A compositional approach to short answers in dialogue

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Abstract

Non-sentential utterances, and especially short answers, are pervasive in dialogues. Some researchers have observed that there are complex syntactic, semantic and pragmatic constraints on acceptable short answers. This has been used to motivate a radically unmodular architecture for their analysis, where information from grammar and from discourse isn't distinguished. Here we suggest an alternative analysis, which separates the (underspecified) compositional semantics of fragments from their resolved meaning in context.

1 Introduction

In the following examples, B's utterances are *non-sentential*, consisting only of phrases, possibly modified by an adverb:

(1) a. A: Who was seen by a policeman?
i) B: John. ii) B: Every thief.
b. A: Who likes Peter?
B: Definitely he himself.

(2) a. A: Who can we rely on?
b. B: i) Maybe on Sandy. ii) Sandy.

(3) a. A: What did he make you do?
b. B: Kill JFK.
c. A: What did he force you to do?
d. B: To kill JFK.

(4) A: {When/How/Why} did you do that?
B: i) (On) Wednesday. ii) With a knife. / #a knife. iii) Stress.

Such short answers pose (at least) four puzzles:

First, even though they are non-sentential, their intended meaning is of propositional semantic type. This proposition is partially determined by contextual information. As (1-b) shows,[1] the resolution process cannot consist of reconstruction of syntactic structure which is then interpreted, as for example (Morgan, 1973) proposes, since the reconstruct "definitely he himself likes Peter" is ungrammatical.

Second, as (Ginzburg, 1998) shows with examples like (2) and (3), the resolution can on the other hand not always rely solely on semantic or pragmatic information. The preposition in (2-b)-i)—a verb particle—is normally considered to be semantically empty,[2] and hence is not represented in the semantics. However, (2-b)-i) is not felicitous as an answer to any of the questions in (1). (3) shows another minimal pair: even though (3-b) and (3-d) presumably are of the same *semantic* type, (3-d) wouldn't be a felicitous answer to (3-a). (Ginzburg, 1998) concludes from examples like this that there is a syntactic parallelism between the question and the fragment.

Third, dependent on the type of the question and its rhetorical connection to the fragment, this parallelism seems however to be less strict than the categorial identity assumed by Ginzburg. In (2) and (4)-i), the preposition in the answer is optional, whereas in (4)-ii) it is not; in (4)-iii) the parallelism requirement seems to be dropped altogether.[3]

[1] Adapted from (Barton, 1990).

[2] Cf. eg. (Pollard and Sag, 1994).

[3] The need to access syntactic information being dependent on the type of rhetorical connection is reminiscent of Kehler's (2002) claims with regard to other ellipsis phenomena like VP-ellipsis and gapping.

Fourth, as (1-a) shows, the matter of resolving scope relations is orthogonal to that of resolving fragments: (1-a)-ii) in this context has all the readings the full sentence "Every thief was seen by a policeman" has.

The first two puzzles have been used by (Ginzburg and Sag, 2001) to motivate a radically unmodular architecture for representing the semantics of fragments in context, where information from grammar and from discourse isn't distinguished. We will present here an alternative analysis, the basic idea of which is that fragments are viewed as introducing an anaphoric element which must find, according to certain constraints, an antecedent for the utterance to be a *coherent* contribution. We will address the second and the third puzzles via different coherence constraints that are associated with different rhetorical connections and/or different types of arguments to those connections; the fourth puzzle is addressed by ensuring that the resolution of the fragment is done over partial descriptions of logical forms, allowing the resolved propositional content to underdetermine scope relations.

The next two sections present the main components of the analysis: a grammar of fragments that produces underspecified representations, and a set of constraints on short answers that guide the (partial) resolution of this underspecification. We conclude with a comparison of our approach to previous ones, and with an outlook on further work.

