Dialogue-Grammar Correspondence in Dynamic Syntax

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Abstract

In this paper, we argue, contra a prevailing trend to classify elliptical structures in terms of sub-types specific to conversational dialogue, that despite their diversity of uses in conversational dialogue, such fragments are analysable in terms of structure-building mechanisms that have motivation elsewhere in the grammar (the framework adopted is *Dynamic Syntax*, Kempson et al. (2001); Cann et al. (2005)). Fragment types modelled include *reformulations*, *clarification requests*, *extensions*, *corrections* and *acknowledgements*. We argue that incremental use of such ellipses serves a specific role in dialogue, namely a means of incrementally narrowing down the range of otherwise mushrooming alternative structural and interpretative options, a problem known to constitute a major challenge to any parsing system. We conclude that with grammar seen as a set of parse procedures, we have a basis for an integrated characterisation of dialogue phenomena while nonetheless not defining a grammar of conversational dialogue.

1 Introduction

In confronting the challenge of providing formal models of dialogue, with its plethora of fragments and rich variation in modes of context-dependent construal, it might seem that linguists face two types of methodological choice. Either (a) conversational dialogue demonstrates dialogue-specific mechanisms, for which a grammar specific to such activity must be constructed; or (b) variation arises due to the employment of independent parsing/production systems which are nevertheless based on some mode-neutral grammar. However, as dialogue research continues to develop, there are intermediate possibilities, and in this paper we discuss the approach developed within *Dynamic Syntax* (*DS*, Kempson et al. 2001, Cann et al. 2005), a grammar framework within which, not only the parser, but indeed "syntax" itself is seen as the progressive construction of semantic representations set in context. Here we extend the analyses presented in Kempson et al. (2007) to a range of further fragment types, in particular *reformulations*, *fragment requests* and *corrections* accompanied by *extensions*. From a DS perspective, such apparently dialogue-specific constructions can be seen to result from perfectly general structural processes, despite being characteristic of cross-party conversational data.

Further, we claim that the grammar itself constitutes the basis for parsing strategies that facilitate an efficient online processing, both structural and semantic. In this respect, the DS dialogue model provides the means of achieving this *during* the course of the sub-sentential construction process, demonstrating that timely application of such generally available "syntactic" mechanisms directly contributes to the human processor's high degree of success in linguistic interaction. Contrary to conventional assumptions of the grammar-parser feeding relation whereby the parser exclusively handles disambiguation, we conclude that grammars, as employed in dialogue, can also be seen as restricting ambiguity provided their formal specification can model this incremental facilitating function.

2 Background

The data we focus on are non-repetitive fragment forms of acknowledgements, clarifications and corrections (henceforth, A female, B male):

(1) A: Bob left.
B: (Yeah,) the accounts guy.

(2) A: They X-rayed me, and took
a urine sample, took a blood sample.
A: Er, the doctor
B: Chorlton?

A: Chorlton, mhm, he examined me, erm, he, he said now they were on about a slight [shadow] on my heart. [BNC: KPY 1005-1008]

(3) A: Are you left or
B: Right-handed.

(4) A: Bob left.
B: Rob?
A: (No,) (Bob,) the accounts guy.

Even though in the literature the NP fragments in (2) - (4) might be characterised as distinct constructions, they all illustrate how speakers and hearers may contribute, in some sense to be made precise, to the joint enterprise of establishing some shared communicative content, in what might be loosely called *split utterances*. And even (1), an *acknowledgement*, can be seen this way upon analysis: B's addition is similar to an afterthought *extension* added to A's fully sentential utterance. It can be seen in (2) that such joint construction of content can proceed incrementally: the *clarification request* in the form of a *reformulation* is provided by B and resolved by A within the construction of a single proposition. The attested example in (3) represents an intermediate case, in which the respondent realising what the question is provides the answer AS the *completion* of the initiator's question, so that the fragment serves simultaneously as question and answer. In (4) the fragment reply involves *correction*, with parties to the conversation confronting the need for negotiation as to whose information is more reliable before coordination can be said to be achieved. Nevertheless such corrections can be also *extensions* in the above sense, enabling a single conjoined propositional content to be derived before the requisite coordination can be achieved.

