)} \& f \in \text{NAT}_{c,w} \& f(w) \in \text{PAPER}_w. (z, f(w)) \in \text{TURN-IN}_w)]$
 b. $\lambda c: c \in K. \text{ANS}_{w_c}(\{(\mathbf{m}, \mathbf{B}), (\mathbf{f}, \mathbf{A}), (\mathbf{s}, \mathbf{T})\})$

A pair (β, α) is a congruent interrogative-reply pair in *c* only if $(\llbracket \beta \rrbracket^{c,w_c}, \llbracket \alpha \rrbracket^{c,w_c})$ or $(\text{DET}_c(\beta), \llbracket \alpha \rrbracket^{c,w_c})$ is a QuAns pair in *c*. $\text{DET}_c(\beta)$ is defined only if β contains exactly one occurrence of [*Determiner* ...][%] and $\{x \mid \llbracket \gamma \rrbracket^{c,w_c}(x) = \text{True}\} \subseteq \text{Dom}(\Omega_c)$ (where γ is the sister of *Determiner*, and Ω_c is a distinguished function such that for each $x \in \text{Dom}(\Omega_c)$, $\llbracket \Omega_c(x) \rrbracket^{c,w_c} = x$). When defined, $\text{DET}_c(\beta)$ is that function *h* such that $\text{Dom}(h) = \{x \mid \llbracket \gamma \rrbracket^{c,w_c}(x) = \text{True}\}$ and for each $z \in \text{Dom}(h)$, $h(z) = \llbracket \wedge [\beta[\Omega_c(z)/[\text{Determiner } \gamma]]] \rrbracket^{c,w_c}$.⁸ For any *Q* and *g*, (*Q*, *g*) is a QuAns pair in *c* only if (a) or (b) holds: (a) $\text{cs}_c \subseteq \{w \in W \mid Q(w)(g) \text{ is defined}\}, \{w \in \text{cs}_c \mid Q(w)(g) = \text{True}\} \neq \emptyset$ and $\{w \in \text{cs}_c \mid Q(w)(g) = \text{False}\} \neq \emptyset$; (b) $\text{Dom}(g) = \text{Dom}(Q)$, $\text{Dom}(g) \neq \emptyset$, and for each $z \in \text{Dom}(g)$, (*Q*(*z*), *g*(*z*)) is a QuAns pair in *c*.

⁶ $\llbracket \text{turn-in}^{t2} \rrbracket^{c,w} = \lambda x: x \in D_c. \lambda f: f \in D_{(s,e)} \& w \in \text{Dom}(f). \llbracket \text{turn-in} \rrbracket^{c,w}(f(w))(x)$

⁷ Various scoping mechanisms can achieve this. We are not committed to any specific mechanism.

⁸ $\beta[\delta/\varepsilon]$ is just like β except that δ replaces any and all occurrences of ε in β .

The pair ($[[\textit{which}^{(s,e)} \textit{paper}] [? [[\textit{every student}]^{\%} \textit{turn-in}^{T^2}]]]$, $[\sim \textit{Marv}, \textit{Binding}; \sim \textit{Fred}, \textit{Anaphora}; \sim \textit{Sam}, \textit{Tense}]$) may be congruent because: (a) $\sim \textit{Marv}, \textit{Binding}; \sim \textit{Fred}, \textit{Anaphora}; \sim \textit{Sam}, \textit{Tense}$ denotes $\{(\mathbf{m}, \mathbf{B}), (\mathbf{f}, \mathbf{A}), (\mathbf{s}, \mathbf{T})\}$, of type $(e, (s, e))$ (see (14b)); and (b) for some $c \in K$: (i) $cs_c \subseteq \{w \in W \mid \{\mathbf{B}, \mathbf{A}, \mathbf{T}\} \subseteq \{f \in \text{NAT}_{c,w} \mid f(w) \in \text{PAPER}_w\}\}$, (ii) $\{\mathbf{m}, \mathbf{f}, \mathbf{s}\} = (\text{REL}_{c,w_c} \cap \text{STUDENT}_{w_c})$, and (iii) $\text{DET}_c([[\textit{which}^{(s,e)} \textit{paper}] [? [[\textit{every student}]^{\%} \textit{turn-in}^{T^2}]]]) = [\lambda z: z \in (\text{REL}_{c,w_c} \cap \text{STUDENT}_{w_c}). \lambda w: w \in W. \lambda f: f \in D_{(s,e)} \& f \in \text{NAT}_{c,w} \& f(w) \in \text{PAPER}_w. (z, f(w)) \in \text{TURN-IN}_w]$.

