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Abstract

In this paper we adopt the hypothesis that *languages* are mechanisms for interaction, and that *grammars* encode the means by which such interaction may take place, by use of procedures that construct representations of meaning from strings of words uttered in context and conversely strings of words are built up from representations of content in interaction with context. In a review of the systemic use of ellipsis in dialogue and associated split-utterance phenomena, we show how, in Dynamic Syntax, *words* give rise to a range of procedures for the building of representations of the content of some utterance, which both speakers and hearers use. We then extend the discussion to take account of adjuncts, showing how they contribute to content construction both in single utterances and across speakers. The same mechanisms are then shown to underlie the building of inferential extensions of meaning in context, giving rise to the creation of the ad hoc concepts expressed by phrases or single words in relation to the utterance context and ultimately to the creation of metaphorical uses of language.

1 Grammar, processing and interaction

With the recognition of the endemic context-relativity of natural language interpretation becoming well-established, there is now increasing realisation that both parsing and production involve incremental, context-relative decisions, requiring the concepts of both evolving contents and evolving contexts as underpinning all language processing (Pickering and Garrod 2004, 2013, and for a useful survey see Clifton et al 2012). In this paper, we explore the significance of such incrementality for our concepts of language content, in particular for the modelling of the contribution made by words to the incremental projection of interpretation and utterances.[1] We will first show why the dynamics of informal conversational dialogue cannot be set aside by linguists as irrelevant to the articulation of grammar frameworks; we will then give a sketch of a framework in which the concept of incrementality, partial specifications and update lie at the core of natural language; and we will then use this framework to explore the types of procedures which words of natural languages make available for the ongoing process of building up representations of content, or conversely from contents to utterances (Cann et al 2005, Purver at al. 2014, Kempson et al 2016).

Some of the most striking evidence that modelling language processing involves the articulation of how strings and contents evolve incrementally comes from the data of conversational dialogue. When one looks at such data, notably the only data to which a small child is exposed, we see that conversations are littered with so-called fragments where speakers and hearers simply assume that in some sense to be made explicit, the context provides all that is needed to see their apparently fragmentary contribution as providing a coherent and consistent add-on to what has just preceded.

[1]We are grateful to many people for direct or indirect contributions to this project. We especially thank Eleni Gregoromichelaki, Stergios Chatzikyriakidis, Arash Eshgi, Robyn Carston, Nik Gisborne and a number of anonymous referees. The usual caeats apply.

We can join one another's conversations, becoming a new speaker while the previous speaker shifts into being an addressee. Indeed, this shift of roles is the sine qua non of informal conversations, monologues being the exception rather than the norm:

(1) A: I need a a
B: mattock. For breaking up clods of earth [BNC]

(2) Jack: I just returned
Kathy: from
Jack: Finland [Lerner 2004]

The take over may take the form of an overt attempt to be helpful to the other party, but this is by no means their only function. One may be simply seeking to extend what the other has said:

(3) A: We're going to
B: Marlborough
C: Marlborough?
B: to see Granny
C: With the dogs?
A: if you can keep them under control
C: in the garden?
B: unless it rains
C: which it always does

Conversations such as these, where there may be covert competition as to who can have the last word, are the bedrock of informal conversation, by no means constrained by any over-arching aim of achieving some co-operatively constructed communicative act. And, of course, extensions such as these may be uttered by a single interlocutor refining and elaborating an initial sentence, as in (4) where we have a first extension providing the time of the event given in the initial utterance, then a source of the event, then a modifier of the subject:

(4) Mary's back. Late last night. From the US. Tired and frustrated at the delays.

There is an open-ended flexibility in how such interactive construction of dialogues can be achieved. They may be used for novel effect at the level of the speech act, when apparently dual speech acts can be achieved within a single emergent utterance:

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

Such interaction is effective even when the parties may be in sharp dispute:

(6) A: It's obvious from what he says (that)
B: (that) you are wrong

Partial fragments may also be being used to direct one's interlocutor to construct something novel, an ad-hoc context-specific concept that depends on knowledge of the individuals in question:

(7) Bird-expert: I watched birds yesterday all afternoon, in the sunshine
Friend: with your grand-son?
Bird-expert: It was great fun. He did really well . . . for 20 minutes.

And even metaphorical utterances can be taken up and extended with non-metaphorical content:

(8) A: How's work?
B: Oh, I shuffled along
A: Not getting much done, I imagine.

The general dynamic is that each such contribution adds unproblematically to whatever string of words has been set out so far, irrespective of whether or not what precedes it is a full sentence, and whether or not the add-on contributes to what the other party is trying to get across. The effect is one of a rich potential for interactivity between dialogue participants.

1.1 Implications for grammar

The existence of interactive construction of utterances, and the fact that utterances by a single individual may only gradually build up information, pose significant problems for all conventional frameworks, in every sub-area of the grammar. From a syntactic perspective, we need to ask: how are split utterances possible; why are they so common in conversational dialogue; and how is it that the shift from one interlocutor to another can occur at any point in a sentence-construction process? Questions such as these might be, and often are, set aside as performance considerations only. But there is one consideration, overwhelmingly, which resists any attempt to dismiss the data as peripheral – the seamless fluency with which individuals take on or hand over utterance responsibility, apparently distributing syntactic and semantic dependencies across more than one participant. The problem for conventional grammars is the commitment to model an individual speaker's linguistic competence as involving knowledge of a set of rules (however defined) that licenses all and only the strings of the language which that speaker judges to be well-formed; and, moreover, only those strings that are defined as sentences with representations rooted in the largest constituent recognised in the theory: S, CP, VP[+SBJ], type t, or whatever.

Even if the goal of a grammar were weakened to characterise only a subset of the total phenomena displayed by a language, the fact that utterances can apparently split apart every single dependency within a language leads to the result that *every* generalisation articulated within a standard grammar will be incomplete. So even according to the more modest evaluation metric, the grammar will fail. This is because, in all cases, there will be split utterance data which, despite being wholly acceptable to individuals in some speech situation, will not be given any characterisation by that grammar in virtue of their apparently fragmentary nature, not only being non-sentential but possibly also not even constituting any phrasal type, as in the first utterance in (1) or the second in (2). In order, then, to retain the grammar as an explanatory tool, such expressions uttered by the individual speaker, independent of any interaction with other speakers, will not be characterised as falling within the remit of the grammar. They will accordingly have to be deemed to be irrelevant, characterisable by some other set of principles. But any such dismissal would solely be on grounds that the distribution of such fragments is inexpressible within the grammar methodology adopted, and so not deemed part of any sort of competence on the part of a speaker (Chomsky 1965). But such fragments are not, by any stretch of the imagination, dysfluent uses of language: to the contrary, they are achieved with total fluency, demonstrating a fine level of sensitivity to the evolving development of the discourse.

The ever-extendability of a structure across more than one speaker may at first sight seem to be a mere idiosyncracy of informal conversational exchange, where people may allow a single composite sentence to unravel apparently indefinitely as in (3), with each providing their own add-on, one after the other. There are two issues here. First, there is the issue of how fully determined the concept of a sentence boundary is. It is commonplace to observe of languages with which we are not familiar that the sentences "seem to go on for ever" and it is hard to find out where one begins and the other ends. But what data such as (3) illustrate is that this is an attribute of spoken conversation.

The assumption that this doesn't occur in well-documented languages is no more than a parochial folk-prescriptive attitude to "correct grammar" as essentially that of written language and thus a function of literacy and not evidence for normal language use (Miller and Weinert 1998). It might then seem to be but a short step to see that in conversation, one contributor to the conversation is merely taking over responsibility for some emergent sentential sequence from someone else, so the activity can be in some sense shared, an explicitly joint activity.

So what seems to require building up by interlocutors hearing an utterance is not the construction of sentences at all, but rather some structured representation of content. In some cases, indeed, the subparts of the sentence-string which appear to be omitted would seem to be either internally inconsistent or even not well-formed, considered as a single sequence of words:

(9) Eleni: Is this yours or
Yo: yours. [natural data]

(10) {A emerging from a smoking kitchen}
A: I've burnt the kitchen rather badly.
B: Have you burnt
A: Myself? No.

In (10), the relevant sub-parts, put back together, yield an ungrammatical string due to the conflict in person between the binder and the reflexive pronoun: **Have you burnt myself*. Yet the exchange is perfectly well-formed, the reflexive pronoun being interpreted locally as the subject of the predicate just constructed from B's utterance, but with the switch of speaker having to be commensurate with attributes of the new speaker, now A. Intuitively, in some sense, these two parts have to go together to determine a whole syntactic structure, even though the result string-wise is not grammatical.

What such data indicate is that these exchanges are not about putting word sequences together to form some string of words constituting a sentence or even a string of sentences in a discourse (see also (3) above which, when put together into a single discourse is incoherent, despite the interaction being perfectly acceptable). Instead, what we appear to need to characterise such dialogue is a grammar that licenses, not sentences as traditionally construed, but sub-sentential units that put together may, or may not, yield a well-formed sentence within a language depending on speech act and other contextual factors. By implication, this yields a view of grammar as providing mechanisms for successful linguistic interaction, rather than a set of rules that define the set of all and only the grammatical sentences taken by speaker-hearers to constitute a language.[2]

However, even though it may be that representations of meanings are what is constructed rather than representations of putative structure defined over strings of words, such structures are nevertheless not wholly insensitive to the morpho-syntactic constraints imposed by the words of the language, as the required reflexive form in (10) indicates. This problem cannot be dismissed as a language-particular idiosyncracy. In all case-rich languages, fragments have to adopt a morphological form appropriate for what would be expected in an overt clausal sequence, commonly replicating the pattern provided by the immediately antecedent context. Thus in (11), the form of the fragment pronoun has to be the nominative form *ego*, not the accusative *emena*:

(11)

A:	*I*	*Maria*	*to*	*egrapse*	*to*	*grama?*	*B:*	*Oxi,*	*ego*	*(*emena)*
	the$_{Nom}$	Maria	it$_{Acc}$	write$_{Past,3sg}$	the	letter		No	I$_{Nom}$	(*me$_{Acc}$)

A: 'Did Maria write the letter? B: No, I did (*Me did)'

[2]We take the arguments here to apply also to concepts of language as involving structures of a particular sort rather than stringsets, such as the notion of I-language (Chomsky 1986).