It might seem that such illustration of diversity of fragment uses is ample evidence of the need for conversation-specific rules to be articulated as part of a grammar. Indeed, Fernández (2006) presents a thorough taxonomy, as well as detailed formal and computational modelling of *Non-sentential Utterances* (NSUs), referring to contributions such as (1) as *repeated acknowledgements* involving *reformulation*. Since such fragments require contextual information singling out a particular constituent of the previous utterance, Fernández models such constructions via type-specific "accommodation rules" which make a constituent of the antecedent utterance "topical". The semantic effect of acknowledgement is then derived by applying an appropriately defined utterance type for such fragments to the newly constructed context. A distinct form of contextual accommodation is employed to model so-called *helpful rejection* fragments, as in (4) (without the reformulation), whereby a *wh*-question is accommodated in the context by abstracting over the content of one of the sub-constituents of the previous utterance. The content of the rejection is derived by applying this *wh*-question in the context to the content of the fragment (see also Schlangen (2003) for another classification and analysis).

The alternative explored here is whether phenomena such as (1)-(2), both of which are non-repetitive appositional next-speaker contributions, can be handled uniformly using the mechanisms for structure-building made available in the core grammar, without recourse to conversation-specific extensions of that grammar and contextual accommodation rules. The range of interpretations these fragments receive in actual dialogue seem to form continua with no well-defined boundaries and mixing of functions (see (3)-(4) and comments in Schlangen (2003)). Thus we propose that the grammar itself simply provides mechanisms for processing/integrating such fragments in the current structure while their precise contribution to the communicative interaction is either calculated by pragmatic inferencing (as in e.g. Schlangen (2003)) or, as seems most often to be the case, left underspecified. The framework within which the explanation will be provided is Dynamic Syntax, in which the dynamics of how information accrues in language processing is the core of the syntactic explanation.

One bonus of the stance taken here is the promise it offers for elucidating the grammar-parser contribution to the disambiguation task. Part of the challenge of modelling dialogue is the apparent multiplicity of interpretive and structural options opened up during processing by the recurrent, often overlapping fragments as seen in (2) above. Thus, it might seem that the rich array of elliptical fragments available in dialogue adds to the complexity of the interpretive task, owing to their high degree of context-dependence (hence the need for accommodation and construction-specific interpretation rules). However, an alternative point of view is to see such phenomena as providing a window on how interlocutors exploit the

incrementality afforded by the grammar to manage the explosion of interpretative/structural options multiplying at each step. The context-dependent interpretation of fragments, when employed incrementally, enables the hearer to immediately respond to a previous utterance at any relevant point in the construction process, thereby enabling interlocutors to (incrementally) constrain interpretation during the very process in which it is developed.

Modelling this kind of flexibility in processing requires fine-grained control of how the current utterance can be combined with previous contextual information. Grammatical frameworks which take the radical context dependency of linguistic processing as being outside the remit of the grammar might make it seem that these phenomena require distinct mechanisms. Alternatively, however, the tight coordination of parsing and generation as defined in the *Dynamic Syntax* model of dialogue (Purver et al. (2006)) enables a straightforward account of how the context-dependence of both tasks allows participants to economise on processing.

3 Dynamic Syntax: A Sketch

Dynamic Syntax (*DS*) is a parsing-based approach to linguistic modelling, involving strictly sequential interpretation of linguistic strings. The model is implemented via goal-directed growth of tree structures and their decorations formalised using *LOFT* (Blackburn and Meyer-Viol (1994)), with modal operators $\langle\uparrow\rangle, \langle\downarrow\rangle$ to define concepts of *mother* and *daughter*, and their iterated counterparts, $\langle\uparrow_*\rangle, \langle\downarrow_*\rangle$, to define the notions *be dominated by* and *dominate*. *Underspecification* and update are core aspects of the grammar itself and involve strictly monotonic information growth for any dimension of tree structures and decorations. Underspecification is employed at all levels of tree relations (mother, daughter etc.), as well as formulae and type values, each having an associated *requirement* that drives the goal-directed process of update. For example, an underspecified subject node of a tree may have a requirement expressed in DS with the node decoration $?Ty(e)$, for which the only legitimate updates are logical expressions of individual type ($Ty(e)$); but requirements may also take a modal form, e.g. $?\langle\uparrow\rangle Ty(e \rightarrow t)$, a restriction that the mother node be decorated with a formula of predicate type. Requirements are essential to the dynamics informing the DS account: all requirements must be satisfied if the construction process is to lead to a successful outcome.

