Referential Transparency and Inquisitivity

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Abstract

The paper extends a *referentially transparent* approach which has been successfully applied to the analysis of declarative quantified NPs to *wh*-phrases. This uses data from dialogical phenomena such as clarification interaction, anaphora, and incrementality as a guide to the design of *wh*-phrase meanings.

1 Introduction

An alternative to Generalized Quantifier Theory (GQT) has recently been developed in terms of *Referential Transparency Theory* (RTT; Lücking and Ginzburg, 2022). RTT draws its main motivation from data of natural language use as observed in dialogical interactions, where higher-order denotations postulated by GQT do not seem to be confirmed. Hence, RTT pursues a witness-based approach to quantification, which arguably simplifies the representation of quantification phenomena.

In this paper, we extend this to questions. This is *prima facie* tricky because in contrast to QNPs *Wh*-phrases (WhPs) are never referential.[1] Indeed a crucial difference between declarative and interrogative quantified meaning is that the former involves *predication*—giving rise to descriptive potential, whereas the latter involves *abstraction*—giving rise to predicational potential. Phenomena we discuss includes the following:

Clarificational potential: Data from clarification allows for a considerable strengthening of compositionality, the classical syntax-semantics interface desideratum. This via the Reprise Content Hypothesis (RCH) due to (Purver and Ginzburg, 2004) They distinguish different kinds of reprise fragments, including *intended meaning* requests, that is, reprise fragments that follow the template "A: …u_1… B: u_1?" exemplified in (2). Purver and Ginzburg (2004) show further that reprise fragments of the *intended meaning* type, at least when they address a non-sentential constituent, do not query pragmatically inferred material but are restricted to direct semantic content. On the basis of this they posit the *Reprise Content Hypothesis* whose strong version is given in (1):

(1) **Reprise Content Hypothesis:** A reprise fragment question queries exactly the standard semantic content of the fragment being reprised.

Whereas non-interrogative QNPs allow for clarification questions relating to their witnesses (but not to properties of properties, as would be expected in GQ accounts), *wh*-phrases allow only for clarification of their restriction property (not to any propositional entities, as might be expected by GQ accounts of interrogatives common in Type–driven Categorial Grammar (Vermaat, 2006; Mihaliček and Pollard, 2012)).[2]

(2) a. A: Most students came to the party. B: Most students? A: Yes, all but Tristan and Isolde.

[1] Of course there are languages where the same form, albeit with distinct intonation, plays a double or even triple role such as Hebrew 'eyze' which serves as a quantificational, interrogative and exclamative determiner:

(i) eyze yeladim azvu(./?/!)
Some/Which/what child-pl left
Some children left./Which children left?/What children left!

Our account will enable us to capture the core similarities between these uses, but crucially also the differences, as we demonstrate in an extended version of this paper.

[2] See (Purver, 2004) for corpus examples of clarification exchanges concerning *wh*-phrases, though he does not discuss examples like our (constructed) (2c,d).

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b. A: Everyone supports the proposals. B: Everyone? A: All the ministers.

c. A: Who should we contact for help? B: Who? A: A lawyer or a psychologist?/#Everyone except Tristan and Isolde.

d. A: When are you leaving? B: When? A: What day./#Saturday.

A similar point can be made for intensional argument roles of verbs, which allow for clarification without expectation of witnesses (Cooper, 2013b):

(3) A: Sam is looking for the trainset.
B: What trainset?
A: The one he was promised for Christmas (Cooper, 2013b),

Anaphoric potential: *wh*-phrases allow for discourse anaphora, though without a referential commitment:

(4) a. A: Who will support the proposal? Will they reveal themselves before the vote? B: No one. A: Yeah that makes sense.

b. A: Where are you going? Can we contact you there?

The same holds for intensional argument roles of verbs:

(5) a. Charlie wants a train for her birthday. Ideally it should be light blue.

Incremental potential: input is processed word by word (and indeed at a higher, sub-lexical latency). Utterances with QNPs are understood incrementally (Urbach et al., 2015), as exemplified also in (6a,b). Although we are not aware of similar empirical studies for *wh*-phrases, (6c,d) suggests that this is the case as well:[3]

(6) a. A: Everyone . . . B: Who?

b. A: [enters class] No students . . . Oh, they're hiding.

c. A: Who. . . B: What are you going to ask me now?

d. A: Which student. . . B: In what class?

[3]For an interesting discussion of incremental interpretation of *wh*-questions, though not in a dialogical setting see (Hopmans, 2019).

Approaches which treat *wh*-phrases as mediated via an operation like Quantifier Raising, where a quantifier is moved out of its syntactic surface position into another position in logical form or more generally involve long-distance binding (Xiang, 2021), seems to be a serious obstacle to this empirical fact.

Answerhood: the substantive semantic contribution of *wh*-phrases is the answerhood conditions they give rise to, the details of which are discussed in section 2.

Response space: any dialogical theory of meaning needs to account for the class of responses a given utterance type gives rise to. In the case of questions there exists detailed empirical and formal work we build on (Ginzburg et al., 2022), briefly summarized in section 2.

An example that combines these aspects of *wh*-phrase meaning is in figure 1, where the exophoric context triggers the bare *wh*–clarification question, which give rise to the short answer.