Furthermore such fragments are required to take a definitive morphological form whether or not there is some overt antecedent in a previous clause to provide the appropriate pattern, again as in the Modern Greek (Gregoromichelaki 2012):

(12) [Context: A is contemplating the space under the mirror while re-arranging the furniture and B brings her a chair]

A to B:	*tin*	*(*i)*	*karekla*	*tis*	*mamas?*	*Ise*	*treli?*
	the.ACC	(*the.NOM)	chair	the.GEN	mum.GEN	be.2.SG.PRES	crazy

'Mum's chair? Are you crazy?

Thus, first and foremost, relative to any sentence-based grammar, the split utterance data seem to fall irretrievably outside its remit. But even if the remit of grammar is somehow extendable to include these data, the structured representations which have to be induced appear to have both to be representations of content and yet also sensitive to what morphological constraints the particular grammar may impose on what representations can legitimately be constructed. Moreover such constraints must be expressible as lexical properties of the given words, despite possibly lacking the environment these need for successful completion. There are thus major hurdles for any conventional syntactic framework in addressing these data, if the framework is to have the expressivity needed to incorporate them within its remit.

The problems posed by naturalistic data are barely less for semantics. First is the issue of how it is that almost every word can have its interpretation modified in context with compositionality to be defined over such modifications. The meaning attributable to our words reflects the context to which it is intended to contribute, shifting so seamlessly from one understanding to another that it is often hard to notice even that there has been such a shift – in (13) three different concepts of 'burn' emerge within a single exchange.

(13) A: I'm afraid I've burned the kitchen ceiling. The paper's blackened and part of it has come away.
B: Did you burn
A: myself? No fortunately not. Well, only my hair.

And in (14), an expression is placed in the conversational arena, so to speak, and immediately modified, or at least justified by one particular attribute of stage-managing:

(14) M: He's stage manager [pause]
He's actually first assistant but- he's calling the show. [Hough 2015]

There is then the question of hand-on from one speaker to another. If meanings evolve over the course of an exchange, with shifts which we are barely aware of, how is it that propositional content can nevertheless be seen to emerge incrementally across a group of speakers?

These data pose very considerable problems for almost all current theories of pragmatics. Probably, the most basic questions needing an answer are: how can speaking and hearing be so seamlessly interwoven; and why is there such systematic cross-speaker use of non-sentential utterances in dialogue? The reason these questions are fundamental is that the answers to them impact on two of the most common assumptions made in pragmatic theory: that pragmatic inference operates over propositions as expressed by sentences; and that successful communication is only achieved if a hearer can identify the proposition or thought that a speaker intends (or could have intended) to convey (Grice 1975, Sperber and Wilson 1986/1995, Bach 1994). The former assumption is seriously called into question by examples like (3). Here, the conditional *if you can keep them under*

control scopes, not over the proposition purportedly expressed by the preceding utterances, *We're going to Marlborough to see Granny with the dogs* but only over the non-sentential prepositional phrase *with the dogs*: going to Marlborough to see Granny is not contingent on C's being able to control the dogs. If inference is defined solely over complete propositions, then any such theory will have to be powerful enough to reconstruct some proposition from the prepositional phrase and further to explain why the scope of the conditional is not over the proposition expressed by the previous utterances taken together. Even assuming that such extra propositions can be constructed (as typically assumed in accounts that treat such utterances as elliptical sentences such as Merchant 2005, 2015), the significant question arises as to what apparently elided propositional contents are derived from, given no previous sentential context that supplies those contents (see Kempson et al. 2015, 2016 for some discussion). In any case, the elliptical account is likely to have difficulty in accounting for and explaining the narrow scope of the conditional in (3).

Additionally, the construction of a speech act, usually taken to be something that only sentences are the vehicle for conveying (Austin 1962, although see Stainton 2006 for a discussion of speech-acts conveyed by sub-sentential utterances), is nevertheless able to be constructed as in (9) above and (15) below in which the first utterances are incomplete interrogatives implying a question, but whose interactive completion yields a statement:

(15) Lawyer: Will you choose your son as your attorney or
Client: My wife.

With respect to the question of intention recognition, there is plenty of evidence in dialogue that, while building on some estimation of the other person's mind-set is commonly made use of both in parsing and in production, it is not a prerequisite for successful communication (Gregoromichelaki et al. 2011). For example, the clarification request in (16) is made before B could possibly have recognised any intended meaning by A:[3]

(16) A: They X-rayed me, and took a urine sample, took a blood sample. 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]

In non-co-operative examples like that in (6) above and (17) below the second speaker completes the previous utterance without any necessary consideration of the intentions of the first speaker. In (17), the son is certainly not waiting for the third of the commands even if he has bothered to process the second, but nevertheless he has responded wholly appropriately

(17) Mother: This afternoon first you'll do your homework, then wash the dishes and then
Son: you'll give me 10 pounds?

Taking a step back, what appears to be needed to model these data is a framework in which strings, content, context and even speech-act determination can all be seen as evolving during the course of a conversational interaction. This involves a radical shift of assumptions. Instead of presuming on a methodology which isolates the capacity for language from all attributes of its use, the concept of the process of building up structured mental representations of content needs to

[3]An anonymous reviewer reminds us that a standard response to this criticism is that the addressee has recognised that the speaker has performed a "referential" speech act (Searle 1969). However, in our view, the addressee is merely understanding the function of the definite article, not identifying some intentional act on the speaker's part. If a hearer knows that the function of a definite article (or proper name) is to introduce a referential term, why do they have any need to recognise some intended speech act? They are merely doing what the language tells them to do: identify some referent.

be taken to be central. Instead of such a system being assumed to be articulated in a vocabulary wholly encapsulated from general cognitive considerations, the emergent representations will need to be conceptual representations, so in principle allowing free interface between such grammar-internal specifications and considerations of general context. Any such level of representation will nonetheless have to be sensitive to whatever morphosyntactic constraints the forms of the language may impose, so the articulation of morpho-syntactic constraints will have to be in terms of constraints on the mappings from the morphological forms onto such conceptual representations. In short, we are turning to the exploration of a view of language which breaks out from the stranglehold of the competence-performance division in two ways, putting in its place a methodology for defining language as a set of actions for coordination between interlocutors. The concept of *sentence* will no longer be central to determining the remit of grammar; and the structural properties of any natural language will be defined in terms of mechanisms for mapping words and word sequences onto representations of content. So the system will no longer be an encapsulated set of properties lacking any interface with general cognitive restrictions, but rather will be defined in a domain-general vocabulary and so a proper subpart of the general cognitive architecture, not defined over the strings of words themselves. Principles underpinning structured strings are thus transformed into procedures for incrementally building structural representations of content. With this transformation, the concept of mapping expressions onto emergent contents and contexts as these become available lies at the centre of what has to be expressed, so the concept of procedure becomes central, together with the twinned concepts of initial underspecification and subsequent update.

1.2 Implications for word meaning

It is notable that researchers across semantics, pragmatics, psycholinguistics, and computational linguistics are duly turning to the challenge of modelling language in terms that are compatible with interaction and incrementality. While the means of achieving incremental linguistic analyses vary, there has been an increasing focus on the *procedures* that interlocutors access in implementing how our linguistic knowledge is put to use in talk exchange (Kempson et al 2001, Cann et al 2005, Purver et al 2006, Gregoromichelaki et al 2011, 2013, Poesio and Rieser 2010, Ginzburg 2012, Pickering and Garrod 2013, Cooper 2012). As noted above, modelling linguistic competence in these terms is more easily construable as the construction of representations of meaning in context, rather than decontextualised and static structures defined over strings of words. So the goal of the grammar shifts from characterising the (structures induced by the) set of well-formed sentences of a language to the processes by which subsentential expressions are incrementally provided with interpretations. This shift not only allows the data of conversational dialogue to form a legitimate part of the linguistic data, but predicts that such data are normal and unproblematic, whereas decontextualised full sentences are no longer accorded a central, or even meaningful, role in the definition of what the grammar determines as well-formed.

Crucial to articulating a grammar formalism on these terms is to identify exactly what words provide that enables interlocutors to express and construct the meanings they do. It is a direct consequence of the Principle of Compositionality that words must provide the basic building blocks for the construction of meanings for all linguistic expressions, no matter how complex. In theoretical semantics, the definition of what words mean generally depends on the view of what sentences mean. If sentences express propositions that denote things external to the linguistic or cognitive system such as functions from indices to truth values, then words themselves will be taken to express meanings that are similarly external such as sets of more or less complex objects (or the functions that define them) (Montague 1973, Kaplan 1979). On the other hand, if sentences express

thoughts, the things that words will express will be cognitive concepts of some kind, whether atomic or complex (Jackendoff 1983, 2002, Fodor 1983, 2008). Basic meanings however defined may be extended through the use of Meaning Postulates (Carnap 1952, Dowty 1979), through decomposition (Pustejovsky 1995, Asher 2011, Jackendoff 2002) or through pragmatic processes (Wilson and Carston 2007, Blutner 1998, 2011).[4]

Instead of letting semantic *outputs* determine what words bring to the grammatical process, there is the alternative that the form of the *grammar* itself derives from the properties of words. After all, in acquiring a language a child starts with one word utterances, building on these to eventually construct complex linguistic expressions. Hence, if grammars provide procedures for constructing and expressing meanings in contexts, then we may hypothesize that words do exactly the same. Although implicit in certain philosophical discussions of word meaning (Frege 1970, Quine 1960, Wittgenstein 1953), arguably the idea that procedures could be encoded by linguistic forms was introduced into the field in Blakemore (1987) with the hypothesis, couched in terms of Relevance Theory (Sperber and Wilson 1986/1995), that certain discourse particles like *but*, personal pronouns and the like provide the hearer with procedures to enable them to infer meanings intended by speakers. In recent years, this notion of words inducing procedures for constructing meanings has been increasingly taken up to account for the meanings of words typically construed as having lexical/conceptual content, giving rise to ideas whereby such words too encode something considerably more abstract than some fixed conceptual or denotational content (Blakemore 2002, Recanati, 2003, 2010, 2012, Chierchia et al 2012, Wilson 2011, Carston 2012, 2013, Rayo 2013).