Structure is built from lexical and general computational actions. *Computational actions* govern general tree constructional processes, such as introducing and updating structure, as well as compiling interpretation for all non-terminal nodes in the tree, once individual leaf nodes are successfully decorated (with no outstanding requirements). This may include construction of only weakly specified tree relations, characterised only as dominated by some node from which they are constructed (*unfixed nodes*), with subsequent update (unlike van Leusen and Muskens (2003), partial trees are part of the model). Individual lexical items also provide procedures for building structure in the form of *lexical actions*, expressed in exactly the same terms as the more general processes, inducing both nodes and decorations. Thus *partial trees* grow incrementally driven by procedures associated with particular words as they are encountered, with a *pointer*, $\Diamond$, recording the parser's progress.

Complete individual trees are taken to correspond to predicate-argument structures. More complex structures can be obtained via a general tree adjunction operation defined to license the construction of a tree sharing some term with another newly constructed tree, yielding so-called *Linked Trees* (Kempson et al. 2001). The resulting combined information from the adjoined trees is modelled as a conjunction of terms at the node *from* which the link is made. Importantly, adjunction, as other forms of construction and update, can be employed to model how subsequent speakers may dynamically provide fragmentary extensions in response to the previous utterance.

Structural as well as content underspecification play important roles in facilitating successful linguistic interaction. The content underspecification of pronouns is represented as a place-holding metavariable, noted as e.g. $\mathbf{U}$, plus an associated requirement for update by an appropriate term value: $?\exists\mathbf{x}.Fo(\mathbf{x})$. Similarly, *names* are represented as initially introducing place-holders associated with a constraint providing the name of the individual entity picked out. For example, the name *Bill* contributes the decoration $U_{Bill'(\mathbf{U})}, Ty(e)$. The subscript specification is shorthand for a transition across a LINK relation to a tree whose top node is decorated with a formula $Bill'(\mathbf{U})$, the name being taken as a predicate or name specification of individuals thus

restricting possible updates to the metavariable[1]. Names can thus be seen as a procedure for identifying the individual being talked about, with a logical constant (e.g. $m21$, $m23$ etc. picking out uniquely this individual) eventually replacing the metavariable on the emergent tree. According to the DS account, the update of metavariables can be accomplished if the context contains an appropriate term for substitution. *Context* in DS involves storage of *parse states*, i.e., the storing of partial tree, word sequence to date, plus the actions used in building up the partial tree.

A major aspect of the DS dialogue model is that both *generation* and *parsing* are goal-directed and INCREMENTAL, with parsing as the underlying mechanism and generation parasitic on it. A hearer builds a succession of partial parse trees in order to achieve an interpretation of the speaker's message. A speaker is modelled in DS as doing exactly the same only (s)he also has available a *goal tree* representing what they wish to say. Each possible step in generation, an utterance of a word, is governed by whatever step is licensed by the parsing formalism, constrained via the required *subsumption* relation of the goal tree by the thus-far constructed "parse" (partial) tree. By updating their growing "parse" tree relative to the goal tree (via a combination of incremental parsing and lexical search), speakers produce the associated natural language string.

The DS model of dialogue requires defining and taking into account both the speaker's goal and parse trees, as well as the hearer's parse tree. For fragment construal, we are interested in the extent to which B has successfully parsed what A has said, with the ability at any stage to interrupt to ask for clarification, reformulate, or provide a correction, by either repeating the expression or producing an alternative. As we shall see, B's parse tree reveals where need of clarification or miscommunication occurs, as it will be at that node from which a sub-routine extending it takes place. According to the DS model of generation, repeating or extending a constituent of A's utterance is licensed only if B's goal tree matches or extends a parse tree updated with the relevant subpart of A's utterance. Indeed, this update is what B is seeking to clarify, correct or acknowledge.