Figure 1: (Context: Harden gets called for a foul) Harden: *Who, me*?

In section 2, we sketch a theory of questions, answerhood, and responses. In section 3, we develop our account of *wh*-phrase meaning, which is applied to the initial data in section 4.

2 A KoS-TTR theory of questions

Our explication is formulated using the frameworks of Type Theory with Records (TTR; Cooper and Ginzburg, 2015; Cooper, 2023) (for the semantic ontology) and KoS (Ginzburg, 2012; Ginzburg et al., 2022) (for the theory of dialogue context).

2.1 Basic semantic notions

We will assume a view of questions as propositional functions, a view apparently initiated by Ajdukiewicz (1926), developed significantly in Kubinski (1960), and subsequently shared and further developed by a number of different approaches, e.g., Krifka (2001).

We adopt an implementation of this view within the framework of TTR. The starting point, hence, is the notion of a proposition in TTR. Propositions are construed as typing relations between records (situations) and record types (situation types), or Austinian propositions (Austin, 1961; Barwise and Etchemendy, 1987); more formally:

(7) a. Propositions are records of type

$$\text{Prop} = \begin{bmatrix} \text{sit} & : \textit{Rec} \\ \text{sit-type} & : \textit{RecType} \end{bmatrix}.$$

b. $\text{p} = \begin{bmatrix} \text{sit} & = s \\ \text{sit-type} & = T \end{bmatrix}$ is true iff *p.sit* : *p.sit-type*
i.e., $s : T$ —the situation s is of the type T.

Similarly, we will model questions as records comprising two fields, a situation and a function (Ginzburg et al., 2014). The role of *wh*-words on this view is to specify the domains of these functions; in the case of polar questions there is no restriction, hence the function component of such a question is a constant function. (8) exemplifies this for a unary 'who' question and a polar question:

(8) a. $\textit{Who} = \begin{bmatrix} x_1 : \textit{Ind} \\ \text{c1} : \text{person}(x_1) \end{bmatrix};$

b. *Whether* = *Rec*;

c. 'Who runs?' $\mapsto$
$$\begin{bmatrix} \text{sit} = r_1 \\ \text{abstr} = f{:}\textit{Who}(\begin{bmatrix} \text{c} : \text{run}(r_1.x_1) \end{bmatrix}) \end{bmatrix};$$

d. 'Whether Bo runs?' $\mapsto$
$$\begin{bmatrix} \text{sit} = r_1 \\ \text{abstr} = f{:}\textit{Whether}(\begin{bmatrix} \text{c} : \text{run(b)} \end{bmatrix}) \end{bmatrix}$$

Austinian questions can be conjoined and disjoined though not negated. We view this as an advantage over inquisitive approaches which overgenerate in allowing interrogatives to be negated. The definition for con-/disjunction is as follows:

(9)
$$\begin{bmatrix} \text{sit} & = & s \\ \text{abstr} & = & f : T_1\ (T_2) \end{bmatrix} \quad \wedge \quad (\vee) \quad \begin{bmatrix} \text{sit} & = & s \\ \text{abstr} & = & f : T_3\ (T_4) \end{bmatrix} = \begin{bmatrix} \text{sit} = \text{s} \\ \text{abstr} = f{:}\begin{bmatrix} \text{left:}T_1 \\ \text{right:}T_3 \end{bmatrix} \\ (q_1(s.\text{left}) \wedge (\vee) q_2(s.\text{right})) \end{bmatrix}$$

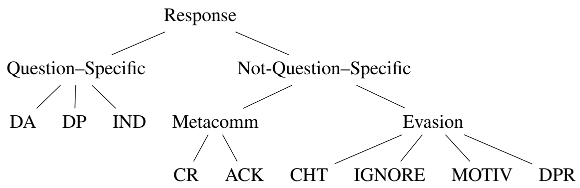

Figure 2: Proposed response space of questions

2.2 Response Space

We assume the following theory of the response space of queries, due to Ginzburg et al. (2022). This amounts to the following general types of responses (see Figure 2):

1. Question–Specific: DirectAnswers (DA), InDirectAnswers (IND) and Dependent Questions (DP):
   (a) Answerhood
   (b) Dependent questions (A: Who should we invite? B: Who is in town?)
2. Metacommunicative Responses:
   (a) Clarification Responses (CR)
   (b) Acknowledgements (ACK)
3. Evasion responses:
   (a) Ignore (address the situation, but not the question)
   (b) Change the topic (CHT; 'Answer *my* question')
   (c) Motive ('Why do you ask?')
   (d) Difficult to provide a response (DPR).

The basic notion of context we adopt is via each participant's view of publicized context, the *dialogue gameboard* (DGB), whose basic make up is given in (10):

(10)
$$\begin{bmatrix} \text{spkr} & : \textit{Ind} \\ \text{addr} & : \textit{Ind} \\ \text{utt-time} & : \textit{Time} \\ \text{c-utt} & : \text{addressing(spkr,addr,utt-time)} \\ \text{facts} & : \textit{set(Prop)} \\ \text{vis-sit} & = \begin{bmatrix} \text{foa} : \textit{Ind} \vee \textit{Rec} \end{bmatrix} : \textit{RecType} \\ \text{pending} & : \textit{list(LocProp)} \\ \text{moves} & : \textit{list(IllocProp)} \\ \text{qud} & : \textit{poset(Question)} \end{bmatrix}$$

Here *facts* represents the shared assumptions of the interlocutors—identified with a set of propositions.

