Completability vs (In)completeness

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Abstract

In natural conversation, no notion of "complete sentence" is required for syntactic licensing. From the perspective of standard formalisms, fragmentary, incomplete, and abandoned utterances constitute the main problematic data of dialogue. We present data that shows: (a) non-sentential utterances are adequate to underpin people's coordination, while (b) all linguistic dependencies are systematically licensed as being resolvable across more than one turn. Most standard grammar formalisms have problems accounting for such data because their notions of 'constituency' and 'syntactic domain' are independent of performance considerations. Moreover, we argue that no notion of "full proposition" or encoded speech act is necessary for successful interaction. Strings, contents, and speech acts emerge incrementally in conversation without any participant having envisaged in advance the outcome of their own or their interlocutors' actions. However, morphosyntactic and semantic licensing mechanisms apply as usual to facilitate and direct the processing of non-sentential/non-propositional utterances. For example, in morphologically-rich languages, speech acts with subsentential/subpropositional elements require appropriate case morphemes and, in all languages, binding restrictions are observed according to current contextual parameters. This shows that grammatical licensing and semantic processing are performed incrementally subsententially online, at each step affording and constraining possibilities for further extension by interlocutors' actions or the situational context. We argue that a representational level of abstract syntax, divorced from conceptual structure and physical action, impedes a natural account of such phenomena. Instead, we argue that we need a view of natural language as a "skill" employing domain-general mechanisms rather than fixed form-meaning mappings. We provide a sketch of a predictive and incremental architecture (Dynamic Syntax) within which underspecification and time-relative update of meanings and utterances constitute the sole concept of "syntax".

1 Introduction

In this paper we take the view that natural language (NL) is first and foremost coordinative joint action. We take utterances as primarily causal physical events having effects (as stimuli) on human agents. As such, they can be characterised as *actions* realising goals distributed across agents and over extended time intervals, i.e., *incrementally* (Kempson et al., 2001). The distributed physical behaviours and cognitive actions that control NL-related behaviours we take to constitute the grammar. From this perspective, it is actions (modelled by *procedures*) that constitute grammar, perception, and cognition, rather than internal representations, symbols, or constructions (Gregoromichelaki and Kempson, 2018; Gregoromichelaki et al., to appear). NL stimuli also have historical provenances linking processing over longer stretches of time (Kempson et al., 2019) and these account for some of the current effects of such stimuli as constraints on the dynamics of an unfolding task towards some intended or unforeseen joint outcome (Gregoromichelaki et al., 2011).

For this reason, memory traces and dispositions are the individual mechanisms grounding NL use with the grammar emerging ad hoc in each interaction instance to provide for the tightly interwoven integration of NL stimuli within joint activities that require moment-by-moment coordination among interlocutors and the environment.

1.1 NL grammar as action coordination

Starting from this perspective, our dynamic approach to NL maintains that what is important for grammar modelling is the time-involving and interactive properties of an NL system while internal static formal structures like symbols, syntactic categories or 'constructions' are epiphenomenal abstractions over the flow of coordination dynamics (see also Hopper, 2011). As evidence, we take the fact that, given data from everyday joint activities, no representational notion of "complete sentence", or even 'syntactic constituent', is required for explaining NL use (Bergs, 2017; Gregoromichelaki et al., 2009, 2011; Kempson et al., 2017a, 2016, 2017b). In fact, we have argued that such notions impede natural characterisations of how NL elements contribute to the achievement of agent coordination (see, e.g. Gregoromichelaki, 2012). Despite claims to the contrary, it is clear that non-sentential utterances (NSUs) are adequate in context to underpin conversational interaction making complete and apposite contributions:

(1) (a) Eleni: You are not leaving, are you? (b) Frank: End of the month.