Notice that because of the incremental definition of DS, B can reuse the already constructed (partial) parse tree in their context, thereby starting at this point, rather than having to rebuild an entire propositional tree or subtree (e.g. of type e). Exploiting the assumed parity of representations in this way enables hearers to provide immediate feedback to the previous speaker, the effect being to narrow the focus on particular aspects of the interpretive space. The advantage of this emerges in the unified characterisation of any type of *ellipsis* construal as strictly context-dependence. Since context in DS involves the storing of current partial tree, word sequence to date, plus the actions used to date to build the partial tree, ellipsis construal can target any of those stored elements. In particular, for split/joint utterances, this enables switch from hearer to speaker at any arbitrary point in the dialogue, without such fragments having to be interpreted as propositional in type (as is standard elsewhere, e.g. Purver (2004)).[2] This can then capture the dynamics involved in taking what the other speaker has just uttered, with the potential at any point to update it to accord with one's own emerging understanding of the interaction. In this way, speakers are able to guide each other's interpretations, and thus *jointly* narrow down as early as possible the burgeoning interpretive space.

4 NSU fragments in Dynamic Syntax

4.1 Non-repetitive Acknowledgement

From a DS perspective, phenomena like *reformulations* as in (1), or *extensions* to what one understands of the other speaker's utterance, (2), can be handled with exactly the same mechanisms as the sentence-internal phenomenon independently identifiable as *apposition* and illustrated below:

(5) A friend of my mother's, someone very famous, is coming to stay.

(6) Bob, the friend of Ruth's, is coming to stay.

According to Cann et al. (2005), such structures are analysed as involving the building of paired terms across a tree transition, building *linked* structures defined to share a term. Reflecting this constraint, the update rule for such structures then takes the pair of type e terms so formed and yields

[1] These *linked* structures are suppressed in all diagrams.

[2] Given the DS concept of linked trees projecting propositional content, we anticipate that this mechanism will be extendable to fragment construal involving inference (see e.g. Schlangen (2003), Schlangen and Lascarides (2003))

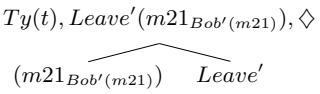
a term whose compound restrictor is made up of the predicative content from each.

We now have the basis for analysing extensions and non-repetitive acknowledgements which build on what has been previously said by way of confirming the previous utterance. Recall examples (1) and (2). There are two ways for the processing of fragments which reformulate an interlocutor A's utterance: either (a) as interruptions of her, A's, utterance in which case immediate confirmation of identification of the individual concerned is provided, see (2), or (b) as confirmations/extensions of A's utterance after the whole of her utterance has been integrated, see (1). Both are modelled by DS as incremental additions.

Turning to (1), B's response *(Yeah,) the accounts guy* constitutes both a reformulation of A's utterance, as well as an extension of A's referring expression, having the same effect as processing the appositive expression *Bob, the accounts guy*. This means that B has processed A's original utterance, according to some identification of the individual associated with the name *Bob*: that is to say, they have constructed a full content representation for this utterance. B's reformulation has the effect of acknowledgement because it signals to A that he has processed/understood her asserted content, and, moreover, has no objection to the content, *unless* mistaken in that identification.

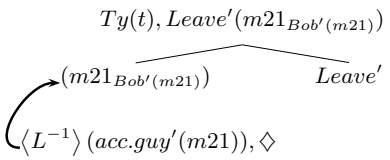
In DS terms, B's context consists of the following tree after processing A's utterance:

(7) B's Context for *Yeah*[3]



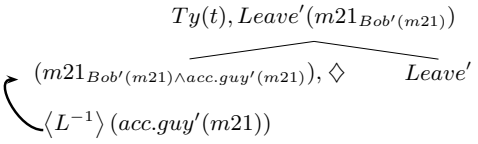
It is now open to B to re-use this representation, stored in his context, as the point of departure for generating the expression *the accounts guy*. In this case his own goal tree will now be decorated with a composite term made up both from the term recovered from parsing A's utterance and the new addition. Simplistically, all this requires is attaching a *linked* tree to the correct node, and then processing the content of the apposition in order to produce the words required. The defined steps include shifting the pointer to the appropriate node, projection of a *linked* tree from that node and processing the words *the accounts guy* (the *linked* tree is simplified below):