Dialogue moves that are in the process of being grounded or under clarification are the elements of the *pending* list; already grounded moves are moved to the *moves* list. Within *moves* the first element has a special status given its use to capture adjacency pair coherence and it is referred to as *LatestMove*. The current question under discussion is tracked in the QUD field, whose data type is a partially ordered set (*poset*). *Vis-sit* represents the visual situation of an agent, including his or her visual focus of attention (*foa*), which can be an object (*Ind*), or a situation or event. We call a mapping between DGB types a *conversational rule*—Conversational rules are the means for specifying how DGBs evolve. The types specifying its domain and its range we dub, respectively, the *pre(conditions)* and the *effects*, both of which are subtypes of DGBType: they apply to a subclass of records that constitute possible DGBs and modify them to records that constitute possible DGBs. Conversational rules are written here in a form where the preconditions represent information specific to the preconditions of this particular interaction type and the effects represent those aspects of the preconditions that have changed.

The first conversational rule we formulate relates to the basic effect a query has on the DGB—as a consequence of a query a question becomes the maximal element of QUD:

(11) Ask QUD-incrementation: given a question q and Ask(A, B, q) being the LatestMove, one can update QUD with q as MaxQUD.

$$\begin{bmatrix} \text{pre} & : & \begin{bmatrix} \text{q} & : \textit{Question} \\ \text{LatestMove} = \text{Ask(spkr, addr, q)} & : \textit{LocProp} \end{bmatrix} \\ \text{effects} & : & \begin{bmatrix} \text{QUD} = \left\langle \text{q, pre.QUD} \right\rangle : & \textit{poset(Question)} \end{bmatrix} \end{bmatrix}$$

Before we consider how question–specific responses get accommodated, we turn to a discussion of answerhood.

2.3 Answerhood

Descriptively the *simple* answers to questions are the range of the propositional abstract, plus their negations.

(12) a. SimpleAns(p?) = $\{p, \neg p\}$;

b. SimpleAns($\lambda x.P(x)$) = $\{P(a), P(b), \ldots, \neg P(a), \neg P(b) \ldots\}$

More formally, an *atomic answer* p is a proposition for which there is a record r such that p is a proposition whose *sit* is identical to the question's *sit* and such that applying the question's *abstr* to r yields p's *sit-type*:

(13) AtomAns =

$$\begin{bmatrix} \text{p} & : \textit{Prop} \\ \text{q} & : \textit{Question} \\ \text{p.sit = q.sit} & : \textit{Rec} \\ \text{p.sit-type = q.abstr(p.sit)} & : \textit{RecType} \end{bmatrix}$$

A *negative* atomic answer p is a proposition for which there is a record r such that p is a proposition whose *sit* is identical to the question's *sit* and such that negating the application of the question's *abstr* to r yields p's *sit-type*:

(14) NegAtomAns =

$$\begin{bmatrix} \text{p} & : \textit{Prop} \\ \text{q} & : \textit{Question} \\ \text{p.sit = q.sit} & : \textit{Rec} \\ \text{p.sit-type} = \neg\text{q.abstr(p.sit)} & : \textit{RecType} \end{bmatrix}$$

To exemplify:

(15) a. Take r_1 : *Who* (cf. (8a)), e.g., r_1 = $\begin{bmatrix} \text{x}_1 = \text{a} \\ \text{c1 = PersObs1} \\ \ldots \end{bmatrix}$, then $p_1 = \begin{bmatrix} \text{sit} = r_1 \\ \text{sit-type} = \text{abstr}(r_1) = \begin{bmatrix} \text{c} : \neg\ \text{run(a)} \end{bmatrix} \end{bmatrix}$ ('a does not run') is a negative *atomic* answer to the question 'who runs'.

b. Take any record r_1, then p_1 = $\begin{bmatrix} \text{sit} = r_1 \\ \text{sit-type} = \text{abstr}(r_1) = \begin{bmatrix} \text{c} : \neg\text{run(b)} \end{bmatrix} \end{bmatrix}$ is the only negative *atomic* answer to the question 'whether B runs'.

The type of negative answers, however, will be slightly revised in adopting answerhood to RTT in section 3.

A *simple* answer is an answer that is either atomic or negative atomic: p is a simple answer to q if r_0 : *AtomAns* and p = $r_0.p$ and q = $r_0.q$ or r_0 : *NegAtomAns* and p = $r_0.p$ and q = $r_0.q$:

(16) SimpleAns =

$$\begin{bmatrix} r_0 : \textit{AtomAns} \vee \textit{NegAtomAns} \\ \text{p} = r_0.\text{p} : \textit{Prop} \\ \text{q} = r_0.\text{q} : \textit{Question} \end{bmatrix}$$

In fact, *simple answerhood*, though it has good coverage in practice, is not sufficient. It does not accommodate conditional, weakly modalized, and quantificational answers, all of which are pervasive in actual linguistic use (Ginzburg and Sag, 2000).

