Quantificational Dynamics via Dialogue

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1 Introduction

Much recent work in formal semantics has focussed on developing a dynamic approach to meaning. Stated in its most general form this means that the meaning of a linguistic form is explicated in terms of the effect its use has on existing commonly shared “resources”. Attention has been focussed on two types of changing resources. First, in order to explicate assertion and presupposition, Stalnaker 1978 and Lewis 1979 urged construing context as a resource that represents the commonly accepted information at any given point in conversation. Second, in order to capture the anaphoric possibilities available at any stage of discourse, Kamp 1981, Heim 1982, Barwise 1987, Groenendijk and Stokhof 1991, proposed keeping track of an additional resource, namely a set of “salient” (assignments to) variables.

The concern of these approaches has been monologue or text. Indeed, these as most formal semantic models, have hitherto abstracted away from issues pertaining to communication, such as the fact that in conversation one participant’s utterances are not automatically and identically comprehended by the other participants. The consequence of this has been that many actually occurring dialogue contributions cannot be analysed, in particular those whose primary function is to indicate comprehension or the need for clarification.

In this paper I start out with a framework designed to explicate certain basic features of dialogue interaction and show how subsentential dynamics such as anaphora and ellipsis emerges.

More specifically: Ginzburg 1994b,c shows how relativising to individual participants and adding extra structure to the common ground conception of Stalnaker 1978 enables one to formalize the processes of utterance grounding and clarification (e.g. Clark and Schaefer 1989), as well as to offer notions of querying and assertion that capture the interactive nature of these acts in dialogue. On this view, the structure of the common ground, or rather each participant’s version thereof, emerges not solely from facts that accumulate as a conversation evolves, but also from the most recent action performed and from questions that enter into discussion. While facts are, to a first approximation at least, permanent components once introduced, questions remain under discussion only so long as they are unresolved, as long as further information about them can be provided, or indeed until another, typically more specific, question has been introduced. What I will demonstrate in the current paper is that this same notion of context can be exploited to provide an account of subsentential dynamics. Consider (1a–c):

(1) a. A: John has been rather unhappy. B: Who?

b. A: Several people seem to have arrived. They sound displeased. B: Do you know who?

c. A: Most cellists have a favourite piece. B: Which one?

A’s utterance in (1a) sets up the potential for an elliptical clarification query. (1b,c) illustrate how utterances involving quantifiers set up the potential both for anaphora and for ellipsis. The aim
here is to offer a unified account of such phenomena. The basic idea I develop is that various kinds of utterances have as their *side effects* the emergence of certain kinds of questions in the context. As long as this question is "active" in the context certain ellipsis and anaphoric possibilities are possible.

The paper is structured as follows: in section 2, I review the main ideas underlying the framework for dialogue semantics of Ginzburg 1994c. In section 3, I offer an initial account of how this system can be extended to deal with quantificational dynamics. This is extended to a more intricate series of phenomena in section 4.

2 Dialogue Dynamics

2.1 Individuals in dialogue

How to talk about a dialogue participant (DP)? Ginzburg 1994b proposes the following schematic partition. On the one hand, we need a way of talking about some quasi-shared object, each DP's version of the common ground, relative to which the conventionalized interaction of the dialogue, both locutionary (uttering) and illocutionary (asserting, querying) takes place. I will call this component the *DP's gameboard* (cf. Hamblin's 1970 notion of 'individual commitment slate').

Separate from this will be the *non-publicized* aspects of each participant's individual mental state. I will call this the DP's *unpublicized mental situation* (UNPUB-MS(DP)). Typically, such things as goals and general inferential capabilities are represented here.

Thus, a participant in a dialogue is modelled as a set of triples, each triple of the form $< GB, ms, t >$ ('a gameboard configuration $GB$, with a mental situation $ms$ at time $t'$). A gameboard is a situation which represents a DP's view of certain attributes of the dialogue situation. These attributes need to include at least the following:

- FACTS: set of commonly agreed upon facts;
- QUD ('questions under discussion'): partially ordered set that specifies the currently discussable questions. If $q$ is topmost in QUD, it is permissible to provide any information specific to $q$.
- LATEST-MOVE: content of latest move made: it is permissible to make whatever moves are available as reactions to the latest move.