(8) B's "parse" tree licensing production of *the accounts guy*: LINK adjunction



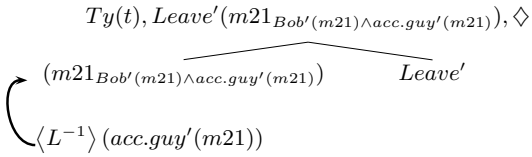
Updating this representation according to the DS processing protocol involves adding the acquired restrictions at the node from which the *linked* tree is projected (individual stages here suppressed):

(9) Updating B's "parse" tree licensing production of *the accounts guy*



Finally, the information is passed up to the top node of the main tree, completing the parse tree to match B's goal tree in uttering the expression *the accounts guy* :

(10) Completing B's "parse" tree licensing production of *the accounts guy*



4.2 Non-repetitive Clarification

In the acknowledgement case above, the term relative to which the *linked* structure is built is fixed; but the very same mechanism can be used when the interlocutor needs clarification. In (2), B again takes as his goal tree a tree decorated with an expansion of the term constructed from parsing A's utterance but nevertheless picking out the same individual. Using the very same mechanism as in (1) of building a *linked* structure constrained to induce shared terms, B provides a distinct expression, the name *Chorlton*, this time before he has completed the parse tree for A's utterance. This name, contributing a metavariable plus the constraint that the individual picked out must be named *Chorlton*, is used to decorate the

[3]Words like *yeah* and *no* are analysed as discourse markers which do not contribute truth conditional content, hence are not represented on the trees

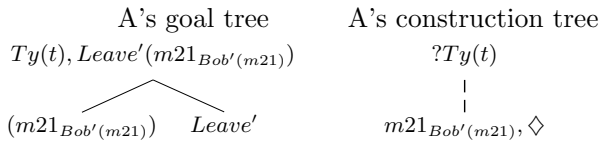


Figure 1: Licensing production of a correction by *ADJUNCTION

linked node so that it makes explicit the additional predicative constraint on the individual being described. The outcome of this process, when the linked structure is evaluated, is a composite term $m21_{Doctor'(m21) \wedge Chorlton'(m21)}$. This process, therefore, is identical to that employed in B's utterance in (1), though to rather different effect at this intermediate stage in the interpretation process. This extension of the term is confirmed by A, this time trivially replicating the composite term which processing B's utterance has led to (see Kempson et al 2007 for such trivial goal tree-parse tree matches). The eventual effect of the process of inducing *linked* structures to be decorated by coreferential type e terms may thus vary across monologue and different dialogue applications, yielding different interpretations, but the mechanism is the same.

4.3 Correction

It might be argued nonetheless that correction is intrinsically a dialogue phenomenon. In (4) for example, reproduced below:

(4) A: Bob left.
B: Rob?
A: (No,) (Bob,) the accounts guy.

As one alternative, we assume here that B has misheard and requests confirmation of what he has perceived A as saying. A in turn rejects B's utterance and provides more information. Presuming rejection as simple disagreement (i.e. the utterance has been understood, but judged as incorrect), in DS terms, this means that A has in mind a goal tree that licensed what she had produced, which is distinct from the one derived by processing B's clarification. As shown in Kempson et al. (2007), this means that A has been unable to process B's clarification request as an extension of her own context. Instead she can parse the clarification by exploiting the potential for introducing an initially structurally underspecified tree-node to accommodate the contribution of the word *Rob*. Subsequently, by re-running the actions stored in context previously by processing her own utterance of the word *left*, she is able to complete the integration of the fragment.