The wide-scope interrogatives corresponding to I2 and I3 in (21) are ill-formed because as argued in Krifka 2001, *no* and *most* (unlike *every*) cannot scope out of a question act/speech act. Indeed, (23a) is a well-formed baptism but (23b,c) are not; (24a) has a description reading as well as a curse reading but (24b,c) only have a description reading. On the assumption that (β, α) is congruent only if β and α are well-formed, the contrast in (21) is expected.

- (23) a. I hereby baptize every one of you John.
 b. #I hereby baptize none of you John.
 c. #I hereby baptize most of you John.
 (24) a. Every one of you is a crook. / Every one of you is a crook!
 b. None of you are crooks. / #None of you are crooks!
 c. Most of you are crooks. / #Most of you are crooks!

3.2.2 Multiple-*wh* interrogatives

Not all pair-list readings of *wh* strings require the presence of *every*. The multiple-*wh* string $[\textit{Which student turned in which paper?}]$ intuitively seeks a reply that provides a list that pairs every student with the paper they turned in. Building on Dayal 2002, we propose that this string realizes $[\textit{which}^{(s,e)} \textit{student}] [?? [\textit{turned-in}^{T^4} [\textit{which}^{(s,e)} \textit{paper}]^@]]$, which denotes a property of pair-lists, as in (25a). $[\textit{which}^{(s,e)} \textit{student}]$ determines the domain of each pair-list as the set of relevant student-valued natural (s, e) -functions, and $[\textit{which}^{(s,e)} \textit{paper}]^@$ (which scopes above $??$) determines the range as a set of paper-valued natural (s, e) -functions.^{9,10} Since *Marv, Binding; Fred, Anaphora; Sam, Tense* denotes the pair-list $\{(\mathbf{M}, \mathbf{B}), (\mathbf{F}, \mathbf{A}), (\mathbf{S}, \mathbf{T})\}$ (see (14b)), of type $((s, e), (s, e))$, it may form a congruent pair with $[\textit{which}^{(s,e)} \textit{student}] [?? [\textit{turned-in}^{T^4} [\textit{which}^{(s,e)} \textit{paper}]^@]]$.

⁹ See Footnote 7.

¹⁰ $[[?^?]]^{c,w} = \lambda g: g \in D_{((s,o),t)} \cdot \lambda k: k \in D_{((s,\tau),t)} \cdot \lambda R: R \in D_{((s,o),((s,o),(s,\tau),t))} \cdot \lambda f: f \in D_{((s,o),(s,\tau))} \& \text{Dom}(f) = \{h \in D_{(s,o)} \mid g(h) = \text{True}\} \& \text{Dom}(f) \subseteq \{h \in D_{(s,o)} \mid f \in \text{Dom}(R(h))\} \& \text{Ran}(f) \subseteq \{h \in D_{(s,\tau)} \mid k(h) = \text{True}\} \cdot \text{Dom}(f) \subseteq \{h \in D_{(s,o)} \mid R(h)(f) = \text{True}\}$
 $[[\textit{turn-in}^{T^4}]]^{c,w} = \lambda g: g \in D_{(s,e)} \& w \in \text{Dom}(g) \cdot \lambda f: f \in D_{((s,e),(s,e))} \& w \in \text{Dom}(f(g)) \cdot [[\textit{turn-in}^{T^4}]]^{c,w}(f(g)(w))(g(w))$