With this view of context, *discussion* can be modelled as the consequence of a particular question $q$ being maximal in QUD. This structures the context to accept either any information $\sigma$ that is *about* $q$ or questions $q_1$ on which $q$ *depends*. Here *about* and *depend* are semantic notions, relations respectively between informational items and questions, and between two questions described below. Whereas the standard view of assertion that $p$ due to Stalnaker only accommodates acceptance or rejection of $p$ as followups, the current view allows us to explicate why an assertion commonly gives rise to a discussion of *whether* $p$. An assertion is modelled as a sequence of actions that starts out with the question *whether* $p$ as maximal in QUD. The context is then structured to accept *that* $p$ as information that resolves the question or leads to a discussion sequence of that question.

The basic principle controlling the presence of a question in the gameboard is the following:

$$ QUD DOWN-DATING: \text{ Assume } q \text{ is currently maximal in QUD, and that } \psi \text{ is a fact that either } $$

$$ \text{(a) resolves } q \text{ relative to UNPUB-MS(DP)} \text{ Or, } $$

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(b) indicates that no information about q can be provided.

Then, adding ψ to FACTS licenses

(1) removing q from QUD, and

(2) if (a) applies, adding the fact φ to FACTS, where φ is the fact that ψ resolves q relative to UNPUB-MS(DP)

2.2 Semantic ontology

The semantic framework utilized here is situation theory (e.g. Barwise and Perry 1983, Barwise and Etchemendy 1990, Barwise and Cooper 1991). The view of questions utilized here is the framework described in Ginzburg 1994a, (forthcoming).

The basic ontology we start out with consists of a non-empty collection of: objects SIT0 called situations, objects SOA0 called SOA’s, and a set of n-ary SOA-abstracts, SOA-ABST0, with some algebraic structure (e.g. Barwise and Etchemendy 1990 propose that the requisite structure for SOA’s is a Heyting algebra.)

Here situations are partial, actual entities, with uses that include: explicating such objects as states or events, denotations of naked infinitive clauses (see e.g. Barwise and Perry 1983), and explicating domain restriction in quantification (Gawron and Peters 1990a, Ginzburg 1992, Cooper 1993). SOA’s here perform a function of describing possible ways the actual situations might be; hence play a similar role to possible worlds in possible worlds semantics, with two obvious differences. SOA’s are structured and they are either “atomic” (the basic ones), or built up from the basic ones by algebraic operations.

Given these “basic” entities of the ontology, we can now introduce propositions and questions, both of which are constructed in terms of a situation and a SOA or SOA-abstract.

A proposition is notated p = (s!r), where s is a situation and r is a SOA. This is the kind of entity that can be believed or disbelieved and is the descriptive content of an assertion.

(3) p = (s!r) is TRUE iff r is a fact of s: denoted as: s ⊨ r

Thus, the proposition (s!(WALK, j; +)) is TRUE iff s ⊨ (WALK, j; +). That is, intuitively, if j’s walking is a fact of s.

A question will be an entity (s?μ), constructed from a situation s and an n-ary abstract μ = λX1, ..., Xn ω(X1, ..., Xn)(n ≥ 0).

Questions are related to SOA’s via two principal relations, ‘ABOUT’ and ‘RESOLVES’. Both relations are formally characterized in Ginzburg 1994a using the notion of informational subsumption → within a SOA-algebra (Barwise and Etchemendy 1990).1

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1 ABOUT is a relation that, intuitively, captures the range of information associated with a question independently of factuality or level of detail:

(ia) Jill: Is Millie leaving tomorrow? Bill: Possibly/It’s unlikely/Yes/No. (ib) Hence, Bill provided information about whether Millie is leaving tomorrow.

(ii) Jill: Who is coming tonight? Bill: Millie and Chuck/Several friends of mine/Few people I know. (ii) Hence, Bill provided information about who was coming that night.

RESOLVES is a notion that, intuitively, characterizes when information is strong enough to close discussion of a question. This notion is intrinsically agent and context dependent: for instance, whether information resolves the question ‘where am I’, for a given agent, will vary depending on whether the agent is getting off an airplane (‘I am in Helsinki’ will do fine) or getting out of a taxi (‘I am in Helsinki’ will definitely not do).
2.3 Questions and Meta-linguistic Interaction

Let us now see how within the framework described above the potential for moves indicating successful comprehension or the need for clarification can be explained as a consequence of the fact that an utterance of a particular linguistic form with a particular meaning has occurred. For instance:

(4) a. A: Bill left last night.
   b. (i) B: Bill, mmh./ Bill?/ He left when?