In this paper, we bring to this debate the challenge posed by conversational dialogue. As we have argued, reflecting the ongoing dynamics of conversational exchange is not a challenge that can be set aside. Taking it up, it would seem that words can in principle no longer be seen as part of a code projecting denotational contents directly: they should be defined as procedures which interact at every level with information provided in an evolving context to determine the particular contribution the word makes in that shifting context to the emergent structure. We thus probe the concept of *procedure* itself, asking what types of procedures words invoke in the construction of meanings in context; what licenses participants in a communicative act to construct meanings interactively using the procedures that words provide; and what machinery the grammar provides for the modification and update of such meanings.

2 Modelling incrementality and context-dependent interpretations

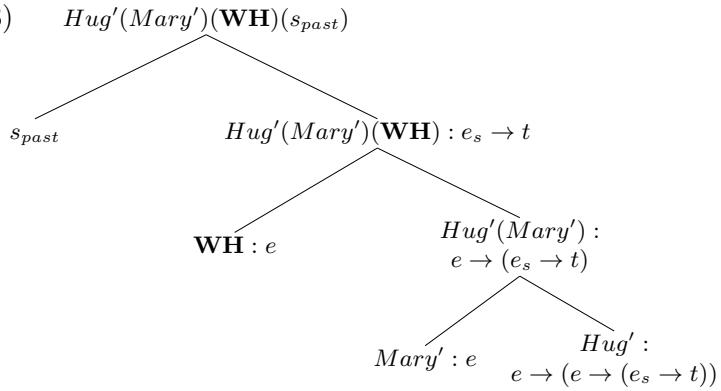
We next sketch out the framework from which the properties of conversational dialogue emerge as an immediate consequence, and in which procedures take centre stage. It is against this backdrop that we then probe what it is that words do. Dynamic Syntax (DS) models grammar as incremental growth of interpretation, with the concept of underspecification plus update being central to the grammatical process (Kempson et al 2001, Cann et al 2005). DS is a representationalist model of interpretation of which the core structural notion is *growth*, of contents or strings, relative to context. What has gone in this approach to language modelling is any concept of static, purely syntactic structure. What is retained is a DRT-like concept of building representations of content relative to context (Kamp and Reyle 1993). The formal devices are defined to model how to pair emergent interpretations with words being uttered in sequence or conversely matching content with the incremental utterance of strings of words. The system defines actions that give rise to expectations of further actions, all involving incremental updates towards some overall goal. On

[4]The heterogeneity of *meaning* in semantics can be seen in a number of papers in Riemer (2016), the introduction of which provides a strong critique of reductionist ideas in semantic theorising.

this view, the setting out of such dynamics constitute the grammar: syntax just is a set of principles for inducing growth of such structures. The syntactic mechanisms are procedures that define *how* parts of representations of content can be introduced and updated, all such growth being relative to context. Moreover, context is as structural and dynamic as the concept of content with which it is twinned, a record of the emergent structures that represent the unfolding of interpretational content plus the actions used to develop this incremental process (Purver et al. 2006). So the overall picture is a shifting one: shifting goals, shifting contents, and shifting contexts, as each established content becomes part of the context for the next step in the process.

These goal-driven sequences of actions are taken to involve building partial trees, with, as output, a tree whose nodes reflect the content of some utterance, as in (18) which represents the content of an utterance of *Who hugged Mary?* in binary tree form.[5]

(18)



The display in (18) indicates only the static output representation of the utterance. What is not shown is the way the process giving rise to this output is initiated and developed. It is thus the process of tree growth and not the structure of the output trees (mere reflections of functor-argument structure) that provides the explanatory core of the framework.[6]

The point of departure for the analysis of *Who hugged Mary?* is some partial tree whose only annotation gives a skeletal indication of the goal to be achieved, a propositional formula, otherwise unspecified, i.e. a single node with the single annotation a goal requirement to derive a formula of the specified type, represented as $?Ty(t)$:[7]

(19) $Tn(0), ?Ty(t), \Diamond$

What has to be built to meet this goal requirement is a formula matching this type, a result which is achieved on the basis of what the context already provides, what general strategies for progressive growth of structure are available, and information provided by the words used. In any complete tree, each node has a content formula, shown to the left of the colon ":" and a type specification to its right (e for entity, e_s for event, $e \rightarrow (e_s \rightarrow t)$ for predicates, etc.). The trees are binary, with, by convention, the functor node on the right, and the argument on the left. Individual terms are invariably of type e, presuming on an account of quantification, which we will sketch later. There is a particularised type e_s for event terms, only schematically represented here (Gregoromichelaki 2006, Cann 2011). The dynamics of growth is partly top down – as general strategies open up possibilities

[5]Such trees are taken to be structured mental representations of the propositional contents of utterances: representations in the Language of Thought (Fodor 1975, 2008). Such representations are open to fairly standard sorts of model-theoretic interpretation given some index of evaluation (Montague 1973, Cresswell 1985).

[6]For a fuller discussion of the framework see Kempson et al. (2001), Cann et al. (2005) and, for an article length review see Kempson et al. (2016) with commentaries on the latter due to appear in *Theoretical Linguistics*.

[7]The label $Tn(0)$ gives the address of the node in the unfolding tree, here address 0, the rootnode. $\Diamond$ is the pointer indicating the node currently under development.

– and partly bottom up – as actions induced by the words provide terminal annotations which provide the input to a bottom-up process yielding the effect of compositionality in the resultant tree.

To flesh out this concept of growth, we need first a vocabulary for defining trees, and then a vocabulary for defining how such trees can be seen to grow. The modal logic of trees of (Blackburn and Meyer-Viol 1994) provides the language of tree description, with two basic modalities. $\langle\downarrow\rangle$: '$\langle\downarrow\rangle\alpha$ holds at a node if α holds at its daughter (one node down)' for which there are variants $\langle\downarrow_0\rangle$ and $\langle\downarrow_1\rangle$ for argument and functor daughter relations respectively. And the inverse $\langle\uparrow\rangle\alpha$: '$\langle\uparrow\rangle\alpha$ holds at a mother node, one node up, if α holds at its mother', equally with argument and functor variants. There are also Kleene star operators which yield concepts of underspecified *dominate* and *be dominated by*: $\langle\downarrow_*\rangle Tn(n)$ holds at a node when a node $Tn(n)$ is somewhere below it (along an arbitrary sequence of daughter relations), $\langle\uparrow_*\rangle Tn(n)$ holds at a node when a node $Tn(n)$ is somewhere above it.[8]

There are three principal kinds of underspecification that require updates. First, there are partially specified trees as some nodes or formulae remain yet to be developed. Secondly, there may be underspecified content formulae which are assigned a type but as yet with only a place-holding metavariable as formula, itself needing update to some specified formula value. Of these, anaphoric devices are the familiar cases of content underspecification, encoded as projecting such a metavariable, possibly with constraints on substitutions for them: for example, $\mathbf{U}_{Female'} : e$ for *she/her* or $\mathbf{U}_{3Plural'} : e$ for *they/them*. Thirdly, the concept of underspecification is extended also to structural underspecification, in which it is a tree-relation that may be incompletely specified, so that a node introduced into a tree may lack a fixed site, hence referred to as an "unfixed node", defined by the Kleene* operator $\langle\uparrow_*\rangle$ and its variants. This is the mechanism which underpins long-distance dependencies and local scrambling.

Underspecification of any parameter (type, formula or position within a tree) is invariably twinned with an associated *requirement*, symbolised as $?X$, for some annotation X. So we have type requirements $?Ty(\alpha)$ to find a formula of some type α; $?\exists\mathbf{x}.Fo(\mathbf{x})$ for a requirement to find a contentful formula value for a metavariable (see below); and $?\exists\mathbf{x}.Tn(\mathbf{x})$ to find a fixed treenode address for an an unfixed node. Requirements may be modal as well as non-modal, with modal requirements imposing constraints on how a structure may be developed at a possibly later stage. For example $?\langle\uparrow_0\rangle Ty(e_s \rightarrow t)$ is a requirement expressing an output constraint imposed by nominative case-marking that a node so annotated be the highest individual argument of a predicate. Requirements are essential for reflecting the incrementality involved in progressively building of trees, providing goals to be achieved that may be satisfied immediately or not until substantially later in a derivation.

2.1 Actions for Incremental Growth

The concept of underspecification is itself a static notion, a property of a given tree configuration. To define the *process* of tree-growth, we adopt a language for formulating actions that determine the (monotonic) transitions between partial trees. There are four primitive actions: `make`(X) for constructing a new node; `go`(X) that moves the pointer to a node; and `put`(Y) that annotates a node with some information. There is also an `Abort` action, which terminates an action sequence. These primitive actions are used to define action-sequences ("macros") that perform a range of tasks during parsing and production.