- (25) a. $\lambda c: c \in K. QU_{wc}(\lambda w: w \in W. \lambda f: f \in D_{((s,e),(s,e))} \&$
 $Dom(f) = \{h \in D_{(s,e)} \mid h \in NAT_{c,w} \& h(w) \in STUDENT_w\} \&$
 $Ran(f) \subseteq \{h \in D_{(s,e)} \mid h \in NAT_{c,w} \& h(w) \in PAPER_w\}.$
 $Dom(f) \subseteq \{g \in D_{(s,e)} \mid (g(w), f(g)(w)) \in TURN-IN_w\})$
 b. $\lambda c: c \in C. ANS_{wc}(\{(M, B), (F, A), (S, T)\})$

As shown in (3), *his term paper* is not an acceptable reply to [Which student turned in which paper?]. This is expected: by assumption, *his term paper* does not have a denotation of type $((s, e), (s, e))$ – basic or derived. The basic denotation of *his term paper* is **TRMPPR** (see (14a)), of type $(s, (e, e))$. It has derived denotations of types $e, (e, e)$ and $(s, (s, (e, e)))$, but not of type $((s, e), (s, e))$.

The question argument of QU in (25a) is modeled on Dayal 2002, but in Dayal's analysis, a *which-which* question seeks a pair-list of type (e, e) , with the first *which* phrase determining the domain of the pair-list as the set of relevant students, and the second *which* phrase determining the range as a set of papers. If (like Dayal (1996, 2002) and Jacobson (2016)) we assumed that *wh* phrases may contribute properties of individuals, it would follow that *his term paper* may be an acceptable reply to [Which student turned in which paper?], because (e, e) is the type of one of the derived meanings of *his term paper*.

It is also worth noting that if we assumed that *he* is a variable of type (s, e) that may be bound (say, by a binding index, in the style of Heim & Kratzer 1998), we could (with the right meaning for 's) obtain the function in (26) – of type $((s, e), (s, e))$ – as the extension of $[3 [\sim he_3 \text{'s term paper}]]$ in any $w \in W$.

- (26) $\lambda f: f \in D_{(s,e)} \&$
 $CARD(\{g \in D_{(s,e)} \mid (g(w), f(w)) \in OF_w \& g(w) \in TERM-PAPER_w\}) = 1.$
 the element of $\{g \in D_{(s,e)} \mid (g(w), f(w)) \in OF_w \& g(w) \in TERM-PAPER_w\}$

It would then follow that *his term paper* can in principle be an acceptable reply to [Which student turned in which paper?]. Crucially, $[3 [\sim he_3 \text{'s term paper}]]$ – or any similar expression – is not well-formed in our system. In addition, if *the term paper* (whose extension, we assume, is in $D_{(s,e)}$; cf. (13)) could have the denotation in (27), it could be an acceptable reply to [Which student turned in which paper?]. But, by assumption, (27) – or any other element of $D_{((s,e),(s,e))}$ – is not a possible denotation of *the term paper*.

- (27) $\lambda f: f \in D_{(s,e)}. \lambda w: w \in W \&$
 $CARD(\{x \in D_e \mid x = f(w) \& x \in TERM-PAPER_w\}) = 1.$
 the element of $\{x \in D_e \mid x = f(w) \& x \in TERM-PAPER_w\}$

To sum up, the current proposal predicts that while some *wh* strings (e.g., *wh* strings with *every*) can have a natural function “bound” reading as well as a pair-list “bound” reading, some *wh* strings can have one reading but not the other.