Moreover, empirical research shows that utterances of various lengths and types are learned and used throughout the lifespan, always embedded within interactional activities with the environment or other agents. Children learn to control their behaviour in order to interact long before they begin to use/perceive NL actions (Fotopoulou and Tsakiris, 2017), so that when various types of utterances are first used they complement existing mechanisms for interaction, e.g. turn-taking (Clark and Casillas, 2016; Hilbrink et al., 2015). These NL stimuli manipulated within interactions then acquire an open-ended variety of functions as procedures specifically and flexibly adapted to the achievement of coordination. In our view, this can be accomplished because NL procedures are not just means for exploiting the 'context' but, also, triggers for unfolding further socially enabled action opportunities (*affordances*) able to direct attention by highlighting precisely the significance of particular features of the context both for oneself and one's interlocutors.

1.2 Joint action and the meaning of NSUs

Jointly exploring the context in this way is achieved because NL affordances selectively activate social dispositions shaping an ad hoc grammar so that they are able to bias perception/action by evoking previous experiences with the current NL signal (i.e., they trigger 'connotational' rather than denotational/referential contents/simulations, (see, e.g. Kravchenko, 2007)). Public reemployment and recognition of a signal thus set out interpretive possibilities of selected aspects of the current experience (i.e., *conceptualisation*) so that various *joint-projects* (Clark, 1996) can be pursued. Such joint-projects (or *language-games* Eshghi and Lemon, 2014, 2017) can then be achieved by use of even minimal NL contributions (e.g., *huh?* in (2(b)) without the need to characterise these as "elliptical" and requiring syntactic/denotational expansion. Instead, by taking the perspective that NL use is subsumed under various forms of "procedural coordination" (Mills, 2011, 2013), the complementarity of the individual actions that enable distributed conceptualisations within language games can be fulfilled by NSUs since they are embedded within interactional routines (3(b)), structured by the temporal sequentiality afforded by turn-taking and the emerging joint agency that shapes the structure of the game:

(2) (a) A: How would'ja like to go to a movie later on tonight?

(b) B: Huh?=

(c) A: **A movie** y'know like **a like ... a flick?**

(d) B: Yeah I uh know what a movie is (.8) **It**'s just **that**=

(e) A: **you don't know me well enough?** [from Sacks (1992)]

(3) (a) A: I'm pretty sure that **the**:

(b) B: **programmed visits**?

(c) A: programmed visits, yes, I think they'll have been debt inspections. [BNC]

Given the methodology of modelling incrementality and joint agency via a distributed emergent grammar, any lexical action can be seen as potentially complete, having effects in its own right but, also, as a trigger for further processing by being perceived as embedded within a wider action context. Wellformedness and "grammaticality" is thus ratified moment-by-moment in context by the participants, rather than being absolutely predefined via some abstract generative mental device. In this way, the local adaptive dynamics of co-action impose an overall structuring in language-games of various scales under which role differentiation and joint responsibility (*action complementarity*) can be induced and sustained without explicit cognitive/public representations of what the agents seek to accomplish. For example, agents – just by taking advantage of incremental processing – can produce, or induce their interlocutor to provide the input required to complete their own actions, thus actualising ad hoc the performance of what have been described as conventional *adjacency pairs* or speech acts (Gregoromichelaki et al., 2013a):

(4) (a) Jane: u:m Professor Worth **said that**, if Miss Pink runs into difficulties, on Monday afternoon, with the standing subcommittee, over the item on Miss Panoff,

(b) Kate: **Miss Panoff?**

(c) Jane: yes, **that Professor Worth would be with Mr Miles all afternoon**, - so she only had to go round and collect him if she needed him [from Clark (1996): 240-241]

(5) (a) Angus: But Domenica Cyril is an intelligent and entirely well-behaved dog **who**

(b) Domenica: **happens** to smell [BBC radio 4 play, 44 Scotland Street][1]

As the grammar primarily underpins joint action, not individual processing, any type of syntactic/semantic dependency can be set up and resolved across more than one turn with the resolving element satisfying expectations generated by either interlocutor. By shifting the focus of NL analysis away from the denotational/referential function of NL strings to their procedural and dynamic potential, we observe that what have been characterised as purely syntactic dependencies can adequately operate as speech-act indicators, or, in our terms, *coordinative structure* across participants:

(6) (a) Jack: I just returned (b) Kathy: from . . . (c) Jack: Finland. [from Lerner (2004)]

(7) (a) Psychologist: And you left your husband because . . . (b) Client: we had nothing in common anymore

[1] Along with natural data, constructed data from literature, film scripts etc. are particularly relevant as they show that such constructions cannot be dismissed as "speech errors" or "performance accidents" that can be easily excluded from theoretical considerations.