In situation semantics (e.g. Gawron and Peters 1990a, Cooper and Poesio 1994), an utterance is reified as a situation, one that supports the various contextual facts needed to obtain a content from a meaning. A meaning for an expression will be an n-ary abstract in which the contextual parameters are abstracted away subject to certain restrictions, facts that must hold in any utterance (situation) of that expression. For example: a simplified, tenseless meaning for an assertoric use of (5a) is given in (5b):

(5) a. Bill likes me
   b. $\lambda u, b, a, s\{\text{ASSERT}, a, (s!(\text{LIKE}, b, a; +))\}$

RESTRICTIONS: $u \models (\text{NAMED}, 'Bill', b; +)$.
$u \models (\text{SPEAKER}, a; +)$ $u \models (\text{DESCRIBING}, a, s; +)$

For its full effect to go through, the utterance situation $u$ needs to provide values for a speaker $a$, the situation described $s$, and a referent $b$ for the NP 'Bill'.

Given this and the notion of question described above, it follows that an utterance $u$ and a meaning $\mu$ of a sentence $S$, serve to define a question $q(u, S) = (u?\mu)$. This question can be paraphrased approximately as: what values are assigned to the contextual parameters of $\mu$ in the current utterance.

The analogy to the interactive view of assertion mentioned above is strikingly clear. Rather than assume that information about the content of the utterance that requires fixing by the context is necessarily available to the addressee (in other words can be automatically added in as part of the gameboard), we allow for the option of discussing any of these contextual parameters.

How can dialogue move rules be revised to take these issues into consideration? The basic alteration involves composing any move that involves producing an utterance $u$ of sentence $S$ with a potential discussion sequence of $q(u, S)$.

Once an utterance has been posed, if the stimulus of an utterance $u$ of a sentence $S$ is good enough for the addressee to recognize what sentence has been uttered, she is expected to act as follows:

(6) If DP$_2$ believes that $S$ was uttered, she updates QUD with $q(u, S)$

$u$ will be grounded (in the sense of Clark and Schaefer 1989) if and only if there is a fact that the addressee knows and which resolves the question $q(u, S)$ relative to her UNPUB-MS. In this perspective, grounding involves the utterer and addressee coming to be satisfied that the addressee knows an answer to the meaning question, specific enough for current purposes. In such a case, just as with an assertion, the addressee has the option of explicitly accepting the utterance, as in (4b(i)). Otherwise, DP$_2$ has the option of following up DP$_1$'s utterance of $S$ with any clarification.
question on which \( q(u, S) \) depends.\(^2\) Let us consider an example: why does (7a) license (7b) as a clarification?

(7) a. Bill left.

b. WHO?

On an analysis of the content of echo queries as in Ginzburg 1992, 1994a, (7b) gets a reading with content (8b):

(8) a. \((u? \lambda b, a, s(\text{ASSERT}, a, (s!(\text{LEAVE}, b)))\))

b. \((u? \lambda x(\text{ASSERT}, a, (s!(\text{LEAVE}, x))))\) (‘who does A assert that left’)

Given that the meaning question defined by (7a) is (8a) (ignoring the associated restrictions here for simplicity), it follows that (8a) is a question that depends on (8b) and hence (8b) is licensed.

3 Quantificational Dynamics

Let us move now to see how quantificational dynamics can be captured within the current setup. Consider first an example such as (9):

(9) a. A: Who called this morning? B: I’m not sure.

b. A: Did they sound foreign? B: Wait a minute, I’ll check.

A’s first utterance has the effect of making the question \( (s? \lambda x(CALLED-THIS-MORNING, x)) \) maximal in QUD.\(^3\) This has two effects: first, it licenses ellipses such as (10a) to be interpreted as (10b):

(10) a. B: (i) No one./(ii) Several people from the ministry of agriculture./(iii) A friend of Bill’s.

b. (i) No one called this morning./(ii) Several people from the ministry of agriculture called this morning./(iii) A friend of Bill’s called this morning.