| (28) | Natural function “bound” reply (s, (e, e)) | Pair-list “bound” reply (e, (s, e))/((s, e), (s, e)) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|------------------------------------------------------------------------------------|
| Interrogative | | |
| a. [<i>which</i> ^{(s,(e,e))} <i>paper</i> ^s] [? [<i>every/no student</i> <i>turn-in</i> ^{T3Q}]] (20a) | <i>his term paper</i> (20b) | N/A |
| b. [<i>which</i> ^(s,e) <i>paper</i>] [? [[<i>every student</i>] [%] <i>turn-in</i> ^{T2}]] (22a) | N/A | ~ <i>Marv, Binding</i> ; ~ <i>Fred, Anaphora</i> ; ~ <i>Sam, Tense</i> (22b) |
| c. *[<i>which</i> ^(s,e) <i>paper</i>] [? [[<i>no student</i>] [%] <i>turn-in</i> ^{T2}]] | N/A | N/A |
| d. [<i>which</i> ^(s,e) <i>student</i>] [?? [<i>turned-in</i> ^{T4} [<i>which</i> ^(s,e) <i>paper</i>] [@]]] (25a) | N/A | <i>Marv, Binding</i> ; <i>Fred, Anaphora</i> ; <i>Sam, Tense</i> (25b) |

Thus, basic forms of reply to *wh* strings are accounted for. We now discuss two non-basic forms of reply: gapped fragments of a higher order and full replies.

4 Some non-basic replies

4.1 Higher order questions and their semantic answers

Consider the string |Which paper did Marv turn in?|. According to the current proposal, it may phonetically realize [*which*^(s,e) *paper*] [? [~*Marv turn-in*^{T2}]]. But notice that, in principle, the same string could also phonetically realize [*which*^(s,e) *paper*] [? [[~*Marv*][%] *turn-in*^{T2}]], yielding the Krifka-style (29) (cf. (22a)).

$$(29) \lambda c: c \in K. \mathcal{ALL} z \in \{\mathbf{m}\} [\text{QU}_{w_c}(\lambda w: w \in W. \lambda f: f \in D_{(s,e)} \& f \in \text{NAT}_{c,w} \& f(w) \in \text{PAPER}_w. (z, f(w)) \in \text{TURN-IN}_w)]$$

A minor adjustment of the definition of DET (see 3.2.1) makes (DET_c[[*which*^(s,e) *paper*] [? [[~*Marv*][%] *turn-in*^{T2}]]), {(**m**, **B**)} a QuAns pair in some $c \in K$. However, while the utterance of *Binding* as a reply to |Which paper did Marv turn in?| is often acceptable, the utterance of ~*Marv, Binding* rarely is.

We propose that (β, α) is congruent in c only if it respects Avoid Singleton List Answers (ASLA); i.e., only if α denotes a non-singleton, unless there is no alternative congruent (β', α') such that α' denotes a non-singleton, and settling β' with α' in c amounts to settling β with α in c . Accordingly, $([[\text{which}^{(s,e)} \text{ paper}] [?\text{ } [\text{Marv}]^{\%} \text{ turn-in}^{T2}]]], [\text{Marv}, \text{Binding}])$ is not a congruent interrogative-reply pair in every c where $(\text{DET}_c([\text{which}^{(s,e)} \text{ paper}] [?\text{ } [\text{Marv}]^{\%} \text{ turn-in}^{T2}]]], \{(\mathbf{m}, \mathbf{B})\})$ is a QuAns pair, because $([[\text{which}^{(s,e)} \text{ paper}] [?\text{ } [\text{Marv} \text{ turn-in}^{T2}]]], \text{Binding})$ – which brings about essentially the same update of cs_c without “involving” a reply that denotes a singleton – may be congruent in c . For space limitations, we do not discuss circumstances where a singleton list does not lead to a violation of ASLA or the connection between ASLA and Scope Economy (from Fox 2000).

With this in mind, consider again $[\text{Which student turned in which paper?}]$. The single-pair gapped (30a) is not a fully acceptable reply to this string. Interestingly, the multiple-pair gapped (30b) may be a fully acceptable reply in situations where all the relevant students are either syntax students or semantics students.

- (30) a. Every student, his term paper.
 b. Every syntax student, his phonology term paper; (and) every semantics student, his syntax term paper.