1.3 Syntax as state transitions

However, shifting the view of syntax as constituted by a set of procedures complementary to all other actions in dialogue, instead of the encoding of independent static constraints, does not mean that we deny its significance. Even though complete sentences/clauses are not needed in dialogue processing, morphosyntactic/semantic constraints are implicated in the incremental continuity of discourse and the choice and licensing of NSUs. For example, in English and other languages, the obligatory binding of a reflexive pronoun can be distributed over turns uttered by distinct interlocutors shifting its form in accordance with contextual parameters that subsententially switch as they track the current speaker/addressee roles:

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

Moreover, in morphologically-rich languages, speech acts with NSUs, e.g. clarification in (9), require the presence of appropriate "agreement" morphemes, e.g. case, gender, indicating how the uttered "fragment" is to fit in the distributed conceptualisation of the context triggered by the utterance:

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

A to B:	tin karekla tis mamas?	/ #i karekla tis mamas?
	the-ACC chair-ACC of mum's?	/ #the-NOM chair-NOM of mum's?
	(Ise treli?)	(Are you crazy?)

From a dynamic perspective, such "morphosyntactic" constraints are not arbitrary and/or parasitic on some referential function of the phrases involved. Instead, these constraints themselves are a constitutive part of the set of situated affordances attributed by participants to the entity involved. Perceiving/inducing this set of affordances (which is the most basic notion of how an 'entity becomes differentiated in context, (Bickhard, 2009)) is achieved via the integration of stimuli in the environment with their NL characterisation (their afforded 'conceptualisation'). Hence use of particular morphosyntactic forms allows a range of particular functions to be associated with features of the entity within the action under way, while excluding others.

1.4 Joint achievement of meaning

Given the seamless contribution of NL actions to the set of available multimodal affordances, there is no need for NSUs to be semantically expanded to yield propositional contents either (contra Ginzburg, 2012). In fact, such expansion does not accord with empirical evidence of how coordination proceeds. In dialogue, participants are afforded the opportunity to negotiate subsententially the construal of the lexical and phrasal items involved (see, e.g., (5), (4a-c)) as they incrementally process the NL signal. Moreover, NL use is already meaningfully embedded in the dynamics of multimodal interaction, which means that utterances contribute qualitatively identical "contents" (i.e., selective expansion of action opportunities) to such multimodal backgrounds. Thus we argue that what is needed is a grammar of NL *performance* that models NL contributions as *affordances* for interaction (Gregoromichelaki, 2013, 2017; Gregoromichelaki and Kempson, 2018). As parts of sequences of other actions, such affordances do not need any sentential, constructional, or propositional grounding, in fact, such NL-based expansions, if encoded in the grammar, are bound to be inadequate given the infinite potential of NLs for innovation and creativity (Gregoromichelaki (2012)). Semantically, NL elements functioning as affordances rely on semantic/syntactic *potentials*

(Larsson, 2007; Norén and Linell, 2007) rather than encoded referential/representational contributions, in our terms, they are triggers for anticipations of further action based on dispositions built through previous experiences with the relevant NL structures.

Under this view of NL content, incrementality means that, first, during production, interlocutors do not need to plan whole propositional units before they start speaking; instead, they need to generate multiple local (probabilistically ranked) predictions of the following perceptual inputs (multimodal external/interoceptive signals or agent-internal cognitive operations), i.e., anticipate how the projected units (words, phrases, or non-verbal actions) will affect the context, which includes the interlocutors' reactions. Through a process of *affordance competition* (Cisek, 2007, but under a joint-agency interpretation), producers then select a minimal NL action that would ensue in the most rewarding outcome concerning the (joint) task (Cisek and Kalaska, 2010). This is why speakers can unproblematically intergrate gradual modifications of their utterance (e.g. repairs) induced by themselves (2(c)) or their interlocutor (4)-(5) and they can go on extending and elaborating their own utterance (4a) or the one offered by an interlocutor ((3(c)). Thus, the production process is very tightly incrementally coordinated with the interlocutors' responses as it includes a feedback loop that controls all participants' actions (Goodwin, 1981; Bavelas et al., 2000).