The second effect is to enable the use of the pronoun in (9b) which gets construed roughly as

(11) ‘They’ = the people that called this morning.

Now, if B responds with information as in (10a(i)), then by virtue of the QUD downdate principle (2) above, the question \( q_0 \) can be downdated from QUD: the topic is no longer of any interest, blocking off also the possibility of subsequent ellipsis and anaphora. If, however, a response as in (10a(ii),(iii)) occurs, the question (and the possibilities for anaphora and ellipsis it underwrites) can be maintained in the context. In what way can the conversation develop following (10b,c)? One possible option is for A to follow up with (12a), which in this context means roughly (12b) (with singular/plural distinctions corresponding to whether (10a(ii)) or (10a(iii)) were uttered):

\(^2\)Here, inspired by Karttunen 1977, I define the relation of dependence between two questions as follows: \( q_1 \) depends on \( q_2 \) iff \( q_1 \) is resolved by a fact \( \tau \) only if \( q_2 \) is also resolved by \( \tau \). This is a very simple and overly reductive notion of dependence but suffices for current purposes.

\(^3\)For simplicity, I will be ignoring VP internal structure wherever this is immaterial.
(12) a. A: Who?

b. Who are/is the people/person that called this morning.

One argument that this is the correct paraphrase is that (12) is infelicitous following (10a(i)). The point is then that the contextual effect of the quantificational statements in (10a(ii),(iii)) is to license the utterance of the elliptical question (12).

Let us now take a somewhat different perspective of the connection between (10b(ii),(iii)) and (12). Note that (12) is a potential followup to utterances of (10b(ii),(iii)) even in a context where no question such as (9a) is explicitly posed. Instead, we can think of the question expressed by (12b) as part of the contextual effect of their use. More specifically, restricting ourselves for the moment to sentences with one quantifier, we can view the scoping of a quantifier as having two outputs, a proposition and a question:

(13) a. A: Several men called.

b. Output context:
   LATEST-MOVE: the proposition that several men called.
   QUD: the question who are men that called.

For the kinds of questions discussed hitherto, a simple view of the meaning of wh-phrases suffices: a wh-phrase introduces a variable together with a restriction. Such variables are then abstracted away with maximally wide scope and together with a contextually supplied situation define a question. In similar fashion, for the kinds of cases described above, pronouns can be treated in (almost) classical E-type fashion (Evans 1977): the pronoun is scoped maximally wide, with the descriptive condition provided by the question raised by its antecedent quantified NP. It is crucial that the pronoun be treated as a quantifier since this means that it will cause a new question to be raised, one that refines the question raised by the original antecedent. What quantificational force should the pronoun bear? It is certainly the case that by using a singular pronoun, one implicates that its associated descriptive property is uniquely instantiated, entirely analogously, I suggest, with the exhaustiveness implication associated with a question. As Heim’s sageplant example indicates, however, this uniqueness is defeasible. Hence, the (semantic) quantificational force I will associate here with a singular pronoun is existential, though background pragmatic factors might strengthen this. With plural pronouns, the quantificational force I associate is universal.

Consider how the following dialogue gets processed:

(14) a. A: Exactly one student came in. He sat down.

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4(12a) uttered with a pitch accent can be construed as an echo query in which case it will be felicitous following (10a(i)) as well. The potential for such queries was discussed in section 2.3.

5The relevant example from Heim 1982 is:
(i) Everybody who bought a sage plant here bought eight others along with it.

6As we shall see below, nonetheless, there are cases where singular pronouns need to be treated as universals, to wit the following variant of (21):
(i) Does he record it with a major label.

7For simplicity here, I am assuming perfect communication, as well as ignoring various potential contextual processes that arise in assertion and querying.