2 A Grammar of Fragments

This section gives a description of how we represent the compositional semantics of fragments, and shows how these representations can be built in an HPSG (Pollard and Sag, 1994).[4]

2.1 Underspecified Representations

We couch our semantic analysis in the framework of Minimal Recursion Semantics (MRS, (Copestake et al., 1999)), a language in which (sets of) formulae of a logical language (the *base language*) can be *described* by leaving certain semantic distinctions unresolved. This is achieved via a strategy that's standard in computational semantics (e.g., (Reyle, 1993)): one assigns labels to bits of base language formulae so that statements about the combination of these sub-formulae can be made. By way of example, (5) shows an MRS-representation of "Peter walks", where so called elementary predications (EPs) are labelled with a *handle* (h_n), with h being the top handle that outscopes all others; '$h_1 =_q h_2$' stands for an 'outscopes' relation between EPs where only quantifiers can be scoped in between h_1 and h_2; e is the semantic index.

(5) $\langle\, h, e, \{\, h\!:\!prpstn(h_1),\ h_2\!:\!walk\_v\_rel(e,x),$
$\quad h_6\!:\!def\_np\_rel(x,h_8,h_9),$
$\quad h_{10}\!:\!named\_rel(x,\text{"Peter"}) \,\},$
$\quad \{\, h_1 =_q h_2,\ h_8 =_q h_{10} \,\} \,\rangle$

The compositional semantics of fragments leaves more information unresolved than just semantic scope, however. All we know about the meaning of fragments like those in (1) independent from their context is that a) they will resolve to a proposition, of which b) the main predicate is unknown, but c) one participant in the main event of the proposition is specified, even though its exact role isn't.[5] We represent this with an anaphoric relation *unknown_rel*, and so the NP-fragment "Peter" is represented as:

(6) $\langle\, h, e, \{\, h\!:\!prpstn(h_1),\ h_2\!:\!unknown\_rel(e,x),$
$\quad h_6\!:\!def\_np\_rel(x,h_8,h_9),$
$\quad h_{10}\!:\!named\_rel(x,\text{"peter"}) \,\},$
$\quad \{\, h_1 =_q h_2,\ h_8 =_q h_{10} \,\} \,\rangle$

The *unknown_rel* acts as a 'place-holder' for a potentially complex sub-formula, which is constrained to have e and x amongst its variables. Procedurally, this can be understood as a signal for attention to a resolution mechanism.[6]

This describes the basic principle behind our representations; those for PP-fragments differ only in that a further relation (corresponding to the preposition) is present, whereas VP- and S[*comp*]-fragments have as an argument of *unknown_rel* the handle of a subformula rather than an individual variable.

[4] In the examples below we present analyses provided by the English Resource Grammar (ERG), which we extended to deal with fragments. The ERG is built as part of the LinGO project, cf. `http://lingo.stanford.edu` and also (Copestake and Flickinger, 2000).

[5] Interrogative and imperative fragments are specified to resolve to questions or request, respectively, see below.

[6] It is possible to provide the relation with a model-theoretic semantics along the lines of (Asher and Fernando, 1999); we forgo details here for reasons of space.

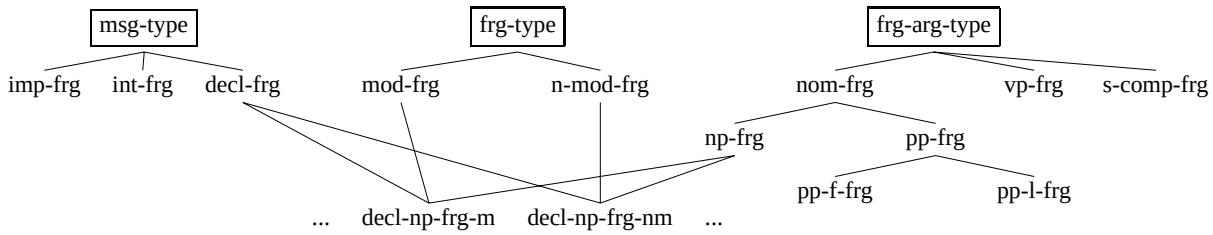

Figure 1: The construction-hierarchy for fragments

In the ERG, even functional PPs like that in (2-b) are represented in the MRS, even though they might eventually translate into the trivial (ie., always true) predicate $\top$ in the base language. We will make use of this in the resolution, and so we represent "on Sandy" in (2-b)-i) as in (7) below. Note that the handle of the EP corresponding to the preposition is constrained to be subordinate to that of the *unknown_rel* (ie. $h_2 \leq h_3$), not just $=_q$. This is because this *unknown_rel* can resolve to a complex formula containing not only the predicate for the phrasal verb that selects for *on*, but possibly also other scope-bearing elements that aren't quantifiers, eg. in the context of a question like "who might Peter rely on?".