In the same way, during comprehension, efficient incremental procedural coordination imposes that addressees also continuously predict the upcoming stimuli and check whether their own and the interlocutors' actions as well as the actually perceived stimuli conform to those. Thus addressees incrementally generate and seek the satisfaction of local predictions ranked according to reward value, intervening in a timely manner where their anticipations are found in over-threshold error and some "surprising" input cannot be integrated as an unforeseen but adequately rewarding outcome. This local adjustment to task requirements via affordance competition avoids the need to impose the necessary calculation of whole propositional intentions or even implicate (an infinite regress of) mutually known facts. Experimental and empirical conversation analysis (CA) evidence shows that interlocutors do not engage in complex mindreading processes trying to figure out "speaker meaning", or need to calculate common ground (Engelhardt et al., 2006, a.o.). The reason for this is that each agent during an interaction does not act independently to realise a predefined action plan, in fact, often, no such plan exists or only emerges post hoc independently of the agents' explicit goals (hence the value of conversation, see also, Suchman (1987)).

Instead, from an incremental and dynamic perspective, shared understanding proceeds via a principle of 'progressivity' (Robinson, 2014; Zama and Robinson, 2016; Healey et al., 2018): given the tight coordination and potential for feedback at any point, interlocutors can allow interactions to progress as though shared understanding has been achieved unless misunderstanding is overtly raised as an issue. As a result, individuals assume complementary roles locally and opportunistically attempt to figure out and direct the conceptualisation of the task itself (Suchman, 1987). To coordinate their perspectives and skills they engage in orientation actions ("repair") employing the minimum of resources in order to direct the activity to their predicted reward-affording outcomes (see (4b), (3b)). But incremental processing also affords the advantage that interlocutors can abandon unfruitful courses of action midway (see (2c)), even within a single proposition, without presupposing that such productions will be taken as having remained unprocessed:

(10) A: **Bill**$_i$, who ..., sorry, Jill$_i$, **he**'s abroad, she said to let me finalise the purchase.

Even though useful as a descriptive characterisation of normative practices (Schegloff, 2007), from a dynamic modelling perspective, singling out a notion of "repair" for explicating the function of all such fragments is misleading since any behaviour in dialogue is already taken as aiming to control perception (feedback), with perception in turn providing motivation for further action. From a processing perspective, repair as a separate category of constructions (Clark, 1996) is an

artifact of assuming that the interlocutors aim for the establishment of shared common world "representations" employing speech acts that contribute propositional contents (Poesio and Rieser, 2010; Ginzburg, 2012) in the service of reasoning and planning. Instead, we can see the goal of feedback control, striving to repair 'prediction error' (Clark, 2017a,b), as a joint constant local aim and structuring factor of any (joint) activities. These local adaptive dynamics ensue in more global organisations with the appearance of a preplanned whole even though NL grammars do not necessarily manipulate overarching notions of "complete sentence", "full proposition" or clearly demarcated speech acts. Various speech acts, potentially implementing 'pushmepullyou' functions (i.e., not differentiated as 'referential'/'descriptive' vs 'directive', (Millikan, 1995)), can be accomplished while a single proposition is under way with strings, contents, and intentions emerging incrementally without any participant having envisaged in advance the global structure and outcome of the interaction (Gregoromichelaki et al., 2013b; Hopper, 2011):

(11) Hester Collyer: It's for me.
Mrs Elton the landlady: **And Mr. Page?**
Hester Collyer: **is not my husband**. But I would rather you continue to think of me as Mrs. Page. [from The Deep Blue Sea (film)]