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b. Input context: ... Exactly one student came in
Output context:
LATEST-MOVE: Asserts: that exactly one student came in
\(s!(\text{EXACTLY}-1, \lambda x(\text{STUDENT}, x), \lambda x(\text{CAME } - \text{IN}, x),)\)
QUD: who is a student and came in
\(s?\lambda x.(\text{STUDENT}, x) \land (\text{CAME } - \text{IN}, x)\)

He sat down:
Output context:
LATEST-MOVE: a male that is a student and came in sat down
\(s!(\exists, \lambda x.(\text{MALE}, x) \land (\text{STUDENT}, x) \land (\text{CAME } - \text{IN}, z), \lambda x(\text{SAT } - \text{DOWN}, x),)\)
QUD: who sat down and is a male and a student and came in
\(s?\lambda x.(\text{MALE}, x) \land (\text{STUDENT}, x) \land (\text{CAME } - \text{IN}, z) \land (\text{SAT } - \text{DOWN}, x)\)

c. B: who?
Output context:
LATEST-MOVE: Query: who is a male student that came in
QUD: who is a male student that came in
\(s?\lambda x.(\text{MALE}, x) \land (\text{STUDENT}, x) \land (\text{CAME } - \text{IN}, z) \land (\text{SAT } - \text{DOWN}, x)\)

In particular, the idea here is that in the query made by B, she makes use of a question already implicitly introduced by A's two utterances.

4 Functional uses of wh-phrases and other NP's

How to generalize the treatment above to accomodate the existence of narrowly scoped quantifiers? Let us consider first some more data.

(15) a. A0: Various cellists particularly admire some piece.

Assume A0 is uttered with 'various cellists' taking wide scope. Then, whereas the potential for and content of the question B1 and for the pronoun 'they' in A2 can be accommodated using the tools described above, the same does not apply to the question B2. This latter arises from what, following Engdahl 1980, 1986, has been called a functional use of a wh-phrase (though as we shall see shortly, we need to distinguish two classes of such uses.). This is because the response in A2 does not denote a single piece but rather varies with each cellist. Following proposals of Gawron and Peters 1990b and Jacobson 1992, the response in A2 can be taken to describe a function, as in (16a). And hence, Ginzburg 1992 argues that the question expressed in B2 is the question in (16b):

(16) a. \(s!\exists g(\lambda h(VARIOUS, \lambda x(CELLIST, x), \lambda x(PART - ADMIRE, x, h(x)),),
   \forall x(PIECE-PLAYED-IN-1st-RECITAL(x)=g(x))))\)
   b. \(s?\lambda h(VARIOUS, \lambda x(CELLIST, x), \lambda x(PART - ADMIRE, x, h(x)),))\)

What contextual effect does (15a) have that licenses the ellipsis in (15c)? By analogy with the proposal for (12), I suggest that scoping the NP 'various cellists' results in an output that includes both a proposition and two questions:
(17) a. Various cellists particularly admire some piece.

b. Output context:
   LATEST-MOVE: the proposition that various cellists particularly admire some piece.
   \( \langle s \mid \forall VARIOUS, \forall x \text{CELLIST}, x, \exists y \text{PIECE}, y, \lambda y \text{PART} - \text{ADMIRE}, x, y \rangle \rangle \)
   QUD: \{q_1, q_2\} where:
   
   q_1: the question who are cellists that particularly admire some piece
   \( \langle s \mid \forall x \text{CELLIST}, x, \exists y \text{PIECE}, y, \lambda y \text{PART} - \text{ADMIRE}, x, y \rangle \rangle \)
   q_2: the question what piece do various cellists like (functional reading)
   \( \langle s \mid \forall h \text{VARIOUS}, \forall x \text{CELLIST}, x, \exists y \text{PIECE}, y, \lambda y \text{PART} - \text{ADMIRE}, x, y \rangle \rangle \)

   q_2 arises in the following way: scoping in a QNP with less than maximal scope causes a specification for function to be placed in storage.\(^8\)

(18) \( h : x \rightarrow \lambda y \text{PIECE}, y) \wedge (\text{PART} - \text{ADMIRE}, x, y) \)

When the wide scope QNP is retrieved, the function is fully specified. Consequently, in such a case, two questions are outputted, one a functional question, the other a normal one.

In what way do we need to enrich our view of the meaning of wh-phrases and pronouns? What we need to do is to recognize the possibility that the role \( \alpha \) associated with a wh-phrase or indeed any other NP can introduce a dependency \( f \) with another argument role \( \beta \). Although this means that \( \alpha \) cannot have scope wider than \( \beta \), \( f \) can be scoped as wide, wider than \( \beta \) or remain free.