Thus, we suggest that the semantic notion relevant to direct answerhood is the relation *aboutness*—a relation between propositions and questions that any speaker of a given language can recognize, independently of domain knowledge and of the goals underlying an interaction.

The most detailed discussion of Aboutness we are aware of is (Ginzburg and Sag, 2000, pp. 129–149), which offers (17a) (reformulated here in TTR as Austinian questions). This requires the situational type component of the proposition to be a subtype of the join of the situational type of the question's simple answer set. As it stands, this definition allows in principle very informationally strong types as direct answers, since nothing bounds the proposition from above. Plausible upper bounds for direct answerhood familiar in the semantics of questions from the classic proposal of (Karttunen, 1977) are the meets of the question's atomic and negative atomic answer set.[4] This condition is formulated in (17b):

(17) For $p = \begin{bmatrix} \text{sit} = \text{s}_1 \\ \text{sit-type} = \text{T}_1 \end{bmatrix}$: *Prop*,
$q = \begin{bmatrix} \text{sit} = \text{s}_1 \\ \text{abstr} = \text{r} : \text{T}_2(\text{T}_3) \end{bmatrix}$: *Question*

a. $\mathit{About}(p, q)$ holds iff $T_1 \sqsubseteq \bigvee\{T | \exists p'[p' : \mathit{Prop} \wedge \mathit{SimpleAns}(p', q) \wedge T = p'.\text{sit-type}]\}$

b. $\mathit{DirectAns}(p, q)$ holds iff $\mathit{About}(p, q)$ and either

(i) $\bigwedge \mathit{AtomAns}(q) \sqsubseteq T_1$

or

(ii) $\bigwedge \mathit{NegAtomAns}(q) \sqsubseteq T_1$

For reasons of space, we omit discussion here of indirect answers and dependent questions, which figure in the following conversational rule, which is the main engine in driving question–specific responses:

(18) a. Given $r : \mathit{Question} \vee \mathit{Prop}$, $q : \mathit{Question}$, $\mathit{dgb} : \mathit{DGBType}$, $\text{QSpecific}(r, q, \mathit{dgb})$ iff $\mathit{DirectAns}(r, q) \vee \mathit{IndirectAns}(r, q, \mathit{dgb}) \vee \mathit{Depend}(q, r)$

b. QSPEC =

$$\begin{bmatrix} \text{pre} : \begin{bmatrix} \text{QUD} = \left\langle \text{q, Q} \right\rangle : \mathit{poset(Question)} \end{bmatrix} \\ \text{effects} : \begin{bmatrix} \text{spkr} = \text{pre.spkr} \vee \text{pre.addr} : \mathit{Ind} \\ \text{addr} : \mathit{Ind} \\ \text{c}_{\text{addr}} : \neq(\text{addr,spkr}) \\ \text{p} : \mathit{Prop} \vee \mathit{Question} \\ \text{c1} : \text{QSpecific(p,q,pre)} \end{bmatrix} \end{bmatrix}$$

Ginzburg and Cooper (2004); Purver (2004); Ginzburg (2012) show how to account for the main classes of clarification requests using rule schemas of the form "if u is the interrogative utterance and u_0 is a constituent of u, allow responses that are *co-propositional*[5] with the clarification question $\text{CQ}^i(u0)$ into QUD.", where '$\text{CQ}^i(u0)$' is one of the three types of clarification question (repetition, confirmation, intended content) specified with respect to $u0$.

For instance, responses such as (2) can be explicated in terms of the schema in (19):

(19) if A's utterance u is yet to be grounded and u_0 is a sub-utterance of u, QUD can be updated with the question *What did A mean by u_0?*

More formally: the issue q_0, *What did A mean by u_0?*, for a constituent u_0 of the maximally pending utterance, A its speaker, can become the maximal element of QUD, licensing follow up utterances that are CoPropositional with q_0.[6]

(20) Parameter identification:

$$\begin{bmatrix} \text{pre} : \begin{bmatrix} \text{MaxPENDING} = \begin{bmatrix} \text{sit} = u \\ \text{sit-type} = T_u \end{bmatrix} : \mathit{LocProp} \\ \text{A} = \text{u.dgb-params.spkr} : \mathit{Ind} \\ u_0 : \mathit{Sign} \\ \text{c1} : \text{member}(u_0\text{,u.constits}) \end{bmatrix} \\ \text{effects} : \begin{bmatrix} \text{MaxQUD} = \lambda x.\text{Mean}(\text{A},u_0,\text{x}) : \mathit{Question} \\ \text{LatestMove} : \mathit{LocProp} \\ \text{c1} : \text{CoPropositional(LatestMove.cont,} \\ \quad \text{MaxQUD)} \end{bmatrix} \end{bmatrix}$$

(21) a. $\lambda x.\mathit{Mean}(A, u_0, x)$

[4]For a polar question p? the meets of the question's atomic and negative atomic answer set are respectively p and $\neg p$, whereas for a *wh*–question $\lambda x.P(x)$ (e.g., 'who left') they are respectively $\bigwedge P(a_i)$ ('Bo left and Millie left ...'), whereas $\bigwedge \neg P(a_i)$ ('Bo did not leave and Millie did not leave ..., i.e., equivalent to 'No one left').