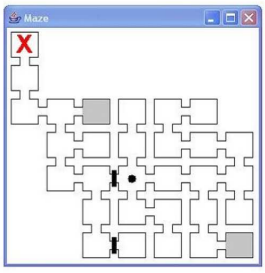
In these circumstances, the meanings and structure of such "fragments" are shaped during the interaction via procedural mechanisms, not based on encoded semantic meanings or stored form-meaning mappings ('constructions'). Such emergent meanings, being predicted affordances, are locally opportunistic, open-ended and flexible. In order to deliver those, the grammar associates NL signals with coordinative procedural instructions, rather than structural elements accruing referential functions. Both NL signals and their "contents" function as induced (first- and second-order) affordances biasing the choices of each co-actor during the 'affordance competition' stage of action selection (Cisek, 2007). For this reason, we argue that NL grammars need to model the *mechanisms* allowing such affordance creation/perception rather than positing stored stocks of symbols, concepts, categories, or word meanings as stable and a priori shared across individuals.

1.5 Interaction of individual and social cognition in the processing of NSUs

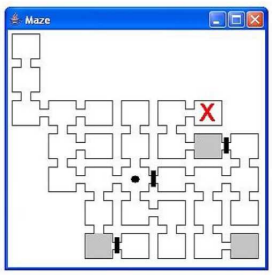
From the intra-individual psychological point of view, mechanisms of processing NL signals evoke selective aspects of previous experiences with those signals, while inter-individual feedback leads to the creation of temporary inter-individually distributed "grammars" and "conceptual structures". Thus, concepts, like words, are just triggers of further action-organising affordances inducing the prediction of further possible outcomes in the form of anticipated feedback from the interlocutor or the environment (Cisek and Kalaska, 2010). These second-order affordances are constructed (enacted) ad hoc each time but, with repeated use, come to establish reinforcing memory traces that result in easily recoverable cascading routines ('macros'). Therefore the conceptual mechanisms implementing the grammar can be seen as relatively entrenched, culturally-enabled abilities to track culturally or environmentally significant invariances (Millikan, 2005; Casasanto and Lupyan., 2015). Processing words and syntactic structures, like other stimuli, trigger these processes of conceptualisation, and participants in a dialogue need to coordinate on these procedures as well as their physical actions (e.g. turn-taking).

As Mills (2011, 2013) and Mills and Gregoromichelaki (2010) argue, interlocutors encountering a novel situation, interactively and incrementally organise their joint, complementary predictions to establish ad hoc routines for coordinating with each other. This is shown in experiments (e.g. Healey and Mills, 2006) where dyads playing "the maze game" (see (12)), develop group-specific procedural interdependence employing NL structures with the appearance of NSUs.

(12)



Participant A's maze



Participant B's maze

Such "fragment" uses emerge gradually over time so that over the course of a series of games, participants progressively increase their efficiency and, with the accumulation of expertise and shared interaction histories, the amount and size of NL signals decreases. Eventually, interlocutors develop *sequences* of physical actions and highly formulaic fragmentary utterances, which condense the complex meanings expressed linguistically in the initial stages (Mills and Gregoromichelaki, 2010):

(13)

Trial 1

8.	A:	describe your first switch
9.	B:	top left corner, the very top
...	...	...
14.	B:	wheres yours?
15.	B:	ok can u take the space 2 cubes below
16.	A:	the waht?
17.	B:	ok
18.	A:	im now stuck in the top lft corner, the gates shut
19.	B:	my switch is on the 3rd cube down from your sw, i mean on the 3rd cube down
...	...	...
38	B:	btw in in the 6 top cubes, *im
39.	A:	you see each individual square
40.	B:	yep
...	...	...

⇒

Trial 11

1.	A:	1,2 2,6 1,4
2.	A:	5,6
3.	B:	4,5 3,4 7,1
4.	B:	1,4
5.	A:	4,5
6.	B:	1,2
7.	A:	4,5

Moreover, participants in these games develop ad hoc linguistic signals with idiosyncratic meanings. Consider Dyad 8, Trial 6: A explicitly introduces "ATG", which is subsequently recast as "AYG", to abbreviate "at [your] goal", immediately using it subsequently as a question, asking 'are you at your goal?':