Computational Actions constitute generally available strategies for tree-growth, either inducing

[8]Various types of locality can be defined over dominance relations, inducing different domains in which unfixed nodes can be fixed. See Cann et al (2005) for details.

the unfolding of an emergent tree on a top-down basis, or inducing bottom-up processes which, once appropriate terminal nodes are annotated, lead to the annotations for all non-terminal nodes. For example, as one of a very restricted number of initial steps in a derivation starting from a propositional requirement, $?Ty(t)$ as in (18), a computational rule licenses the construction of a node characterised solely as being unfixed within a given tree domain, as expressed by annotation $\langle\uparrow_*\rangle Tn(a)$ which indicates that "somewhere above me is the Treenode a'.[9] Rules are given as standard conditional statements of the form $\langle IF \ldots, THEN \ldots, ELSE \ldots\rangle$ statements. The example in (20) shows the actions and output tree that define the construction of such an unfixed node.[10]

(20)

Actions:			Output tree:
IF	$?Ty(t), Tn(a)$		$?Ty(t), Tn(0)$
THEN	IF	$\langle\downarrow\rangle\langle\downarrow_*\rangle\top$	⋮
	THEN	Abort	⋮
	ELSE	$\texttt{make}(\langle\downarrow_*\rangle); \texttt{go}(\langle\downarrow_*\rangle);$	⋮
		$\texttt{put}(\langle\uparrow_*\rangle Tn(a), ?Ty(e),)$	$?Ty(e),$
		$\texttt{put}(?\exists x Tn(x))$	$?\exists \mathbf{x}.Tn(\mathbf{x}),$
			$\langle\uparrow_*\rangle Tn(0)$
ELSE	Abort		♢

Words also invoke actions of the same sort: making and annotating nodes and moving the pointer around a tree. The simplest of such macros of actions is when nodes are merely annotated with formulae as in a parse of the name *Mary* as in the entry in (21):[11]

(21)

Mary		
	IF	$?Ty(e)$
	THEN	$\texttt{put}(Ty(e), Fo(Mary'))$
	ELSE	$\texttt{Abort}$

Verbs induce more structure than names, triggering conditional actions that induce all the nodes that define their predicate-argument structure, including an event argument where lexical aspect information may be added and tense is specified by finite verb forms. Languages vary as to what options for the argument node annotations they license. In English, verbs specify argument nodes as open type requirements of the appropriate sort ($?Ty(e)$ for individual term arguments, $?Ty(t)$ for propositional complements, etc.) which ensures that there has to be some further step of linguistic-input to satisfy the type requirement. Languages also vary in word order, with English finite main verbs unable to appear sentence initially and necessarily appearing after the subject and before a direct object (modulo discontinuous dependencies). These constraints are guaranteed by the set of actions in (22) where the second condition requires some structure to have already been built, while the first two actions ensure that this is identified as the logical subject (for non-passive forms). The remaining actions build an event argument which is annotated with lexical aspectual information and tense (for finite forms) and then construct the remaining predicate-argument structure, leaving the pointer on the open logical object node, thus ensuring that some object term be identified next. This complex of conditions and update actions are illustrated in the lexical specification of the verb *hugged* in (22):[12]

[9] The tree displays the unfixed node diagrammatically using a dashed line. Fixed tree relations are shown with a solid line. Note that such tree diagrams record only the effect of the rule, and not conditions on its application.

[10] There is a condition on this action that it can only take place if no other node from this point of departure already exists within this newly emergent tree. This is the second condition preceding the sequence of actions, aborting the action if there are already constructed nodes within this emergent tree.

[11] We discuss what these formulae mean below.

[12] These actions have been slightly simplified for expository reasons. See Cann (2011) for details and discussion.

(22) *hugged*

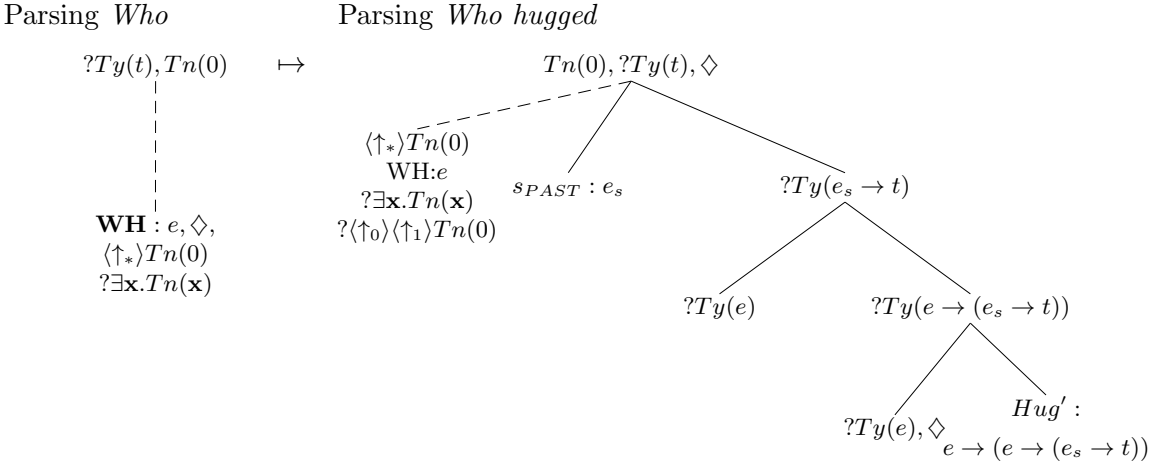
IF	$Tn(a), ?Ty(t)$	
THEN	IF	$\langle\downarrow_*\rangle\top$
	THEN	$\texttt{go}(\langle\downarrow_*\rangle); \texttt{put}(?\langle\uparrow_0\rangle\langle\uparrow_1\rangle Tn(0))$
		$\texttt{go}(\langle\uparrow^*\rangle Tn(a))$
		$\texttt{make}(\langle\downarrow_0\rangle) : \texttt{go}(\langle\downarrow_0\rangle);$
		$\texttt{put}(Ty(e_s), Fo(U_{PAST}), ?\exists x Fo(x)); \texttt{go}(\langle\uparrow_0\rangle)$
		$\texttt{make}(\langle\downarrow_1\rangle); \texttt{go}(\langle\downarrow_1\rangle); \texttt{put}(?Ty(e_s \rightarrow t));$
		$\texttt{make}(\langle\downarrow_0\rangle); go\langle\downarrow_0\rangle; \texttt{put}(?Ty(e)); \texttt{go}(\langle\uparrow_0\rangle);$
		$\texttt{make}(\langle\downarrow_1\rangle); \texttt{go}(\langle\downarrow_1\rangle); \texttt{put}(?Ty(e \rightarrow (e_s \rightarrow t)));$
		$\texttt{make}(\langle\downarrow_0\rangle); \texttt{go}(\langle\downarrow_0\rangle); \texttt{put}(?Ty(e)); \texttt{go}(\langle\uparrow_0\rangle)$
		$\texttt{make}(\langle\downarrow_1\rangle); \texttt{go}(\langle\downarrow_1\rangle);$
		$\texttt{put}(Fo(\text{Hug'}), Ty(e \rightarrow (e \rightarrow ((e_s \rightarrow t)))))$
		$\texttt{go}(\langle\uparrow_1\rangle); \texttt{make}(\langle\downarrow_0\rangle); \texttt{go}(\langle\downarrow_0\rangle);$
	ELSE	Abort
ELSE	Abort	

Relative to the prefixed condition, the subsequent sequence specifies step by step how to build the necessary tree structure, for each relation between nodes in such a structure, building that relation, going along it to the new node so constructed; annotating it, coming back to some more central point, and repeating this sequence of actions as many times as there are argument and functor nodes. The result is a skeletal propositional template associated with the predicate Hug', together with a partially specified event term (only sketched here), notably with only that predicate node having some content specification. As these lexical specifications indicate, words project very much more than just a representation of some concept, able to construct and modify a range of nodes in a tree (see section 3.1 for some discussion).

2.2 Combining actions in sequence

With this minimal sketch in place, we can see how structure is built up for (18). The first step listed is to induce an unfixed node from the underspecified tree in (19) by the actions specified in (20) yielding the tree specified there. This provides the context (an open term requirement) for the parse of *who* which annotates the node with a particularised metavariable, **WH** and a type specification. With the pointer returned to the topnode, the trigger for the processing of the verb *hugged* is satisfied, inducing the sequence of actions given in (22). These steps are shown in (23):

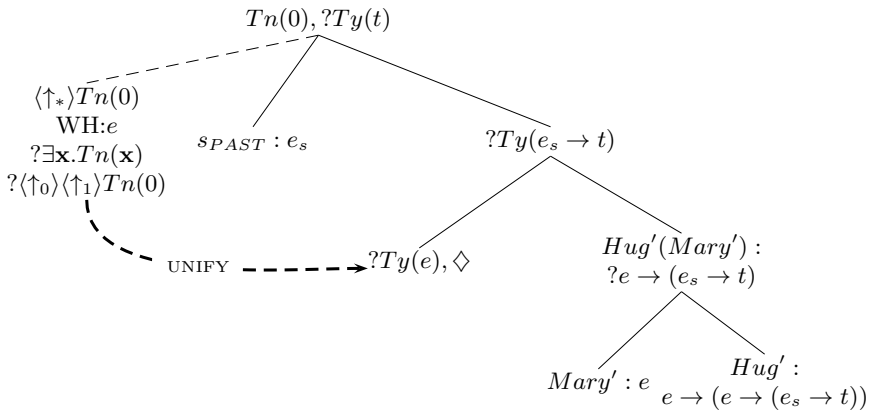
(23)