(7) $\langle\, h_0, e, \{\, h_0{:}prpstn(h_1),\ h_2{:}unknown\_rel(e,x),$
$h_3{:}\_on\_rel\_s(e',x),\ h_6{:}def\_np\_rel(x,h_8,h_9),$
$h_{10}{:}named\_rel(x,\text{"Sandy"})\},$
$\{\, h_1 =_q h_2,\ h_8 =_q h_{10},\ h_2 \leq h_3 \,\}\,\rangle$

2.2 A grammar of Fragments

The grammar rules with which we produce these MRSs are relatively straightforward. We make the assumption that fragments are phrases,[7] possibly modified by adverbs. As (8) shows, only scopally modifying adverbs are allowed.

(8) A: Who sang this song?
B: Maybe Sandy. / *Badly Sandy.

We will allow both sentential modification, where an adverb attaches to an S[*frag*], and 'VP'-modification, where the adverb is selected by the fragment rule. Semantically, the difference is whether the whole proposition is modified or only the *unknown_rel*.

[7]This goes back to (Morgan, 1973); explicit rules can be found in (Barton, 1990). We ignore for now more complicated examples like 'A: Does John devour or nibble at his food? — B: Oh, John devours.'

In a pseudo phrase-structure notation, the rules simply are of the form 'S-frag $\rightarrow$ (ADV) XP'. We formalise this in a version of HPSG that allows *constructions* (Sag, 1997), ie. phrase-types that make a semantic contribution. The fragment-signs are organised along three dimensions (see Figure 1): the message type, ie. whether they resolve to a proposition, a question or a request; whether they are modified by an adverb or not; and what the type of the argument is (ie., whether it's for example an NP-fragment or a PP-fragment). There is a common core to these rules; the main difference along the first dimension is whether the top-level relation is a *prpstn_rel*, *int_rel* or *imp_rel*; the rules for modified fragments in the second dimension (*mod-frg*) have an additional daughter (the adverb); and *frg-arg-type* takes care of the semantic differences according to the category of the fragment phrase described above.

For reasons of space, we only give one example, Figure 2, an NP-fragment sign in a tree-style notation. It shows how the CONTent of the fragmental sentence (an MRS in AVM notation) is a combination of the contribution of the construction (C-CONT) and the content of the fragment-phrase, with the index of that phrase (5) being the argument to the *unknown_rel*.

We now turn to the question of resolving the underspecification indicated by the *unknown_rel*.

3 The Resolution Procedure

The architecture of the interface between grammar and pragmatics we assume is that of dynamic semantics,[8] where new utterances update a representation of the context in ways dependent on the speech act performed. We assume for now that the speech act which is performed by uttering the fragment is

[8]Eg., (Traum et al., 1999; Asher and Lascarides, 1998).