(14) Dyad 8. Trial 6

1.	A:	ATG -at your goal
2.	A:	ATG?
3.	B:	huh
4.	A:	AYG -at your goal
5.	B:	no im not i need u to open my gate
6.	B:	lol
7.	B:	ok u ATG

Four trials later (Dyad 8, Trial 10), the dyad has developed a much richer system, using "AMG" to abbreviate 'At my goal', "AYS" for 'At your switch', and "GC" for 'gates clear':

(15) Dyad 8. Trial 10

1.	A:	AMG lol
2.	B:	4,1 and 3,5
3.	A:	AYS
4.	B:	nope u sure
5.	B:	GC
6.	A:	AYS
7.	B:	AMG

As shown from the transcripts (Mills, 2013), the actual meaning of each such "fragment" encapsulates elaborate procedural information and instructions, disambiguated by the fragment's time-linear location within the dialogue, in our terms, the predictions it is produced to satisfy at these particular points and the affordances it is meant to induce. These ad hoc expressions thus constitute control strategies over the state of the game by exploiting and reinforcing reliable prediction satisfaction regularities (*procedural coordination*) rather than implementing referential functions.

It might be argued that, besides procedural coordination, referential coordination is also needed since there is also evidence that the conceptualisation of the task environment systematically shifts to more abstract, less localised description schemas (Healey, 1997, 2008), as in the transition from the left ("figurative") to the right-hand side ("abstract") of (13). This has been taken to indicate that symbolic referential conventions have emerged at the abstract descriptions stage and such conventions are qualitatively distinct from iconic/indexical situated conceptualisations like the figurative ones (Raczaszek-Leonardi et al. (2018); cf Fusaroli and Tylén (2014)). However, this is not a necessary conclusion (Steffensen and Harvey, 2018). We do not have to assume that interlocutors manipulate anything referential beyond their prediction-generation/manipulation mechanisms. As argued by Hutchins (2012), general cultural practices emerge via mechanisms like dimensionality reduction and filtering due to the need to decrease entropy (i.e. increase predictability) in the environment. Similarly, in these games, we can assume that the need to take another agent's perspective(s) into account (their predictions) adds dimensions at the affordance competition stage to the point of intractability due to infinite regress. However, cycles of communication including overt feedback and repeated attempts to minimise prediction errors act as a means of dimensionality reduction (Riley and Turvey, 2002) by providing a constrained channel through which shared attention can be focused on selected invariances of the recurring environments (the various mazes), a process that creates jointly perceived affordances for both interlocutors. This process results in a qualitative difference between a highly coordinated team of players and the cognition of the individual agents that constitute it. After a history of interaction, the initial relative independence of the individual cognitive mechanisms is severely restricted gradually resulting in a unit whose component agents are highly predictable to each other (Clark, 2017b). The abilities and procedures employed by this agentive unit, a distributed ad hoc grammar, is not reducible to the additive perception-action abilities of the individuals. This is because the degrees of freedom of the individual agents (their perception/action options) are severely constrained reducing cognitive load due to the limited range of affordance competition. Moreover, minimal and very general overt signals between agents can then reliably trigger particular courses of predictions fulfilled by complementary actions (routines) that are sufficiently anticipated so that no significant error detection is expected or encountered. This view of an emergent grammar is confirmed by the fact that such a coordinated unit can be perturbed by artificially-inserted negative feedback with pernicious effects as unexpected error signals disable the previously effective joint procedures (Mills and Healey, 2006; Healey et al., 2018). In such cases, reception of unexpected negative feedback causes the failure of prediction satisfaction, which serves as an 'error signal' for the emergent joint grammar. However, instead of the interaction breaking down, or explicit negotiation and mindreading processes taking over, participants systematically redeploy their flexible conceptualisation mechanisms now applied anew to the local environment. This means that participants revert to what appear to be indexical/iconic signals, figurative descriptions, i.e., locally grounded affordance triggers. It can also be shown experimentally that such potential to employ flexible, situated conceptualisation and incremental feedback mechanisms, instead of relying on preexisting common ground representations (cf. Clark, 1996), promotes and enhances coordination. As argued by Healey et al. (2018), artificially enhanced negative feedback signals that amplify each agent's awareness of the other's distinct perspective, rather than their commonality, cause faster shifts to dimensionality compression of the task conceptualisation. This is expected because, given the principle of 'progressivity', rather than

any requirement for constructing matching internal world-representations, negative feedback concentrates attention resources to the variables that need to be subsumed under the control of the emergent joint agentive unit and its grammar thus being critical for enhancing predictability.