This update leaves the pointer at the logical object node, ensuring that the syntactic object, *Mary*, can be parsed next to annotate the relevant node with type and formula information as in

(21). One of the effects of the actions induced by the verb is that the unfixed node is required to be the logical subject and this is achieved by a process of unifying the unfixed node with the open term node to yield (24) satisfying all outstanding requirements on the unified nodes. From this interim result, a simple sequence of applications of the computational action of modalised function-application is all that is needed to successively satisfy all nonterminal node requirements up the functor spine of the tree, giving (18) above:

(24)



Of course, there is more to be said, in particular because these actions build relative to context, with both hearer and speaker following the same sort of activity. The only difference between the dynamics of parsing and production is that, in parsing, there is only the relatively weak goal of trying to build some propositional formula relative to the utterance and context, while, in production, there is some more particular goal to be achieved, some (possibly partial) tree representing something to be communicated. So every update associated with a putative word must be extendable towards that goal tree to allow that word to be produced. The only difference between being a speaker or a hearer is thus the checking of the relation in the former activity between the tree under construction and some entertained (partial) goal tree.[13] So from this perspective the shift from hearer to speaker and back again is seamless and unproblematic: both interlocutors entertain a partial tree representing the content of the utterance so far. To start generating an utterance all a hearer has to do is extend the current parse state to act as a new goal tree and then start speaking, again checking output parse with the goal tree (Gregoromichelaki et al 2013, Gregoromichelaki and Kempson 2015). And this may go on as long and as often as the interlocutors want to. There is, however, no need for a hearer/addressee to have to recognise what a speaker intends to communicate. Parsing is a predictive activity[14]; and a current goal in the parse tree may be extended by a hearer that yields the retrieval of conceptual information that is, for whatever reason, relevant to the *hearer* in the current context which may then lead to them adopting the extended parse tree as a goal tree and begin to speak. What is then uttered might match what the original speaker was intending to say, or might not. All that is required for communicative activity to take place is for speaker and hearer to use the mechanisms for incrementally building representations of contents or strings provided by the grammar. A *communicative act* is thus envisaged as the interactive construction of meanings, shown in DS as possibly partial proof trees, acting as structured mental representations. The *informational content* of utterances in some discourse is thus a set of complete trees (ones without any outstanding requirements) compiled to yield well-formed formulae as outputs. Of course, if a previous hearer now taking over as speaker utters something completely

[13] The hearer may well also have some extended tree in mind as an anticipated or possible development of the tree already constructed through parsing an utterance, by updating unsatisfied goals that are active in the parsing process.

[14] Predictive behaviour is argued to be an essential part of human consciousness in Clark (2016).

random, then communication may fail, but principles of communicative activity will generally ensure that speakers and hearers engage in activities that lead to a successful exchange – without there being any rational choice on either's part to do so. All structure is built by progressive emergent pairing of words and representation of interpretation, with each such induced partial structure becoming part of one's own context for establishing the next update. In consequence, the model is entirely flexible with respect to our intentions to interact with each other and how big a role such intentions might play.[15]

3 Extending content

3.1 Building names

A striking illustration of such dynamic construction-devices are quantifiers. The conventional way of expressing natural language quantification has been to seek to match the predicate-logic template in which quantifiers are propositional operators. Accordingly, quantified noun phrases are either said to be subject to covert movement to some adjunction site of the requisite sentential node from which some appropriate scopal relation can be defined (May 1985 and many others following), or they are defined to be subject to storage, from which they can then be extricated at a level at which some appropriate scopal relation is definable (so-called "quantifying in": Montague 1973, Cooper 1983, and many others following). But this, we suggest, doesn't do justice to the name-like properties of quantifying expressions, occurring as they do in the overwhelming majority of human languages in exactly the same range of positions as all other noun phrases; and it is notable that in proof systems for predicate logic, these quantifying propositional operators are substituted by "arbitrary names" that stand for some random witnesses that satisfy the property associated with some quantified expression which allows the temporary elimination of the quantifier throughout the core of the proof, operators themselves having no role to play within that core, until the closing stages of the proof (Lemmon 1965). Reflecting this, in DS, quantifiers are taken to initiate a process through which, within some propositional domain, arbitrary names are constructed. It is only later, once the overall proposition has been compiled, that they are subject to an evaluation step applying to the overall proposition, picking out an arbitrary "witness" for each such name. With the epsilon calculus as a basis for seeking to express the tension between local combinatorial processes for the term under construction and the global nature of its resulting semantics, a process is defined whereby such names grow throughout the derivation, making the process of name construction ineliminably dynamic – a progressive mapping from the first initial step of its construction process as encoded in the quantifying determiner to some final evaluation of the resulting name once the full propositional structure is set out.

The semantic grounding that will need to be matched in the evaluation of such names, is given by the equivalence of predicate logic and the epsilon calculus, the latter being a conservative, but more expressive extension of the former[16] in which a propositional formula containing just one

[15] In this paper, we have concentrated on English. However, Dynamic Syntax has been successfully brought to bear on a range of languages including German, Spanish, Greek, Swahili, Rangi, Korean, Japanese and Chinese. Within these languages and in English a large range of recalcitrant linguistic phenomena (both synchronic and diachronic) have been analysed, including: pronominal clitics in Spanish and Greek; subject agreement in Swahili; cleft constructions in Romance, Swahili and Chinese; the auxiliary system in English; word order in German; Right Node Raising in English; scrambling in Korean and Japanese; and much more (see Cann et al. 2005 for coverage of some of these points).

[16] For these purposes we ignore issues of plurality, taking these to be an extension of the basic case, and we assume along with Steedman 2012 that so-called quantifying determiners such as *most* are in fact adjectives. Despite full cognisance of how this step may turn out to be over-cavalier, we nevertheless focus on setting the dynamics of the

existential quantifier and some predicate on the variable it binds is by definition equivalent to the epsilon-calculus formula containing an arbitrary name predicated on that same predicate (Hilbert and Bernays 1939):[17]

(25) $P(\epsilon_x, P(x)) \equiv \exists x.P(x)$

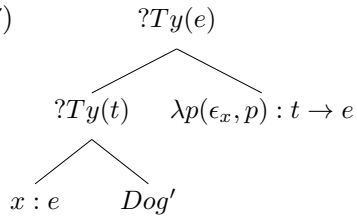
Note the crucial replication of the predicate as the restrictor for the variable which that name-operator binds. It is this equivalence which has to be reflected in the ultimate evaluation of the emergent name to reflect its evolving context.

We now turn to the process whereby such names are progressively constructed in which this equivalence will constitute the final step. Suppose we are constructing some representation of (26):

(26) A dog barked.

In processing *a dog* the determiner induces the skeletal template of an epsilon binding operator and the requirement for an attendant predicate, which the nominal then provides.

(27)



The compiled output of the construction process local to the processing of the determiner-nominal sequence is $(\epsilon_x, Dog'(x))$. The propositional formula defined over the containing tree is shown in (28), alongside which will be a statement of any scope restrictions collected along the way, here the only possible dependency being that of the individual term on the event term:

(28) $Bark'(\epsilon_x, Dog'(x))(s_{past}) \quad [x < s]$

However, the formula $(\epsilon_x, Dog'(x))$ is a "name" referring to some arbitrary witness for the set of dogs: as such this witness may or may not be barking. To ensure the existential force of (26) we need a second step in a name-extension process to reflect the equivalence in (25). The formula (28) is then subject to an evaluation algorithm making explicit its witness property expressing the essentially conjunctive nature of the existential proposition, by definition preserving the guiding equivalence of (25):

(29) a. $Bark'(\mathbf{a})(s_{past}) \wedge Dog'(\mathbf{a})$

b. $\mathbf{a} = (\epsilon_x, Bark'(x)(s_{past}) \wedge Dog'(x))$

The result is that the terms which are derived as a result of this evaluation step contain all information needed to identify a suitable witness, i.e. a dog who barked prior to the time of utterance.[18]

The significance of this result is far from trivial. Each evaluated term provides an ad hoc name for an object, possibly unique in its context of utterance, thus demonstrating how the ongoing

construction process in order to ensure that we have in place a first attempt at expressing the recursive richness of natural-language quantification, leaving the challenge of matching the mereological subtleties of plurality to be developments of the base case.

[17]The semantics of these simple epsilon terms requires the selection of some element in the set that P denotes if it is not empty, or some random other element if nothing satisfies the predicate: hence, the equivalence.

[18]So essentially yielding 'A witness for a dog who barked prior to the time of utterance barked prior to the time of utterance'.

dynamic construction of terms is a core part of the interpretation process, and not some peripheral add-on solely for particular expressive effects. So we have terms that are incrementally built up with all the information needed in the current speech situation to identify a witness for that term. There is in these instances no extension of the propositional structure, just an extension of particular formulae that can be updated as the text/utterance continues; so it is the actions and ongoing revision of the constructed content which lie ineliminably at the core of the account.

3.2 Extending structures

There is another means of extending formulae, this time through extensions to the structures determining predicate-argument arrays. Basic sentences may be extended using adverbs, prepositional phrases, appositive noun phrases, relative clauses, temporal clauses and so on (4). And as discussed above such adjunct extensions may be jointly constructed in dialogue, apparently indefinitely, as in (30).