[5]Here *CoPropositionality* for two questions means that, modulo their domain, the questions involve similar answers: for instance 'Whether Bo left?', 'Who left?', and 'Which student left?' (assuming Bo is a student) are all co-propositional. More precisely, two questions q_1 and q_2 are copropositional iff there exist a record r such that $q_1(r) = q_2(r)$.

[6]Assuming a propositional function view of questions, CoPropositionality allows in propositions from the range of $\mathit{Range}(q_0)$ and questions whose range intersects $\mathit{Range}(q_0)$. Since CoPropositionality is reflexive, this means in particular that the inferred clarification question is a possible follow up utterance, as are confirmations and corrections, as exemplified in (21).

b. ?Mean(A,u_0,b) (‘Did you mean Bo’)

c. Mean(A,u_0,c) (‘You meant Chris’)

The formulation of this rule is based on the existence of a feature CONSTITS which tracks all the constituents of an utterance and therefore licences clarification of all constituents down to the word level. It presupposes the existence of a relation $Mean$ that holds between the speaker of an utterance, the utterance, and the intended content. In general, this has been identified with the value instantiated by dgb-params (on a distinguished label ‘x’) for that utterance:

(22) Mean(A,u,c) iff u.dgb-param.spkr = A and u.dgb-param.x = c

This definition was motivated by the assumption that what gets queried in intended content CRs is the intended instantiation of contextual parameters.

3 An RTT theory of WhP meaning

As we have suggested, building on much past work, QNPs have more duties than merely contributing to truth conditions: QNPs act as antecedents for anaphoric expressions, they supply verbal affiliates of co-speech gestures, and they are objects of discourse dynamics which becomes apparent in terms of acceptance or clarification requests (we restrict attention here to nominals, but the conditions generalize cross-categorially):

(23) **Referential Transparency**: a semantic representation for an NP is *referentially transparent* if

a. it provides antecedents for pronominal anaphora;

b. it provides the semantic type required by a clarification request;

c. it provides an attachment site for co-verbal gestures;

d. its content parts can be identified and addressed.

Recall from section 1 that the Reprise Content Hypothesis provides a stronger claim than Fregean compositionality: more complex contents are not just systematically combined from their parts, but the contributions from the parts have to be traceable within the complex content. This we achieve in virture of the feature CONSTITS mentioned above, whereas potential clarifiability arises from the update rule **parameter identification**, formulated above as (20)

The “QNP anatomy” (a phrase due to Cooper, 2013a), which will be an important basis for satisfying these desiderata, is based on a set triplet:

(24)
$$\begin{bmatrix} \text{q-params}: & \begin{bmatrix} \text{refset} & : \textit{Set(Ind)} \\ \text{compset} & : \textit{Set(Ind)} \\ \text{maxset} & : \textit{Set(Ind)} \\ \text{c1} & : \overrightarrow{\textit{PType}}(\text{maxset}) \\ \text{c2} & : \text{union(maxset,refset,compset)} \end{bmatrix} \\ \text{q-cond} & : \textit{Rel}(|\text{q-params.refset}|, |\text{q-params.compset}|) \end{bmatrix}$$

The arrow indicates a plural predicate type (*PType*), that is, a predicate that expects a set-valued argument. Condition c2 simply states that refset and compset add up to the maxset. The value of condition c1 is donated by the head noun and distributed over all maxset members (and thereby over refset and compset). The quantificational workhorse is the quantifier condition “q-cond”: it captures what can be called the descriptive meaning of a QNP. For instance, the q-cond of *most* states that the refset is larger than the compset (|refset| $>$ |compset|). Hence, q-cond not only expresses NP-internal quantification (i.e., quantification without a scope set from the VP), it also implements quantifiers as “sieves”, a metaphor due to Barwise and Cooper (1981).

Singular is seen as a special case of plural which just adds the following constraint:

(25)
$$\begin{bmatrix} \text{q-params}: \begin{bmatrix} \text{refind} & : \textit{Ind} \\ \text{c3} & : \text{in(refind, refset)} \end{bmatrix} \end{bmatrix}$$

RTT involves a twist in predication: the compset gives rise to “two-headed” propositions. For example, the propositional structure for the simple sentence *Most squirrels sleep* is given in (26), where sit-type is of type *RecType*:

(26)
$$\begin{bmatrix} \text{sit}{=}s_1 : \textit{Rec} \\ \text{sit-type}{=} \begin{bmatrix} \text{q-params}: & \begin{bmatrix} \text{maxset} & : \textit{Set(Ind)} \\ \text{refset} & : \textit{Set(Ind)} \\ \text{compset} & : \textit{Set(Ind)} \\ \text{c0} & : \overrightarrow{\text{squirrel}}(\text{maxset}) \\ \text{c1} & : \text{union(maxset,refset,compset)} \end{bmatrix} \\ \text{q-cond} & : |\text{q-params.refset}| > |\text{q-params.compset}| \\ \text{nucl} & : \overrightarrow{\text{sleep}}(\text{q-params.refset}) \\ \text{anti-nucl} & : \neg\overrightarrow{\text{sleep}}(\text{q-params.compset}) \end{bmatrix} \end{bmatrix}$$

Hence, there are several ways to form a propositional abstract from RTT propositions—namely over refset, compset, or refind. Two remarks are in order:

- Since refind is a special case of refset, we do not distinguish those cases and subsume refind to refset abstractions.