We propose that $[\text{Which student turned in which paper?}]$ may phonetically realize the interrogative $[\text{which}^{(s,((e,t),t))} [\text{PART} \wedge \text{student}]] [?? [\text{turned-in}^{T4Q} [\text{which}^{(s,(e,e))} \text{ paper}^{\$}]^@]]$ (in addition to $[\text{which}^{(s,e)} \text{ student}] [?? [\text{turned-in}^{T4} [\text{which}^{(s,e)} \text{ paper}^{\$}]^@]]$), yielding the higher order Dayal-style interpretation in (32) (cf. (25)).¹¹ PART denotes a distinguished c -salient function as described in (31).¹²

- (31) For any $c \in K$, $w \in W$ and $P \in D_{(s,(e,t))}$:
 (i) for all Q , if $[[\text{PART}]]^{c,w}(P)(Q) = \text{True}$, then there is an element of $D_{(s,(e,t))} - P_Q$ – such that $Q = [\lambda v: v \in W. [[\text{every}]]^{c,v}(P_Q(v))]$ and:
 (a) $\{x \in \text{REL}_{c,w} \mid P_Q(w)(x) = \text{True}\} \neq \emptyset$,
 (b) for all $v \in W$, $\{x \in D_e \mid P_Q(v)(x) = \text{True}\} \subseteq \{x \in D_e \mid P(v)(x) = \text{True}\}$; and
 (ii) $\{x \in \text{REL}_{c,w} \mid P(w)(x) = \text{True}\} = \mathbf{U}\{Z \mid \text{there is a } Q \in \text{NAT}_{c,w} \text{ such that } [[\text{PART}]]^{c,w}(P)(Q) = \text{True} \text{ and } \{x \in \text{REL}_{c,w} \mid P_Q(w)(x) = \text{True}\} = Z\}$.

¹¹ $[[\text{turn-in}^{T4Q}]]^{c,w} = \lambda g: g \in D_{(s,((e,t),t))}. \lambda f: f \in D_{((s,((e,t),t)),(s,(e,e)))} \& [\lambda z: z \in \text{Dom}(f(g)(w)). [[\text{turn-in}]]^{c,w}(f(g)(w)(z))(z))] \in \text{Dom}(g(w)).$
 $g(w)(\lambda z: z \in \text{Dom}(f(g)(w)). [[\text{turn-in}]]^{c,w}(f(g)(w)(z))(z))$

¹² This is a first approximation. The definition of PART will have to be adjusted to admit, in some situations, “mixed” replies such as *Every syntax student, his phonology paper; most semantics students, their syntax paper*.

- (32) a. $\lambda c: c \in K. \text{QU}_{w_c}(\lambda w: w \in W. \lambda f: f \in D_{((s,((e,t),t)),(s,(e,e)))}) \&$
 $\text{Dom}(f) = \{h \in D_{(s,((e,t),t))} \mid h \in \text{NAT}_{c,w} \& \llbracket \text{PART} \rrbracket^{c,w}(\llbracket \text{student} \rrbracket^{c,w})(h) = \text{True}\} \&$
 $\text{Dom}(f) \subseteq \{h \in D_{(s,((e,t),t))} \mid h(w)(\lambda z: z \in D_e. z \in \text{Dom}(f(h)(w))) = \text{True}\}$
 $\&$
 $\text{Ran}(f) \subseteq \{h \in D_{(s,(e,e))} \mid h \in \text{NAT}_{c,w} \& \text{Ran}(h(w)) \subseteq \text{PAPER}_w\}.$
 $\text{Dom}(f) \subseteq \{g \in D_{(s,((e,t),t))} \mid g(w)(\lambda z: z \in \text{Dom}(f(g)(w)). (z, f(g)(w)(z)) \in \text{TURN-IN}_w) = \text{True}\}$
 b. $\lambda c: c \in C. \text{ANS}_{w_c}(\{\llbracket \text{every syntax student} \rrbracket^{c,w_c}, \text{PHON-TRMPPR},$
 $\llbracket \text{every semantics student} \rrbracket^{c,w_c}, \text{SYNTAX-TRMPPR}\})$