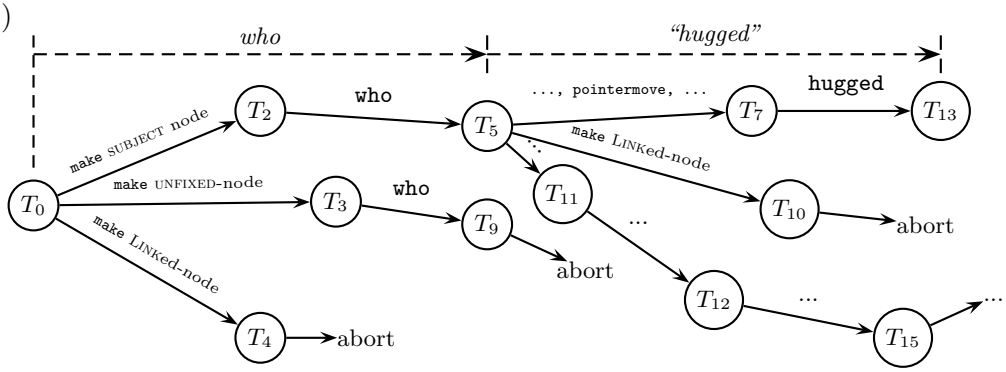
These empirical facts show that grammatical licensing and semantic/pragmatic processing are performed incrementally subsententially online, at each step affording possibilities for further extension by the interlocutors' actions or the situational context. Taking dynamic practices of interaction as foundational, we can ground the appearance of presumed phenomena of "conventionalisation", "processing economy" (Kirby, 1999; Carston, 2002) or "signal economy" (Langacker, 1977), evidenced by NL "fragment" use, in the plastic mechanisms of action coordination rather than stored structures and contents or burdening the inference mechanisms. This requires viewing NLs as "skills" implemented by domain-general procedures rather than fixed form-meaning mappings. For this reason, next we provide a sketch of a procedural grammar architecture that aims to explicitly model such a conception of NLs.

2 Language as action

2.1 Dynamic Syntax

Dynamic Syntax (DS, Cann et al., 2005; Kempson et al., 2001) is a grammar architecture whose core notion is incremental interpretation of word-sequences (comprehension) or linearisation of contents (production) relative to context. The DS syntactic engine, including the lexicon, is articulated in terms of goal-driven actions accomplished either by giving rise to expectations of further actions, by consuming contextual input, or by being abandoned as unviable in view of more competitive alternatives. Thus words, syntax, and morphology are all modelled as "affordances", opportunities for (inter-)action produced and recognised by interlocutors to perform step-by-step a coordinated mapping from perceivable stimuli (phonological strings) to conceptual actions or vice-versa. To illustrate, we display below the (condensed) steps involved in the parsing of a standard long-distance dependency, *Who hugged Mary?*.[2] The task starts with a set of probabilistically-weighted predicted *interaction-control states* (ICSs) represented as a directed acyclic graph (DAG) keeping track of how alternative processing paths unfold or are progressively abandoned (see also Sato, 2011; Eshghi et al., 2013; Hough, 2015):

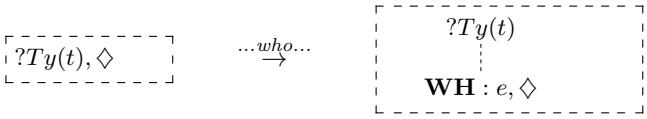
(16)



Such ICSs track salient environmental information, means of coordination, e.g. "repair" (Eshghi et al., 2015; Howes and Eshghi, 2017), and the recent history of processing. On this basis, they induce triggering of goals (*requirements*) to build/linearise conceptual structures ('ad-hoc concepts') under the guidance of labels characterising ontological types (e for entities in general, e_s for events,

[2]The detailed justification of DS as a grammar formalism is given elsewhere (Kempson et al., 2001, 2016; Cann et al., 2005, a.o.).