Thus, for wh-phrases we allow at least one kind of dependent uses to arise: the use I will be concerned with here involves the imposition of a dependency between a wh-phrase role and another argument role. Once this occurs, the consequence is that the variable associated with the wh-phrase role gets abstracted with scope no wider than the role on which it depends. But the variable for the dependency is abstracted with widest scope, just as in an "ordinary" wh-phrase use. This technique is spelled out in more detail in Ginzburg 1992.

Corresponding remarks apply to NP's including pronouns, an analogy originally pointed out by Engdahl 1986: the simplest kind of dependent use arises when the dependence is simply identity, as in "bound variable" uses such as

(19) Every dog liked himself

A so-called donkey sentence can be accommodated analogously to the derivation of the functional question in (17): here 'it' introduces a dependence on the role associated with the subject NP. This dependence is then unified with the dependence introduced into storage by scoping in the indefinite 'a favourite piece' within the subject. The dependence is finally existentially quantified away once the subject is quantified in:

(20) a. A: Every cellist with a favourite piece plays it occasionally.

b. Output context:
   LATEST-MOVE: the proposition that every cellist with a favourite piece plays it occasionally.
   \( \langle s \mid \exists h \text{EVERY}, (\forall x \text{CELLIST}, x) \wedge \exists y \text{PIECE}, y, \lambda y \text{FAVOURITE}, x, y \rangle \rangle \),

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\(^8\)The \( \iota \) notation used here is used here as a simplifying assumption. In general, the dependency between the narrow and wide scoping quantifiers cannot be assumed to involve an injective mapping and hence the technique described here need to be modified by substituting a choice function for the \( \iota \).

\(^9\)This is formally captured in the Absorption Principle postulated by Gawron and Peters 1990a, 1990b.

\(^10\)In this abstract I confine myself to one. There are grounds motivating the need for a wh-phrase to directly introduce a dependency, analogously to a functional use of an NP as in (16).
\[ \lambda x (\text{PLAY} - \text{OCCASIONALLY}, x, h(x))) \]

QUD: \{q_1, q_2\} where:

\( q_1 \): the question who are cellists with a favourite piece that play that piece occasionally.
\[ (s? \lambda x \exists h(\text{CELLIST}, x) \land (\exists, \lambda y (\text{PIECE}, y), \lambda y (\text{FAVOURITE}, x, y) \land (\text{PLAYS-IT-OCCASIONALLY}) \]

\( q_2 \): the question what piece does every cellist with a favourite piece play occasionally (functional reading)
\[ (s? \lambda h (\text{EVERY}, (\lambda x (\text{CELLIST}, x) \land (\exists, \lambda y (\text{PIECE}, y), \lambda y (\text{FAVOURITE}, x, y)), \lambda x (\text{PLAY} - \text{OCCASIONALLY}, x, h(x)))) \]

Indeed we can derive directly the possibility of the following followup to A's utterance:

(21) B: Do they record it for a major label?

Here 'they' can be given an account of the type sketched in section 3, whereas 'it' is cashed out as dependent on the role filled by 'they'. Which dependency? One with the property specified by \( q_2 \). Roughly:

(22) \[ (s? \exists h, h : Q_2 (\text{EVERY}, \lambda x (Q_1, x), \lambda x (\text{RECORD-FOR-MAJOR-LABEL}, x, h(x))), ) \]

Here \( Q_1 \) and \( Q_2 \) are shorthand for the properties specified by \( q_1 \) and \( q_2 \) above.

5 Summary

In this paper, I have suggested that subentential dynamics such as the anaphoric and elliptical potential evoked by quantificational use can be accommodated within a general system that describes how semantic entities such as propositions, facts and questions structure a dialogue. The account eschews both an intermediate level of discourse representation as in Discourse Representation Theory (Kamp 1981, Kamp and Reyle 1993), or a view of context as in Dynamic Predicate Logic (Groenendijk and Stokhof 1991) based on notions such as variable assignments. In this regard, the account presented here bears the conceptual advantage of providing a notion of context that utilizes solely entities towards which an agent can have an attitude to (propositions [e.g. belief, assertion], facts [e.g. knowledge, discovery] and questions [e.g. wonderment, querying]). On the empirical side, I have shown how a unified semantic account can be provided both for the ellipsis that arises in "meta-linguistic" interaction and and for ellipsis and anaphora in followups to quantificational statements. For more detailed exposition of and argumentation for this approach see Ginzburg (in preparation).

6 References


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