The singleton $\{\llbracket \text{every student} \rrbracket^{c,w_c}, \text{TRMPPR}\}$ may form a QuAns pair with $\llbracket \llbracket \text{which}^{(s,((e,t),t))} [\text{PART} \text{ student}] \llbracket \text{turned-in}^{\text{T4Q}} [\text{which}^{(s,(e,e))} \text{paper}^s] @ \rrbracket \rrbracket^{c,w_c}$, but ASLA might be violated due to the congruence of $(\llbracket \text{which}^{(s,(e,e))} \text{paper}^s \rrbracket \llbracket \text{every student turn-in}^{\text{T3Q}} \rrbracket, [\text{his term paper}])$; see (20). It is worth noting that the string [Which paper did every student turn in?] is correctly predicted to have a higher order Krifka-style interpretation along similar lines, with the subject scoping out of the question act (cf. (22a)), making (30b) a fully acceptable reply.

It should also be noted that the higher order analysis of pair-list *wh* interrogatives is indirectly motivated by quantificational variability effects (QVE; see Berman 1991 and Lahiri 1991). The motivation is reflected in the similarity between the higher order analysis of pair-list *wh* interrogatives and the analysis of QVE in Beck & Sharvit 2002, as illustrated below. *For the most part* in (33) is the phonetic realization of MOST in (34b), whose domain of quantification is $\text{PART}_{c,w}^1(\llbracket \text{who}^{(s,e)} \llbracket ? \text{left}^{\text{T1}} \rrbracket \rrbracket^{c,w})$ – a c-relevant set of sub-questions of $\llbracket \text{who}^{(s,e)} \llbracket ? \text{left}^{\text{T1}} \rrbracket \rrbracket^{c,w}$ such that the conjunction of their answers implies the exhaustive answer to $\llbracket \text{who}^{(s,e)} \llbracket ? \text{left}^{\text{T1}} \rrbracket \rrbracket^{c,w}$.

(33) John knows, for the most part, who left.

(34) a. Intuitive meaning of (33), roughly:

The cardinality of $\{x \mid \text{John knows whether } x \text{ left}\}$ is greater than the cardinality of $\{x \mid \text{John doesn't know whether } x \text{ left}\}$.

b. Formal interpretation of (33) (in the style of Beck & Sharvit 2002):

$\lambda c: c \in K. \text{ASSERT}_{w_c}(\lambda w: w \in W.$

$\text{MOST } Q \in \text{PART}_{c,w}^1(\llbracket \text{who}^{(s,e)} \llbracket ? \text{left}^{\text{T1}} \rrbracket \rrbracket^{c,w})[(j, Q) \in \text{KNOW}_w])$

An example of a sub-question of $\llbracket \text{who}^{(s,e)} \llbracket ? \text{left}^{\text{T1}} \rrbracket \rrbracket^{c,w}$ is $[\lambda v \in W. \llbracket \text{Yes/No} \rrbracket^{c,v}(\mathbf{M}, \text{LEAVE})]$ (informally, ‘Did **m** leave?’). Accordingly, $\text{PART}_{c,w}^1(\llbracket \text{who}^{(s,e)} \llbracket ? \text{left}^{\text{T1}} \rrbracket \rrbracket^{c,w})$ might be $\{Q \mid \text{there is a } g \in (D_{(s,e)} \cap \text{NAT}_{c,w}) \text{ such that } Q = [\lambda v \in W. \llbracket \text{Yes/No} \rrbracket^{c,v}(g, \text{LEAVE})]\}$.

4.2 Full replies

To account for the acceptability of some full replies (in particular, (2a) and (3a) as replies to both |Which student turned in which paper?| and |Which paper did every student turn in?|), we adjust our notion of congruence. (β, γ) is a congruent interrogative-reply pair in c only if β and γ are well-formed, and (i) or (ii) holds: (i) $(\llbracket \beta \rrbracket^{c,w_c}, \llbracket \gamma \rrbracket^{c,w_c})$ or $(\text{DET}_c(\beta), \llbracket \gamma \rrbracket^{c,w_c})$ is a QuAns pair in c , subject to ASLA; (ii) γ is β -parasitic in c on some α such that $(\llbracket \beta \rrbracket^{c,w_c}, \llbracket \alpha \rrbracket^{c,w_c})$ or $(\text{DET}_c(\beta), \llbracket \alpha \rrbracket^{c,w_c})$ is a QuAns pair in c . This works as described in (35) and illustrated in (36).