- In principle, the refset/compset distinction allows us to semantically distinguish positive and negative WhPs: positive ones ("Who PRED?") target the refset, negative ones ("Who does not" PRED?) can be seen to target the compset of the situational abstract of the question. However, in line with the distinction of negative and positive propositions in TTR-KoS, we treat negative questions as involving a negated nucl (and a double negated (equivalent but distinct from positive) anti-nucl).

The basic contribution of a *wh*-phrase to an interrogative meaning is the domain from which a propositional function will be constructed. It is this domain clarification for which can be sought. Hence, we add additional structure in *abstr* with a label *wh-dom*, which also gets projected as the dgb-params.x value of that sub-utterance.[7] Hence, the basic "anatomy" of WhP meaning in RTT is: The situation types of propositions on the RTT account factor out referential parameters in terms of q-params—see (24) and (26). Hence, questions and answers are constructed in terms of these parameter sets.

(27)
$$\begin{bmatrix} \text{wh-dom} = \begin{bmatrix} \text{refset} : \textit{Set(Ind)} \\ \text{c1} \quad : \overrightarrow{\textit{PType}}(\text{refset}) \end{bmatrix} : \textit{RecType} \\ \text{cont} : \begin{bmatrix} \text{x} = \text{wh-dom.refset} \end{bmatrix} \\ \text{dgb-params} : \begin{bmatrix} \text{x} = \text{wh-dom} : \textit{RecType} \end{bmatrix} \end{bmatrix}$$

A question's abstr now works as follow:

(28)
$$\begin{bmatrix} \text{s} = r_1 \\ \text{abstr} = f : T_1(T_2\text{.sit-type.q-params.refset}) \end{bmatrix}$$

which yields contents as in (29):

(29) a. *Who sleeps?* $\mapsto$

$$\begin{bmatrix} \text{sit} = r : \textit{Rec} \\ \text{abstr} = \begin{bmatrix} \text{wh-dom} = \begin{bmatrix} \text{refset} : \textit{Set(Ind)} \\ \text{c1} \quad : \overrightarrow{\text{person}}(\text{refset}) \end{bmatrix} : \textit{RecType} \\ f = \text{wh-dom}(\begin{bmatrix} \text{refset}{=}r\text{.refset} : \textit{Set(Ind)} \\ \text{nucl} : \overrightarrow{\text{sleep}}(\text{refset}) \end{bmatrix}) \end{bmatrix} \end{bmatrix}$$

b. *Who does not sleep?* $\mapsto$

$$\begin{bmatrix} \text{sit} = r : \textit{Rec} \\ \text{abstr} = \begin{bmatrix} \text{wh-dom} = \begin{bmatrix} \text{refset} : \textit{Set(Ind)} \\ \text{c1} \quad : \overrightarrow{\text{person}}(\text{refset}) \end{bmatrix} : \textit{RecType} \\ f = \text{wh-dom}(\begin{bmatrix} \text{refset}{=}r\text{.refset} : \textit{Set(Ind)} \\ \text{nucl} : \neg\overrightarrow{\text{sleep}}(\text{refset}) \end{bmatrix}) \end{bmatrix} \end{bmatrix}$$

Note that refset abstraction accommodates both singular and plural answers. Note further that the compset provides a straightforward link for maintaining situational identity between questions and answers in case of negative answers. For instance, answering "Who sleeps?" with "Not the squirrel" can be straightforwardly understood in an Austinian manner as being about the same situation since the NP negation indicates compset membership (cf. Lücking and Ginzburg, 2019).

- SimpleAns(p?) =
$$\left\{ \begin{bmatrix} \text{sit} = \text{s0} \\ \text{sit-type} = \begin{bmatrix} \text{nucl} : p \end{bmatrix} \end{bmatrix}, \begin{bmatrix} \text{sit} = \text{s0} \\ \text{sit-type} = \begin{bmatrix} \text{nucl} : \neg p \end{bmatrix} \end{bmatrix} \right\}$$

- SimpleAns($\lambda x.P(x)$) =
$$\left\{ \begin{matrix} \begin{bmatrix} \text{sit} = \text{s1} \\ \text{sit-type} = \begin{bmatrix} \text{nucl} & : \text{P(s1.refset)} \\ \text{anti-nucl} & : \neg\text{P(s1.compset)} \end{bmatrix} \end{bmatrix}, \\ \begin{bmatrix} \text{sit} = \text{s2} \\ \text{sit-type} = \begin{bmatrix} \text{nucl} & : \text{P(s2.refset)} \\ \text{anti-nucl} & : \neg\text{P(s2.compset)} \end{bmatrix} \end{bmatrix}, \\ \ldots \end{matrix} \right\}$$
SimpleAns(p?) is answer to polar question ("whether Bill is running?" "No, he's not"/"Bill is not running"), SimpleAns($\lambda x.P(x)$) involves *Not NP* ("Who is running?" "Not Bill").