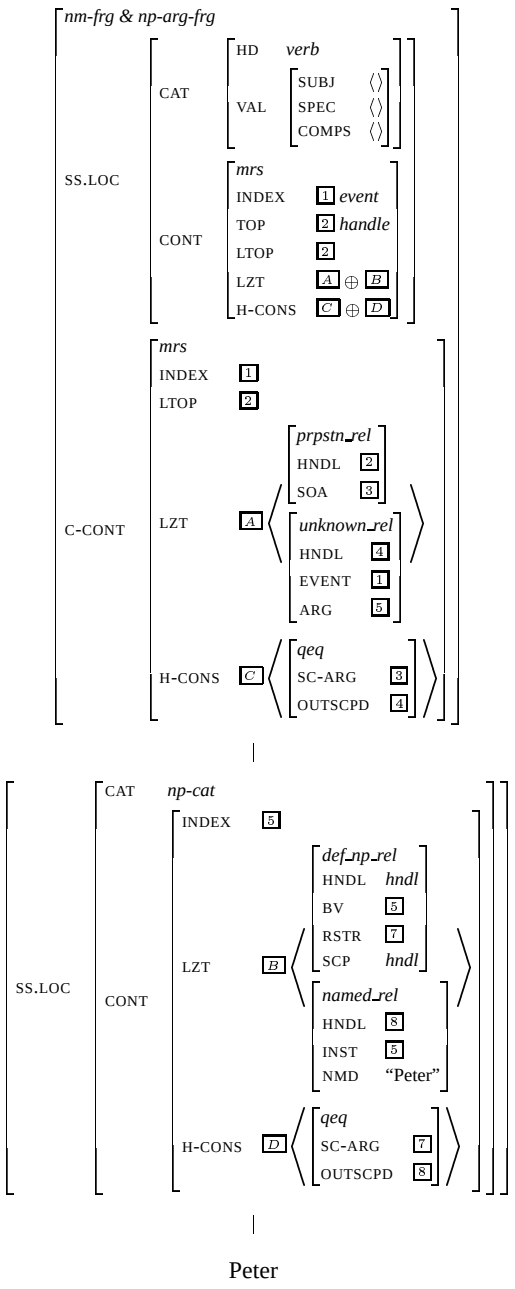

Figure 2: "Peter" as a declarative fragment.

known, and that it is that of question-answering. We represent this with a relation *QAP(*α, β*)* (Question-Answer-Pair), where α is the top-handle of the MRS of the question and β that of the fragment.[9] The resolution of the fragment then is a by-product of satisfying the coherence-constraint(s) on this speech act type, which for short answers (except of those to *why*-questions) is the following single constraint:

- `Coherent Short-Answers`
  QAP$(\alpha, \beta) \wedge ncq(\alpha) \wedge frag(\beta) \rightarrow$ *resolves*(α, β)

In words, if this relation between a 'non-*why*-question' ($ncq(\alpha)$, this name will be explained shortly) and a fragment is assumed, then the question α must contain enough information to resolve the fragment β.

It is important to remember that our MRSs do retain some syntactic information; as we will show, this allows us to model the apparent syntactic parallelism fully via this relation *resolves* between MRSs. It is computed in three steps: first, the question-MRS is transformed into a feature-structure equivalent of a λ-abstract; second, this abstract is 'applied' to the fragment meaning; and third, the well-formedness of the result is checked. This well-formedness constraint is *not* a test for parallelism between wh- and fragment-phrase. Rather, we check whether we can "assemble" a well-formed MRS from both utterances: it must be possible to partition the resulting MRS so that all partitions are semantic representations for verb-relations, their arguments or possibly their adjuncts. This relies on two features of the ERG: first, adjunct questions introduce an underspecified preposition-relation in the MRS, as seen in (9), the MRS for "when shall we meet?"; second, as already mentioned, all lexical items, including semantically empty ones, introduce an EP.

(9) $\langle\ h_1,\ e_2,\ \{h_1{:}int\_rel(h_{20}),\ h_{15}{:}meet\_rel(e_2, x_{10}),$
$h_{15}{:}unspec\_loc\_rel(e_2, x_4), h_3{:}temp\_rel(x_4),$
$h_5{:}which\_rel(x_4, h_8, h_7),\ h_9{:}pron\_rel(x_{10}),$
$h_{11} : def\_rel(x_{10}, h_{12}, h_{13}),\},\ \{h_{20} =_q\ h_{15},\ h_8 =_q$
$h_3,\ h_{12} =_q h_9\}\ \rangle$

Short-answers like those in (1) are resolved straightforwardly through functional application by this approach; PP-answers like (4)-i) are accepted because after applying the question to the fragment, the variable that denotes the Wednesday will be argument of the *unspec_loc_rel* introduced by "when". The well-formedness constraint involving partitions above then forces this underspecified relation to resolve to the EP corresponding to the "on" from the answer.

[9] This relation is taken from (Asher and Lascarides, 1998), where procedures for inferring this relation from the compositional semantics of α and β can be found.