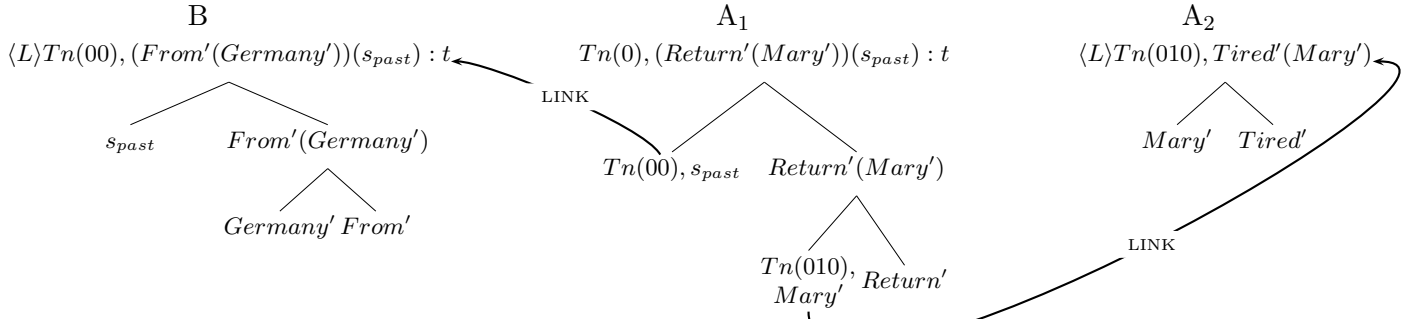
(30) A_1: Mary's just returned.
B: From Germany?
A_2: Very tired.

To analyse such exchanges (and for all kinds of modification), DS postulates a mechanism for constructing independent structures in tandem that are nevertheless connected through the sharing of some term. These structures are adjunct to the main propositional core, being type independent and potentially associated with any node in a tree. The classic use of these so-called LINK structures is in analysing relative clauses (Kempson et al. 2001), but they have also been used to model hanging topic and afterthought constructions, as well as apposition and nominal and adverbial modification (Cann et al. 2005). The LINK modality may be used to model *any* extension of nodes of any type, providing a means of encoding additional information provided by adjuncts without the need to postulate fixed 'positions' for such things in the unfolding propositional structure. All that is important is that LINKed structures attach to nodes of the appropriate type with a term shared between both structures.

Consider the analysis of (30). The basic proposition provided by the initial utterance (A_1) is extended twice, the first providing the source of Mary's journey (B) and the second a property of Mary (A_2). Both of these extensions can be analysed using the LINK mechanism projecting open propositional nodes from the event term in the first instance and the logical subject in the second as illustrated in (31)[19] which compiles to give the output formula:

$$(Return'(Mary'))(s_{past}) \wedge (From'(Germany'))(s_{past}) \wedge Tired'(Mary')$$

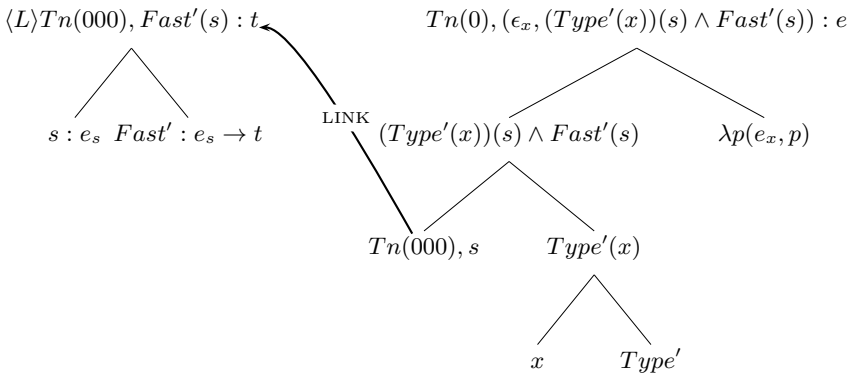
(31)



[19]Note that in (31), treenode addresses start from the rootnode as 0, adding to the right of this 1 for a functor daughter and 0 for an argument as you go down the tree. In this and all subsequent trees, irrelevant details are omitted. The first line of the display in (31) indicates which speaker and which utterance in (30).

It is important to note here that these loosely connected structures are *not* structures defining hierarchical and linear dependencies between words, but structures defining the content of strings of words. As such, while the construction of LINKed trees may be licensed by linguistic input, they need not be. They may, therefore, be used to model steps of inference (of whatever sort, deductive, inductive, associative, abductive, etc.) that may be required to achieve a well-formed output formula. As an example, take a simple case of polysemy, that of the word *fast* in English. Arguably fast things involve actions so we may take the content of the word to be a predicate of events of type $e_s \rightarrow t$. As a modifier for a word like *typist* parsing the adjective is straightforward under the (very plausible) assumption that the semantic structure induced by the noun contains an event term since a typist is someone who engages in activities of typing. The output tree of parsing the noun phrase *a fast typist* is that in (32) where the adjective licenses a propositional structure LINKed to the event term and sharing its structure:

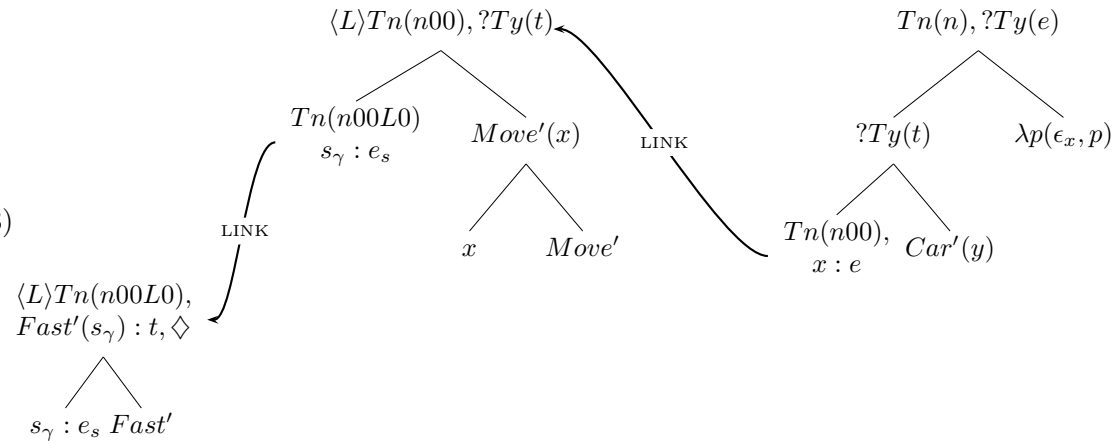
(32)



When appearing as a modifier of a noun like *car*, however, there is no reason to assume that the noun directly gives an event term and so there is no node of the right type in the tree for the adjective to modify. To incorporate the modifier there needs to be a step of associative (non-logical) inference over *car* to provide an appropriate event term. Since cars are things that move, that information can be added to the unfolding tree via the LINK mechanism to yield a structure that does contain an event term. In (33), encyclopedic knowledge that cars move licenses a LINK from the bound variable node to a propositional structure that specifies a property of that variable that it engages in generic or potential acts of moving symbolised as the event term s_γ. The event predicate $Fast'$ then links to that event term which compiles as: $(\epsilon_x, Car'(x) \wedge (Move'(x))(s_\gamma) \wedge Fast'(s_\gamma))$, a witness for a car which engages in generic or potential activities of moving fast:[20]

[20]There are technical issues in providing a fully incremental account of how this structure is derived which we leave aside here, pending further research on adjectival modification.

(33)



Notice here that, unlike decompositional or generative theories of lexical meaning (Pustejovsky 1995, Jackendoff 2002) the derived information that cars move is not encoded as part of the lexical meaning of the word *car*. Instead, we assume it derives from encyclopedic knowledge on the part of speakers and hearers about what cars do, however such information is modelled theoretically. Thus, adjectives like *fast* can be seen as expressing some underspecified core content 'having the potential for moving at a certain velocity byond an expected norm' where the standard of velocity and exactly what is that moves is derived from context, linguistic or encyclopedic.

4 So what do words do for us?

We have so far sketched how the DS grammar works including processes of term extension which give us the means of naming specific concepts on particular occasions of utterance and extensions to concepts either through linguistic input or various inferential processes driven by the need to satisfy type requirements. We now look back at this sketch to bring out the different things words do in the process of constructing meanings incrementally in context.

4.1 Words and actions

We have seen that words provide procedures of various sorts that update partial trees representing the content of an utterance up to the current time. As such, they form a core part of the dynamic system that is the grammar, inducing operations of the sort that general computational rules also provide. They do not simply determine static bundles of features or merely concepts or denotations.

In the brief sketch of DS just given, words are shown to carry out a range of different actions. Some words project an array of nodes: verbs project a predicate formula and a complete predicate-argument template, including an event node which they may annotate with information about situation aspect and tense if finite; quantifiers project a subtree with nodes for logical quantifier, a bound variable and a propositional requirement for an attendant restrictor; and relational nouns, some adjectives and prepositions also build and annotate structures. Very few words simply annotate nodes with formula and type specifications.

Other words initiate quasi-independent (LINK) structures. This is typically the function of clausal connectives like *and, or* which LINK together two trees with the same type, while *but* only LINKs two propositional trees, as do discourse connectives like *so, moreover, therefore* etc. Complementisers often project LINK structures from (aspects of) the event/situation term: temporal items like *when, while, after* etc. project nodes from the internal, temporal nodes within the overall event term (see Cann 2011 for how such terms may be structured) while conditional, and possibly concessive and causal complementisers induce structure from the largest event term (Gregoromichelaki

2006). The building of LINK structures, typically to propositional trees, is also a feature of adverbials and prepositional phrases with different traditional sorts associated with different types of expression: manner from predicate nodes; time from event terms; subject-oriented adverbs from the term associated with the syntactic subject; speaker oriented modifiers from the root propositional node and so on. As noted above, attributive adjectives, appositive expressions and other nominal adjuncts can all be analysed similarly, differences are only expressed in terms of the type of LINKed trees and the nodes from which they are projected.