In order to produce the following correction, A is required to establish as the current most recent representation in context her original goal tree. This can be monotonically achieved by recovering and copying this original goal tree to serve as the current most immediate context[4]. Under these circumstances, given the DS grammar-as-parser perspective, several strategies are now available. A is licensed to repeat the name *Bob* by locally extending the node in the context tree where the representation of the individual referred to is located by using the rule of LATE*ADJUNCTION, a process which involves building a node of type e from a dominating node of that type (illustrated in Kempson et al. 2007). An alternative way of licensing repetition of the word *Bob* is to employ one of the strategies generally available for the parsing of long distance dependencies i.e. constructing initial tree nodes as unfixed (*ADJUNCTION).

Starting with Fig 1 above, illustrating the introduction of the unfixed node, we show here how the latter strategy can be exploited to license the production of the fragment. An option available to A at this point is to introduce, in addition or exclusively, a reformulation of her original utterance in order to facilitate identification of the named individual which proved problematic for B previously. She can answer B's utterance of *Rob* with *(No,) (Bob,) the accounts guy*, as in (4) or simply with *(No,) the accounts guy*. Both are licensed by the DS parsing mechanism without more ado. The structure[5] derived by processing such an extension is exactly that of (1) above (compare goal tree in Fig 2 and tree in (10)). As mentioned before, *context*, as defined in DS, keeps track not only of tree representations and words but also of actions contributed by the words and utilised in building up the tree representations. Production of

[4]Corrected representations must be maintained in the context as they can provide antecedents for subsequent anaphora.

[5]Note that DS trees represent derived content rather than structure over natural language strings.

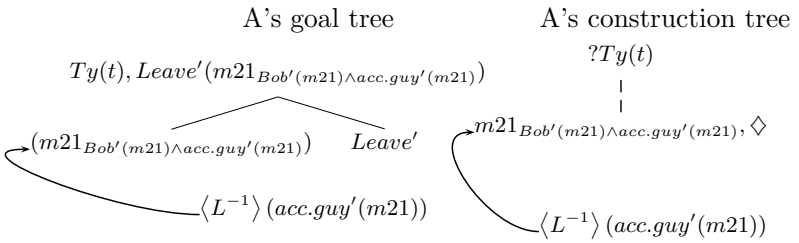


Figure 2: LINK ADJUNCTION and checking goal tree subsumption

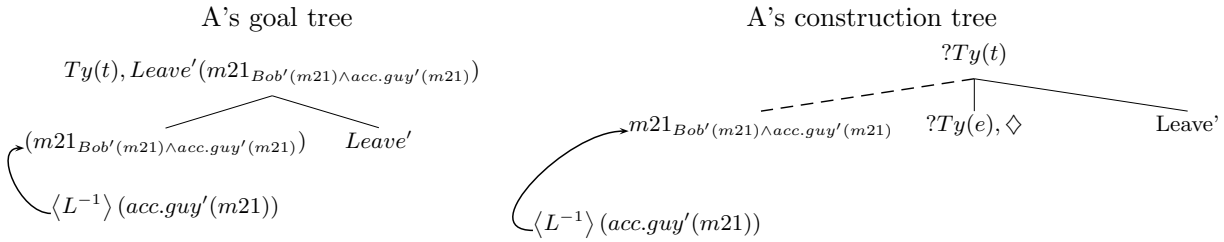


Figure 3: Retrieving and rerunning the actions for *left*, pointer return to subject node and checking goal tree subsumption