- AtomAnsRTT = answer given in terms of nucl

- NegAtomAnsRTT = answer given in terms of anti-nucl

- StrongExhaustiveAns = $\bigwedge\{\text{AtomAnsRTT}, \text{NegAtomAnsRTT}\}$ (i.e., an answer that enumerates all refset and compset members)

4 Accounting for the data

4.1 Putting together *wh*-meanings

In order to develop our account we need to appeal to a grammar for interrogatives. We assume the HPSG-TTR grammar developed in (Ginzburg

[7]We think that a similar account can be developed for intensional argument roles used with QNPs. Such cases are analyzed in RTT, following (Cooper, 2005), as the verb composing with a QNP's type value. Hence all that is required is to ensure also that this value is projected as the dgb-params.x value.

and Sag, 2000) and refined in (Ginzburg, 2012; Lücking et al., 2021). We start by exemplifying three constructions: sentential *wh*-interrogatives and two types of non-sentential *wh*-interrogatives ('sluicing'), one direct and the other used for clarification questions. In the case of sentential *wh*-interrogatives the filler daughter (specified as having a non-empty value for the feature *wh*) contributes the domain for the question; the range is identified with the content of the head daughter, with a substitution of filler daughter variable for gap variable. In the case of direct sluicing content is composed in an analogous way, save for the fact that the queried proposition is supplied by context—it is the nucleus of a quantified proposition that constitutes MaxQUD—and the substitution is the sluice WhP daughter for the focus establishing constituent variable: see Figure 3 (i) and (ii).[8] Finally for reprise sluicing (as well as other uses (Ginzburg, 2012, p. 258)), it allows a bare *wh*-phrase to denote MaxQUD given that the domain of the *wh*-phrase is the same as the domain of MaxQUD: see Figure 3 (iii).

4.2 Clarificational potential

The clarificational potential of *wh*-phrases is captured since the dgb-params.x value of the wh-phrase is the type specified by the label *wh-dom*; since the value specified is a type rather than an individual, there is no possibility of responding to such a clarification question with a witness (set).

4.3 Anaphoric potential

The anaphoric potential of *wh*-phrases in questions is subtle and requires a more detailed discussion, not least of the data, than we can offer here. All NPs provide antecedents via their content.x value. Intrasententially this is available subject to certain binding theory constraints. For discourse anaphora, available antecedents are sub-utterances in *active* moves (Ginzburg, 2012, p. 335) (essentially moves which address QUD or are PENDING). The restricted possibilities of wh-phrases and QNPs in intensional argument roles are due to a basic *horror vacui*, meaning that they avoid empty antecedent denotations, hence the need for accommodation in such cases. The basic idea we sketch for the wh-phrase case is this: via the accommodation rule in (30) (Ginzburg, 1997), the querier increments her *Topical* FACTS with a positive resolution of the *wh*-question;[9] this in turn provides an antecedent for the anaphor.

(30) Positive Resolution Accommodation

$$\left[\begin{array}{ll} \text{pre}: & \left[\begin{array}{l} \text{QUD} = \left\langle \text{q, Q} \right\rangle : \textit{poset(Question)} \\ \text{f} : \textit{Prop} \\ \text{c1} : \bigvee \textit{AtomAns}(\text{q}) \sqsubseteq \text{f} \end{array}\right] \\ \text{effects}: & \left[\text{TOPICAL-FACTS} := \text{TOPICAL-FACTS} \cup \left\{ \text{f} \right\} \right] \end{array}\right]$$

4.4 Incrementality

Following Ginzburg et al. (2020), QUD gets modified *incrementally*, that is, at a word-by-word latency. Technically, this is implemented by adopting the predictive principle of incremental interpretation in (31). This says that if one projects that the currently pending utterance (the preconditions in (31)) will continue in a certain way (pending.proj in (31)), then one can actually use this prediction to update one's DGB, concretely to update LatestMove with the projected move; this will, in turn, by application of the existing conversational rules, trigger an update of QUD:

(31) *Utterance Projection* :=

$$\left[\begin{array}{ll} \text{preconds}: & \left[\text{pending.sit-type.proj} = \text{a} : \textit{Type} \right] \\ \text{effects}: & \left[\begin{array}{l} \text{e1} : \textit{Sign} \\ \text{LatestMove} = \left[\begin{array}{l} \text{sit} = \text{e1} \\ \text{sit-type} = \text{a} \end{array}\right] : \textit{LocProp} \end{array}\right] \end{array}\right]$$

Our proposed treatment of interrogative *clauses* in conjunction with our treatment of interrogative sluices is quasi–incremental (Schlesewsky and Bornkessel, 2004). That is, it allows to explain why an interrogative clause can already be (partially) understood as soon as the *wh*-phrase is uttered—there is already at that point an initial specification of a propositional function, namely its domain. More specifically, after processing '*wh*-phrase . . . ', one can postulate a content where the projected but as yet unuttered constituent $u1$ contributes its content in an existentially quantified form, as in (6c), with a content as in (32a). Equally, this can give rise to a clarification request concerning the initial *wh*-phrase, as in (6d).