- (35) a. When $(\llbracket \beta \rrbracket^{c,w_c}, \llbracket \alpha \rrbracket^{c,w_c})$ is a QuAns pair in c , then for any declarative γ , γ is β -parasitic on α in c only if for all $w \in \text{cs}_c$, $\llbracket \beta \rrbracket^{c,w}(\llbracket \alpha \rrbracket^{c,w_c}) = \llbracket \gamma \rrbracket^{c,w}$ and – in addition – (I) or (II) holds:¹³
 (I) for all $v \in W$, $\llbracket \alpha \rrbracket^{c,w_c} \notin \text{NAT}_{c,v}$;
 (II) for any $k \in K$ such that $(\llbracket \beta \rrbracket^{k,w_k}, \llbracket \alpha \rrbracket^{k,w_k})$ is a QuAns pair in k , for all $v \in \text{cs}_k$, if $\llbracket \beta \rrbracket^{k,v}(\llbracket \alpha \rrbracket^{k,w_k}) = \text{True}$ then $\llbracket \gamma \rrbracket^{k,v} = \text{True}$.
 b. When $(\text{DET}_c(\beta), \llbracket \alpha \rrbracket^{c,w_c})$ is a QuAns pair in c , then for any declarative γ , γ is β -parasitic on α in c only if:
 for each $z \in \text{Dom}(\llbracket \alpha \rrbracket^{c,w_c})$, there is some $(\alpha', \beta', \gamma')$ such that $\llbracket \alpha' \rrbracket^{c,w_c} = \llbracket \alpha \rrbracket^{c,w_c}(z)$, $\beta' = \beta[\Omega_c(z)/\dots]^\circ$, and γ' is a declarative embedded in γ that is β' -parasitic on α' in c .
- (36) a. [$\sim \text{Marv}$ [*turned-in* $\sim \text{Binding}$]] may be:
 – $[[\text{which}^{(s,e)} \text{ paper}] [?\ [\sim \text{Marv turn-in}^{T2}]]]$ -parasitic on *Binding* (by (35a));
 – $[[\text{which}^{(s,e)} \text{ paper}] [?\ [[\sim \text{Marv}]^\circ \text{ turn-in}^{T2}]]]$ -parasitic on $\sim \text{Marv}$, *Binding* (by (35b)).
 b. [$\sim \text{Marv}$ [*turned-in* $\sim \text{Binding}$]], [$\sim \text{Fred}$ [*turned-in* $\sim \text{Anaphora}$]], (*and*) [$\sim \text{Sam}$ [*turned-in* $\sim \text{Tense}$]] may be:
 – $[[\text{which}^{(s,e)} \text{ student}] [?? [\text{turned-in}^{T4} [\text{which}^{(s,e)} \text{ paper}]^\circ]]]$ -parasitic on *Marv*, *Binding*; *Fred*, *Anaphora*; *Sam*, *Tense* (by (35a));
 – $[[\text{which}^{(s,e)} \text{ paper}] [?\ [[\text{every student}]^\circ \text{ turn-in}^{T2}]]]$ -parasitic on $\sim \text{Marv}$, *Binding*; $\sim \text{Fred}$, *Anaphora*; $\sim \text{Sam}$, *Tense* (by (35b)).
 c. $[[\text{every student turned-in}^{T3Q}] \text{ his term paper}]$ may be:
 – $[[\text{which}^{(s,(e,e))} \text{ paper}^s] [?\ [\text{every student turn-in}^{T3Q}]]]$ -parasitic on *his term paper* (by (35a));
 – $[[\text{which}^{(s,e)} \text{ student}] [?? [\text{turned-in}^{T4} [\text{which}^{(s,e)} \text{ paper}]^\circ]]]$ -parasitic on *Marv*, *Binding*; *Fred*, *Anaphora*; *Sam*, *Tense* (by (35a)).