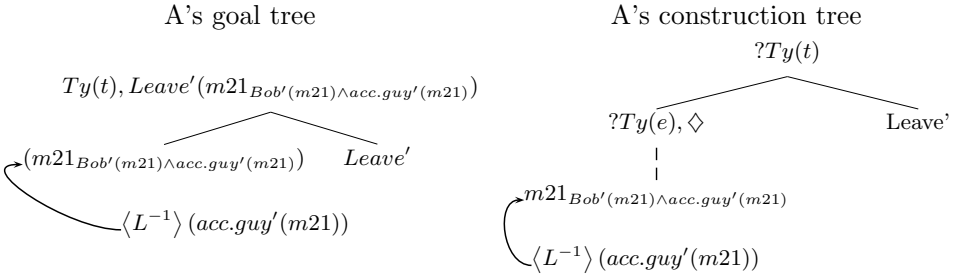


Figure 4: Preparation for UNIFICATION and checking goal tree subsumption

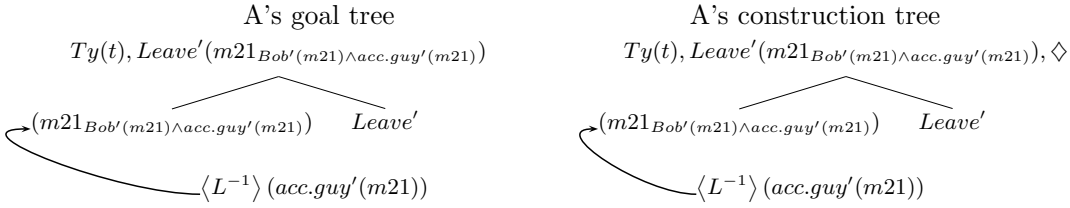


Figure 5: Licensing the production of correction and extension: completed tree matching the goal tree

the correction in (4) is licensed to be fragmental because the original actions for parsing/producing the word *left* are available in the context and can be recalled to complete the structure initiated by processing/producing the name *Bob* (see Fig 3-5).

4.4 Structure and Dialogue Function

In the examples considered so far, we have seen how a single type of mechanism can serve distinct functions. A more striking case is (3), where the hearer, B, is able to leap to a hypothesis as to how A's question is going to be completed, and provides that completion by way of answer. Here we have the case where more than one function can be fulfilled even by a single utterance. As in (1)-(2), license for such a use turns on taking the context that was constructed by parsing input from the interlocutor as the point of departure. That B is extending the structure set up by A's utterance is self-evident; but in addition, both A's utterance, if she had completed it, and B's utterance, as presented, are elliptical as to the second disjunct. The success

of this particular form of split utterance turns on the fact that what A is presenting is a duplex *yes-no* question with both possible answers provided by the two disjuncts. So in completing it by providing just the second disjunct, B can succeed in answering the question while simultaneously completing it. Though there is more to say here, the significance of (3) lies in the use of the single expression *right-handed* to fulfil two functions, both the completion of a question and the provision of an answer. In DS this can be modelled, reflecting the phenomenon itself, without having to assume the superimposition of two distinct structures, one upon the other. Incidentally, this is a case contradicting what is supposedly unique to such interrupting completions, namely, that they require acknowledgement by the hearer before proceeding.

5 Conclusion

As these fragments and their construal show, despite serving distinct functions in dialogue, the mechanisms which make such diversity possible are general strategies for tree growth. In all cases, the advantage which use of fragments provides is a "least effort" means of re-employing previous content/structure/actions which constitute the *context*. As modelled in DS, it is more economical to reuse information from context rather than constructing representations afresh (via costly processes of lexical retrieval, choice of alternative parsing strategies, etc.).

A further quandary in dialogue construal is that, despite such avenues for economising their efforts, interlocutors are nevertheless faced with an increasing set of interpretative options at any point during the construction of representations. One option available to hearers is to delay a disambiguating move until further input potentially resolves the uncertainty. However, as further input is processed and parsing/interpretive options increase potentially rapidly, maintenance of these open options becomes difficult for a human processor. The incremental definition of the DS formalism allows for the modelling of an alternative available to hearers: at any point they could opt to intervene immediately and make a direct appeal to the speaker for more information at the maximally relevant point during construction. It seems clear that the latter would be a preferable strategy and this is what clause-medial fragment interruptions, (2), illustrate.

The phenomena examined here are also cases where speaker's and hearer's representations, despite attempts at coordination, may nevertheless separate sufficiently for them to have to seek to explicitly "repair" the communication (see especially (4)). In the model presented here, the dynamics of interaction allow fully incremental generation and integration of fragmental utterances so that interlocutors can be taken to constantly provide optimal evidence of each other's representations with necessary adjuncts being able to be incrementally introduced. Thus, fragment construal is here modelled sub-sententially with no lifting devices to yield a propositional unit as part of some putative discourse grammar. Indeed, no structures/strategies are posited specific to individual discourse functions to which a fragment is put.

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