[8] 'fec' (focus establishing constituent) is the antecedent utterance whose scope builds up MaxQUD—in the case of sluicing it is the quantified NP in the antecedent utterance.

[9] Topical FACTS are, roughly, those facts that are *About* some question currently in QUD; see (Ginzburg, 2012, pp. 311–313). These play a role somewhat analogous to the right frontier constraint in discourse-tree based theories such as SDRT (Hunter et al., 2015).

(i)

$$\left[\begin{array}{l}\text{syn} : \left[\text{cat} = \text{v} : \textit{PoS}\right] \\ \text{cont} = \left[\begin{array}{l}\text{sit} = \text{hd-dtr.cont.sit} \\ \text{abstr} = \left[\begin{array}{l}\text{wh-dom} = \text{filler-dtr.cont} \\ \text{f} = \text{wh-dom(hd-dtr.cont.sit-type(gap.x} \rightarrow \text{filler-dtr.cont.wh-dom.refset))}\end{array}\right]\end{array}\right] : \textit{Question}\end{array}\right]$$

$$\text{filler-dtr} : \left[\begin{array}{l}\text{syn} : \left[\begin{array}{l}\text{cat} = \text{nom} : \textit{PoS} \\ \text{wh} = \left\{\textit{Cont}\right\} : \textit{set(SemObj)}\end{array}\right] \\ \text{cont} = \left[\text{wh-dom} : \left[\text{refset} : \textit{Set(Ind)}\right]\right]\end{array}\right] \quad \text{hd-dtr} : \left[\begin{array}{l}\text{syn} : \left[\begin{array}{l}\text{cat:} \left[\text{vform} : \text{fin}\right] \\ \text{gaps.cont} : \left[\text{x} : \textit{Ind}\right]\end{array}\right] \\ \text{cont} : \textit{Prop}\end{array}\right]$$

(ii)

$$\left[\begin{array}{l}\text{syn} : \left[\text{cat} = \text{v} : \textit{PoS}\right] \\ \text{dgb-params} : \left[\text{MaxQUD} : \textit{PolQuestion}\right] \\ \text{cont} = \left[\begin{array}{l}\text{sit} = \text{MaxQUD.sit} \\ \text{abstr=} \left[\begin{array}{l}\text{wh-dom} = \text{hd-dtr.cont} \\ \text{f} = \text{wh-dom(MaxQUD.abstr.(fec.x} \rightarrow \text{hd-dtr.cont.wh-dom.refset))}\end{array}\right]\end{array}\right] : \textit{Question}\end{array}\right]$$

$$\text{hd-dtr} : \left[\begin{array}{l}\text{syn} : \left[\begin{array}{l}\text{cat} = \text{n} : \textit{PoS} \\ \text{wh} = \{\} : \textit{set(SemObj)}\end{array}\right] \\ \text{cont} = \left[\text{wh-dom} : \left[\text{refset} : \textit{Set(Ind)}\right]\right]\end{array}\right]$$

(iii)

$$\left[\begin{array}{l}\text{syn} : \left[\text{cat} = \text{v} : \textit{PoS}\right] \\ \text{dgb-params} : \left[\begin{array}{l}\text{MaxQUD} : \textit{Question} \\ \text{G} = \text{MaxQUD.abstr.wh-dom} : \textit{RecType}\end{array}\right] \\ \text{cont} = \text{MaxQUD} : \textit{Question}\end{array}\right]$$

$$\text{hd-dtr} : \left[\begin{array}{l}\text{syn} : \left[\begin{array}{l}\text{cat} = \text{n} : \textit{PoS} \\ \text{wh} = \left\{\textit{Cont}\right\} : \textit{set(SemObj)}\end{array}\right] \\ \text{cont.wh-dom} = \text{G} : \textit{RecType}\end{array}\right]$$

Figure 3: (i) Head-Filler Construction, for *ex situ wh*-sentences such as (2c.A): *Who should we contact __ for help?*, (ii) Sluice clause, for elliptical, non-reprise *wh*-questions such as A: A student left. B: *Who?* (iii) *wh*-anaphoric clause, for reprise or "echo" *wh*-phrases such as Fig. 1: *Who?*

(32)

$$\left[\begin{array}{l}\text{p} : \textit{Prop} \\ \text{q} = \left[\begin{array}{l}\text{sit} = \text{r} \\ \text{abstr} = \left[\begin{array}{l}\text{wh-dom} = \left[\begin{array}{ll}\text{refset=r.refset} : \textit{Set(Ind)} & \\ \text{c1} & : \overrightarrow{\textit{person}}\text{(refset)}\end{array}\right] \\ f = \text{wh-dom(p.sit-type)}\end{array}\right]\end{array}\right] : \textit{Question}\end{array}\right]$$

4.5 The Harden example

Finally, we return to the example from Figure 1. This involves an initial utterance or gesture directed at James Harden. Using *parameter identification* targeting the addressee contextual–parameter, this leads to a context in which a reprise sluice (Figure 5) can be used, giving rise to the reading 'Who do you mean by this pointing gesture?'.

5 Summary and conclusions

In this paper we have sketched an extension of a recent theory of quantification to *wh*-phrases and questions. We have applied this account to several dialogical phenomena which we believe have not been addressed in previous work.

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