Our approach also predicts that questions like (2), where there is a functional preposition in the question, and also the *when*-question in (4), can be answered both with a PP-fragment, in which case the two preposition-rels are equated, and with just an NP-fragment, which is β-reduced into the argument-position of the preposition in the question. PPs (both with functional and with lexical prepositions) are ruled out as answers to NP-questions because there the well-formedness check fails, since there is no preposition-rel in the question that would match that in the answer. Finally, the pattern in (3) is predicted because the complementizer "to" introduces a relation which stops (3-d) from answering (3-a). This also predicts the optionality of "to" in (3-d), in the same way prepositions are optional in (2).

This leaves us to explain why the preposition in (4)-ii) is *not* optional. We hypothesise here that in these cases the underspecified preposition-relation, filled with the index of an NP-meaning, is not enough to interpret the short-answer, since it's not recoverable from the answer whether the NP is a means or an instrument. This we can express by constraining answers to such questions to fully resolve such relations; a more precise formulation of this constraints remains to be worked out.

Clausal adjuncts like (4)-iii) do not impose syntactic constraints and seem to require more powerful reasoning—involving world knowledge—than functional application; we also postpone their discussion to another paper.

4 Comparison with other approaches

We have already given a counter-example against syntactic reconstruction approaches like (Morgan, 1973), (1-b); moreover, it is difficult to see how such an approach could cope with examples like (4)-iii), where some material has to be inferred. Purely semantic approaches from the 'structured meaning'-tradition, according to which "question meanings are functions that, when applied to the meaning of the answer, yield a proposition." (Krifka, 2001, p.289), on the other hand fail to recognise the syntactic constraints described above; the only constraint on short answers in these approaches is that they must provide an argument of the right semantic type for the function (the question meaning).

Semantically, Ginzburg's own approach also belongs to this tradition. However, he extends functional application with a syntactic matching condition, and in (Ginzburg and Sag, 2001) (henceforth, G&S) offers a formalisation in an HPSG-framework. In this approach, a construction type 'declarative-short-answer' enforces the syntactic matching condition and also assembles the content of a short answer using contextual information about syntax and semantics of the 'question under discussion' which is assumed to be available in a feature CONTEXT. We think that our modular approach offers certain advantages over this non-compositional approach.

First, our grammar produces semantic representations for fragments *in general*, not tailored towards a certain *use* one can make of non-sentential utterances. This means that we can keep reasoning about speech acts —which is generally assumed to be non-monotonic (eg. (Appelt and Konolige, 1988; Hobbs et al., 1993))— away from the grammar,[10] where G&S either have to a) provide specific grammar-rules for all the different speech acts that can possibly be performed with a fragment and then apply later a pragmatic filter that decides on the most likely parse, resulting in a duplication of work, or b) extend the logic of the grammar to include further contextual information and do non-monotonic reasoning with it.

Second, as a consequence of our set-up, we can relativise the syntactic constraints to the speech act performed and the compositional semantics of the antecedent and the fragment, as described above for (4). This addresses the third puzzle from the introduction. G&S, as it stands, does not deal with questions of this type.

Third, since the resolution works exclusively over *description* of logical forms, we can keep resolution of scope relations orthogonal to that of fragment-meaning, where G&S must resolve this together with fragment-meaning.

Fourth, we extended the empirical coverage to VP- and S[*comp*]-fragments, and to modification; G&S as it stands is restricted to nominal-type fragments.

[10] See next section for planned extensions of our analysis to other speech acts that can be performed with fragments.

5 Conclusion and Further Work

We have shown that a compositional analysis of fragments can address the puzzles observed in connection with short answers. However, short answers are only one kind of non-sentential utterance to be found in dialogues. Other speech acts than answering can be performed with fragments as well, eg. elaborations or corrections as in (10), with similar complex constraints. We feel that the grammar we have developed, as well as the resolution procedure, provide a basis for an analysis of these kinds of fragments as well.

(10) A: He made him hate JFK.
B: Yes, and despise Nixon.
B′: No, just disrespect him.

At the moment, we're investigating a fuller integration of our approach into a general theory of context-sensitive elements in dialogues (SDRT, (Asher, 1993; Asher and Lascarides, 1998)), and an implementation along the lines of (Schlangen et al., 2001). Also, more subtle questions in the grammar of fragments are being followed up, such as for example the embeddability of fragments in larger constructs.

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