Yet other words project constraints on content; and these notably allow identification either from already existing context or from the evolving utterance. Pronouns, for example, project place-holding metavariables whose value has to be provided from the current linguistic context (*John coughed. He had been smoking.*); from the non-linguistic context (seeing John smoking and uttering *He's taken up smoking again, I see*); or cataphorically from the evolving context following a licensed delay in its construal, as with expletives (*It's obvious that I'm right*) or in certain types of initial subordinate clause (*When she sees Mark, Sue always hides*), in which what occurs later in the string can come to be the immediate context at the point at which the delayed decision on content can no longer be left outstanding (see Cann et al 2005 for details). In English, auxiliary verbs are also taken to provide underspecified content, here of predicate type, which can be resolved by context as in VP ellipsis or with further linguistic input (see Kempson et al 2015 for details).

4.2 Words and concepts

Words, therefore, provide actions for constructing representations of content that can affect a number of different parts of a tree, so doing far more than just annotating a single node with phonological, syntactic and semantic information. Of course, words must do more than just build nodes: they must also provide conceptual content. As noted in the introduction, exactly how this is achieved is a matter of considerable debate. In this paper, we adopt a view of word meaning that is gathering support from linguists and philosophers alike: words do not directly encode specific concepts or denotations. Such things are somehow derived from the words uttered in context but are not fully specified by them.

The idea that content words give schematic rather than determinate meanings has been around in Relevance Theory for many years (Sperber and Wilson 1986/1995, Carston 2002, Wilson and Carston 2007) but nevertheless with an assumption that all such words encode some central concept, whether underspecified or not (Breheny 1999). Recently, Wilson (2011) has argued that all words encode procedures for concept construction but still maintaining that content words directly encode some particular concept, a suggestion that is criticised in Carston (2012) who argues that having both encoded concepts and procedures for constructing concepts is theoretically weak. She points out that Wilson's postulated procedure associated with content words (which can be roughly paraphrased as 'go and construct an ad hoc concept') is required in any case by the overarching theory, guaranteed by the need to achieve relevance. But what then do words directly encode?

Our answer to this is that lexical encoding of words *only* involves a specified type or set of types, tree-building operations and annotation of nodes. The apparent 'content' expressed by words is not some specific and determinable concept nor is it necessarily a set of determinate procedures for constructing such concepts. Instead, words merely 'point to' a memory cluster or address that stores a speaker's knowledge of the word (Recanati 2012, Sperber and Wilson 1998, Carston 2012, 2013). This cluster contains successful uses of a word encountered in the past as speaker or hearer (cf. the notion of usage set in Larsson 2007), a 'grab bag' of memories, images, encyclopedic information, connections between words, connections between related concepts (Rayo 2013), and of course the concepts that have been associated previously with uses of the word by an individual.

A conversational participant's task is then to select a word or construct a relevant meaning by selecting from the store of information associated with their own experience of the use of the word and using the procedures and mechanisms as made available by the *grammar*. Words thus do not necessarily encode idiosyncratic procedures for concept construction, these are determined as part of the linguistic process in general. Any 'ad hoc' concept thereby constructed provides a relevant update of the unfolding propositional meaning so far constructed, which may be modified any number of times as the discourse continues. So words don't have meanings independent of contexts: they merely serve to direct a hearer's attention to information associated with their previous uses, with the task of constructing some more determinable and relevant content for the utterance so far.

It follows from this that 'ad hoc concepts' cannot be solely associated with individual words. Such concepts must be derived from the cluster of information associated with a word in association with the other clusters of information associated with the other words it collocates with or with aspects of the extralinguistic context. Recall how quantifiers merely initiate a process which allows the quantifying terms themselves to receive a full representation of their content only once a tree is complete and compiled to yield an output propositional formula. When we talk of ad hoc concepts we iindicate what it is that phrases express or what words in interaction with context express. So word meanings are derived from the interaction of the information to which a word points and the context in which that word is uttered and thus ad hoc concepts are not associated with individual words but the relation of words to linguistic and extra linguistic context. An ad hoc concept, therefore, is what is expressed by an utterance (or inscription) of one or more words.

This is not to deny that words may come to be more strongly associated with some concepts rather than others. Frequent association of word use and concept retrieved is likely to lead to the routinisation of such associations, leading to situations which induces the effect that speaker/hearers may believe words to have stable meanings out of context. This effect can be easily and demonstrably undermined by presenting words in different contexts, leading to a potential failure to supply a meaning common to all uses of a word (as with the discussion of 'game' in Wittgenstein 1953). In general, routinisation of concept retrieval we suggest will be through association with collocated words, rather than being encoded by the word itself. Hence, the word *open* associated with the frequently collocated *door* can lead to the immediate retrieval of an appropriate concept which we might represent as $Open^{Door*}$ (using an extension of the asterisk notation for ad hoc concepts used by Wilson and Carston (2006, 2007) among many others), whilst with *book* a different concept $Open^{Book*}$ is more easily retrieved, and such concepts may be generalised to other door-like or book-like things as associations develop.[21] While a word may become more readily associated with specific concepts in context, this does not mean that such concepts form part of the linguistically encoded meaning of that word. Such information is *not* strictly grammatical, in the sense of being encoded specifically with respect to grammatical mechanisms, but is nevertheless accessible to it through things like the LINK modality. The information forms part of an individual's general knowledge, potentially therefore varying from speaker to speaker. As noted above, all that a word linguistically expresses are actions for meaning construction involving tree building and annotating operations and a type specification (or set of types), the latter determining not just (semantic) combinatorial possibilities but also constraints on the sort of concept that the word can express.

[21] Such a view is implied in the use of distributional models to account for meaning associations in various forms of Vector Space Semantics. For some discussion see Turney and Pantel (2010).

4.3 Constructing concepts

To see how such a process might work out in practice, we set out in greater depth one means of formally reconstructing the general dynamic of what words and general grammatical meachanisms do in tandem to constrain the meaning speakers may assign to an utterance, while nonetheless reflecting the inherent flexibility in the mechanisms provided by the words. As might be expected given the brief discussion of the construction of the import of the phrase *a fast car*, it is the LINK mechanism that provides the means to formally encode the extensions necessary to derive the concepts words give rise to in contexts of use.

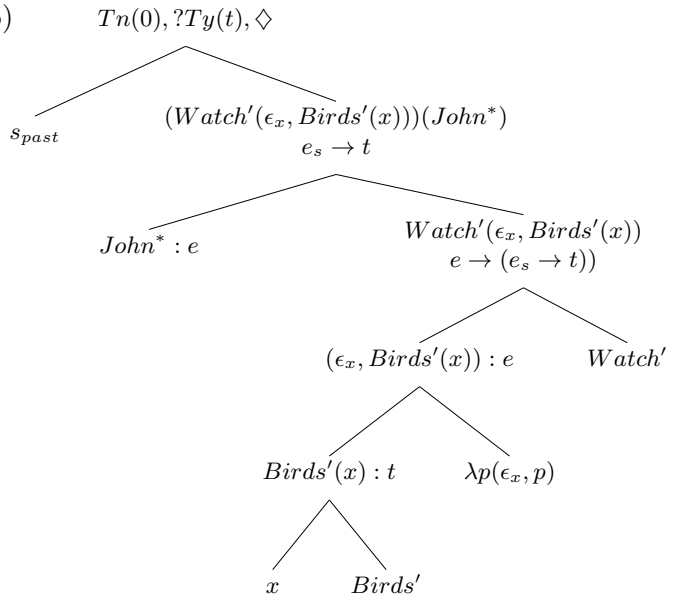
The parse of a word, as we have seen, induces some update of a, possibly partial, tree representing the interpretation of an utterance so far constructed. If contentive, it will also provide a pointer to information associated with the use of the word which we represent using the standard prime convention of formal semantics as displayed on the trees earlier in the paper, i.e. initial parse of the word *cat* yields the pointer $Fo(Cat')$. At any point in the derivation, including the point of parsing a word, a concept may be derived from the the information associated with it and a node may then be annotated with a representation particular to that concept. Any such concept may be further modified later in the discourse, represented by iterating the asterisk or other diacritics indicating the concept constructed (e.g. $Fo(Cat^*)$).

We take as our example the utterance in (34):

(34) John watched birds at Vane Farm with his grandson.

The first three words may be taken to give us the propositional core in (35). Here we assume that the parse of the proper name *John* gives the concept associated with a known individual, $Fo(John^*)$,[22] while the other two words yield just pointers to clusters of information:

(35)



The rest of the utterance in (34) helps to construct the concepts associated with *watch birds* using *selective* extension of structures involving information associated with the words and pragmatic expectations. Implicatures, explicatures, broadenings and narrowings are all induced as adjunct information involving additional premises and derived implications as LINKed structures. Ultimately

[22] Obviously, this is a simplification that raises all sorts of issues concerning the treatment of proper names which it is impossible for us to discuss here.

such extended structures yield extended terms representing ad hoc concepts, as expressed by the utterance overall.

Instead of showing the build up of representational structure diagrammatically (which soon gets cluttered and unreadable), we elect to go through the development of (35) as a fully interpretable structure step by step as LINK structures are introduced by linguistic input or through inference. In the steps shown below, semantic information is given showing what the output would be if the tree were fully compiled.

The linguistically given PP *at Vane Farm* provides a propositional LINK to the event variable giving its location at a named place, the update presenting the conjunction of this information with the main proposition being shown in bold:

LINK 1 $((Watch'(\epsilon_x, Birds'(x)))(John^*))(s_{past}) \wedge (\mathbf{At'}(\mathbf{Vane\text{-}Farm}^*))(\mathbf{s_{past}})$.