¹³ There are also constraints on the size of γ .

- d. [[[every syntax student turned-in^{T3Q}] his phonology term paper], (and) [[every semantics student turned-in^{T3Q}] his syntax term paper]] may be
 [[[which^{(s,((e,t),t))} [PART ^student]] [?? [turned-in^{T4Q} [which^{(s,(e,e))} paper^s]]@]]]-parasitic on
 ^[every syntax student], his phonology term paper; ^[every semantics student], his syntax term paper (by (35a)).

Thus, a full natural function reply may piggyback on a pair-list fragment, but a full pair-list reply cannot piggyback on a natural function fragment. These are welcome predictions. For example, [[no student turned-in^{T3Q}] his term paper] may form a congruent pair with both [[which^{(s,(e,e))} paper^s] [? [no student turn-in^{T3Q}]]] and [which^(s,e) student] [?? [did-not-turn-in^{T4} [which^(s,e) paper]@]], while *his term paper* is an acceptable reply to |Which paper did no student turn in?| but not to |Which student did not turn in which paper?| (cf. (36c)). On the other hand, [~Marv [did-not-turn-in ~Binding], ~Fred [did-not-turn-in ~Anaphora], ~Sam [did-not-turn-in ~Tense]] can form a congruent pair with [which^(s,e) student] [?? [did-not-turn-in^{T4} [which^(s,e) paper]@]] (cf. (36b)), but not with any well-formed β realized by |Which paper did no student turn in?|. If $\beta = [[\text{which}^{(s,e)} \text{paper}] [? [\text{no student turn-in}^{T2Q}]]]$ (see (19a)) or $\beta = [[\text{which}^{(s,(e,e))} \text{paper}^s] [? [\text{no student turn-in}^{T3Q}]]]$ (see (20a)), then for any $c \in K$ and α such that $(\llbracket \beta \rrbracket^{c,w_c}, \llbracket \alpha \rrbracket^{c,w_c})$ is a QuAns pair in c (e.g., $\alpha = \text{Binding}$ in the former case; $\alpha = \text{his term paper}$ in the latter case): (I) for all $w \in cs_c$, $\llbracket \alpha \rrbracket^{c,w_c} \in \text{NAT}_{c,w}$; and (II) there is a $k \in K$ such that: (i) for all $v \in cs_k$, $(s, t) \in \text{TURN-IN}_v$, so $\llbracket \sim \text{Marv} [\text{did-not-turn-in} \sim \text{Binding}], \sim \text{Fred} [\text{did-not-turn-in} \sim \text{Anaphora}], \sim \text{Sam} [\text{did-not-turn-in} \sim \text{Tense}] \rrbracket^{k,v} = \text{False}$, yet (ii) $(\llbracket \beta \rrbracket^{k,w_k}, \llbracket \alpha \rrbracket^{k,w_k})$ is a QuAns pair in k , so for some $v \in cs_k$, $\llbracket \beta \rrbracket^{k,v}(\llbracket \alpha \rrbracket^{k,w_k}) = \text{True}$.

5 Conclusion

Many challenges for fragment-reply approaches to interrogatives are not addressed here. One such challenge is the status of fragment replies vs. full replies to *wh* interrogatives in which some *wh* phrase is in a syntactic island (e.g., *Which committee member wants to hire someone who speaks which language*, discussed in Merchant 2004). The latter problem is extremely difficult to address given the lack of agreement among speakers (and among scholars) regarding the grammatical status of such interrogatives (and their replies) and their relationship to single-pair questions and echo-questions; for discussion, see Dayal 1996, 2002, 2016, Kotek 2014 and references cited there. At the same time, no account of full vs. fragment replies can be satisfactory without accounting for Kang's observation or addressing the challenges discussed in Jacobson 2016.

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