World knowledge associated with the name *Vane Farm* that it is a bird-watching site by Loch Leven in Kinrossshire in Scotland can induce two LINK structures: one providing modification to the predicate node annotated with $Watch'(\epsilon_x, Birds'(x))$ that the specific activity of bird-watching is involved leading to an update of the pointer $Watch'$ to a more specific concept $Watch^{Bird*}$ (LINK 2). At the same time, the locative predicate At' can be updated to provide an ad hoc concept that being at Vane Farm and bird-watching involves sitting in a hide and using binoculars (represented as At^{Hide*}). The knowledge that Vane Farm is by a loch may introduce the information that the birds are waders, again updating the pointer to a concept (LINK 3). Both updates are again shown as boldface conjuncts: the first to the predicate[23] and the second to the nominal restrictor:

LINK 2 $(((Watch^*(\epsilon_x, Birds'(x)) \wedge \mathbf{Watch^{Bird*}}))(John^*))(s_{past}) \wedge At^{Hide*}(Vane\text{-}Farm^*)(s_{past})$.

LINK 3 $(((Watch^*(\epsilon_x, Birds^*(x) \wedge \mathbf{Wader}^*(\mathbf{x})) \wedge Watch^{Bird*}))(John^*))(s_{past}) \wedge$
$At^{Hide*}(Vane\text{-}Farm^*)(s_{past})$

Linguistic input from the comitative PP, which we presume LINKs to the subject node, provides the information that the bird-watchers were John and his grandson (LINK4), with the grandson yielding a concept identifying the individual provided he is known to the speaker:

LINK 4 $(((Watch^*(\epsilon_x, Birds^*(x) \wedge Wader^*(x)) \wedge Watch^{Bird*}))$
$(John^* \wedge (\iota_{\mathbf{y}}, (\mathbf{Grandson}^*(\mathbf{John}^*))(\mathbf{y})))(s_{past}) \wedge At^{Hide*}(Vane\text{-}Farm^*)(s_{past})$

World knowledge that John's grandson is two years old induces further conceptual update. Firstly, the information that John's grandson is two years old updates the relevant term (LINK 5). Secondly, the main predicate is updated via the encyclopedic knowledge that two year old children have short attention spans and prefer playing to activities involving adult acts of bird-watching which is represented by information that playing with the two-year-old was involved being LINKed to the already LINKed predicate annotated by $Watch^{Bird*}$ (LINK 6):

LINK 5 $(((Watch^{**}(\epsilon_x, Birds^*(x) \wedge Wader^*(x)) \wedge Watch^{Bird**}))(John^* \wedge$
$(\iota_y, (Grandson^*(John^*))(y) \wedge \mathbf{Two\text{-}Year\text{-}Old}^*(\mathbf{y})))(s_{past}) \wedge At^{Hide*}(Vane\text{-}Farm^*)(s_{past})$

LINK 6 $(((Watch^{**}(\epsilon_x, Birds^*(x) \wedge Wader^*(x)) \wedge Watch^{Bird**}) \wedge \mathbf{Play^{2\text{-}year*}})(John^* \wedge$
$(\iota_y, (Grandson^*(John^*))(y) \wedge (y)))(s_{past}) \wedge At^{Hide*}(Vane\text{-}Farm^*)(s_{past})$

[23] Note that as stated earlier the LINK modality is not restricted to propositional nodes and so here we have two nodes of type $e \rightarrow (e_s \rightarrow t)$ LINKed together. The interpretation of this relation is one of generalized conjunction (Gazdar 1980, Keenan and Faltz 1985), yielding the result in LINK 2. Of course, by the usual deductive inference over distributive predicates we can derive the information that John watched (some) birds and was bird-watching.

We end up with the derivation of a *single* event expressing a composite ad hoc concept conveying the event of John and his grandson watching birds, bird-watching, and playing which could be represented as the following to bring out the import of the ad hoc concepts being formed from an utterance of (34):

(36) $((Watch^{Bird^{Play}*}(\epsilon_x, Bird^{Wader*}))(John^* \wedge (\iota_y, Grandson^{Two\text{-}Year\text{-}Old*}(John^*)(y) \wedge)))(s_{past}) \wedge At^{Hide*}(Vane\text{-}Farm^*)(s_{past})$

Furthermore, because of the process of term construal sketched in 3.1 we end up with ad hoc names for all the terms in (36) which pick out witnesses for these constructed concepts: for an event of playing at bird-watching at Vane Farm by John and his two year old grandson involving sitting in a hide and watching wader birds with binoculars and a two year old grandson who engaged in that event (as an agent).

Note that in this derivation the propositions associated with world and encyclopedic knowledge are not expressed on the tree as, we assume, these are not part of the concept expressed by the utterance, so not asserted and not contributing to 'what is said', but are merely the means by which explicated concepts can be added to derive the output.

Furthermore, it is also important to note that the building of these composite concepts may not be completely shared by the interlocutors as the hearer's construction of the interpretation of the utterance depends on his knowledge of real world objects, specifically Vane Farm and John's grandson. What is shared is the set of mechanisms the grammar and general pragmatic principles license for building concepts; and, of course, the output concept can be negotiated as part of a dialogue:

(37) A: Yesterday John watched birds
B: With his grandson?
A: Yes, he loved it. They both did.

B's constructed concept of bird watching with John's grandson may differ from that of the concept B entertains, depending on information that is salient or relevant to each. Nevertheless, there is no breakdown in the communicative act.

This potential for mismatch is general. All content construction is relative to one's own context: the problem is only expressible in a process-oriented perspective. And all derivation of concepts operates similarly, including metaphor and other more extended meanings. The difference between metaphor and other uses of words is that metaphor leaves the hearer with an open adjunction problem with only hints for how to create an appropriate interpretable extension of the propositional core; and a metaphorical usage is explicitly offered with the licence that it will be successful insofar as the hearer can construct a concept that is relevant solely to their own background assumptions:

(38) A: How are you?
B: Oh OK, I suppose. I shuffled through yesterday until Bill cheered me up by saying he liked my analysis.

None of the devices provided determine what fixed interpretation to construct, but nonetheless the information provided by the words means that the comprehension task is very far from an open unrestrained guess at interpretation even though the filter of establishing an interpretation the speaker could have intended is, on this view, no longer a pre-requisite.

5 Conclusions

So what does DS as a model have to offer the word-meaning debate? Through this swift tour of DS, with the dynamics of conversational dialogue as the background, we have seen how words

simply provide procedures for non-encapsulated incremental concept construction. The terms so constructed, as they combine with others, whatever their source, allow the possibility of being extended at all levels, both lexical and phrasal. So we can see and formulate how terms can evolve throughout a single structure-building process. Inevitably, in use, this is a private, mind-internal process. All processes are carried out relative to one's own context as this evolves online, severally for speaker and hearer operating in tandem, so there cannot be any cast-iron guarantee of identity shared between parties to a conversation. We never have access to other people's mind-states. Nonetheless, despite no requirement of agreement on *output*, the *process* is inexorably interactive; and it is that process that is manifest, not the resulting content. Although we have presented the interpretation procedure from the point of view of a single hearer parsing a string of words in context, this is simply one aspect of the richness of meaning construction in conversational dialogue where concepts are often co-constructed and developed through the essential interaction between interlocutors as modelled by the Dynamic Syntax view of parsing and generation being in lockstep. The fact that the grammar in this framework is not encapsulated means that any aspect of context may interact with the construction of representations of content, whether shared or not, whether due to other input as well as linguistic or not. The interaction of language, non-linguistic stimuli and the local environment of an exchange provides meanings for participants and yields external significance to the actual linguistic expressions used. The co-ordination of actions guaranteed by the mirroring of parsing and generation in the heads of interlocutors means that the problem of "mind reading" assumed in theories of communication such as Relevance Theory and the potential problems posed by the fact that experiential linguistic knowledge will differ from person to person is largely side-stepped.

Within this perspective, metaphor turns out to be part of the normal process of on-line concept construction, an invitation to the hearer to construct some output on the basis of words offered despite self-evident need of some extension and/or revision. There is nothing in this that violates the normal basis of communication: it is but a subtype of the process of composing contents online during the interpretation process, an interactive effect without indicating some specific content which could be agreed. The puzzle metaphor appeared to pose turns out to have been because of the assumption of fixed content adopted as point of departure. Abandoning that assumption, metaphor starts to seem much less of a problem, indeed wholly natural.

Finally, we offer an answer to the puzzle of why metaphor has existed as a tool in all languages, all cultures, and, so far as we know, at all times of its development. Given the rich emotional responses to what we confront in our lives, some of them aesthetic, some of them painful, some ecstatic, many of them well beyond what we can put into words – as one might say "leaving one speechless" – it would be extraordinary if our languages, rich and expressive as they are, had not evolved to allow some systematic way of making explicit that what one is expressing falls into such a category, indicating overtly to one's interlocutor that all one feels able to do is offer them a gift of words to interpret as they may. This, we suggest, is constitutive of metaphor itself, a means of indicating that nondeterminism is the essence of what the speaker is expressing. In more supposedly "normal" uses, the nondeterministic input given by words is used only as a tool with which, in combination with their immediate context, to build some particular conceptual structure from which to derive some further information. With metaphor, paradoxically, the intrinsically nondeterministic nature of the interpretation process is transparently displayed: in these cases, the nondeterminism manifestly shines forth. The ironic outcome of having appeared to fail to engage with issues of word meanings and their supposedly definitional properties is that by focussing instead on the dynamic formulation of what lies at the heart of a language, with underspecification and update at its core, we have arrived at a point at which we can see metaphor as a straightforward reflection of the intrinsic properties of language. And notably, in that outcome, we have achieved

a means of expressing nondeterminism of output within a model without in any way jeopardising the model itself.

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