$(e \rightarrow (e_s \rightarrow t))$ for predicates, etc.). In (18) below, focussing now on only one snapshot of an active DAG path above (and only the syntactically-relevant part), we see that the initial goal (indicated by ?) is realised as a prediction to process a proposition of type t. Below, this is shown as a one-node tree with the requirement $?Ty(t)$ and the ICS's current focus of attention, the pointer $\diamondsuit$:

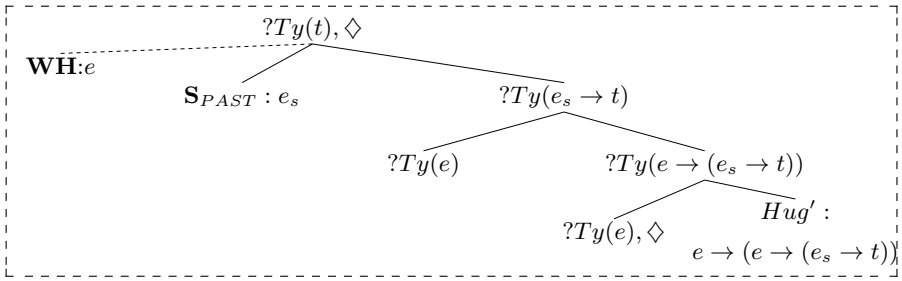
(17) 

Such predictions can be satisfied through input from the interlocutor, the material environment or by the agent themselves producing the requisite mental or physical actions. In the latter case, as here, the pointer at a node including a predicted type t outcome drives the prediction of further subgoals, expected to eventually satisfy the current goal by processing (verbal) input (as a hearer) or producing that input (as a speaker).

For (17), one of the probabilistically-licensed next steps for English (executed by lexical and general computational routines (*macros*) of actions) is displayed in the second partial tree: a prediction that a structurally underspecified node (indicated by the dotted line) can be built and accommodate the result of parsing/generating *who*. As illustrated here, temporary uncertainty about the eventual contribution of some element is implemented through *structural underspecification*. Initially "unfixed" tree-nodes model the retention of the contribution of the *wh*-element in a memory buffer until it can satisfy the prediction associated with some argument node in the upcoming local domain. Grammatical words like *who* and other semantically weak elements (e.g. pronominals, anaphors, auxiliaries, tenses) contribute underspecified content in the form of *metavariables* (indicated in bold font), which trigger search for their eventual type-compatible substitution from among contextually-salient entities or predicates.

General computational and lexically-triggered macros then intersperse to develop a binary tree: in (18), the verb contributes conceptual structure by unfolding the tree further, and fetches an ad-hoc concept (indicated as Hug') developed according to contextual restrictions,[3] as well as placeholder metavariables for time and event entities ($\mathbf{S}_{PAST}$) to be supplied by the current ICS:

(18) ...hugged... →



The conceptual structure being built is indefinitely extendible (Cooper, 2012) and not meant as a passive inner model of the world ("non-reconstructive"; Clark, 2017a,b). Instead, it is relational: a pairing of structures reflecting (aspects of) world (so-called *records*) with humanly relevant processing types (*record types*), i.e., habitual response dispositions to particular stimuli.[4] Thus types function as (higher-order) affordances, i.e., labels of intermediate stages in the generation of further actions. It is the differentiation of the next actions generated that individuates the types, not their labels. To take a "syntactic" example, type t is differentiated from type $(e_s \rightarrow t)$ in that the

[3] In Purver et al. (2010), this is modelled as a *record type* using a Type Theory with Records formulation, but we suppress these details here (see also Eshghi et al., 2013; Hough, 2015; Hough and Purver, 2014; Gregoromichelaki, 2017; Gregoromichelaki and Kempson, 2018, a.o.).

[4] In this externalist perspective, we diverge from standard construals of TTR as in Ginzburg (2012); Cooper (forthcmng).

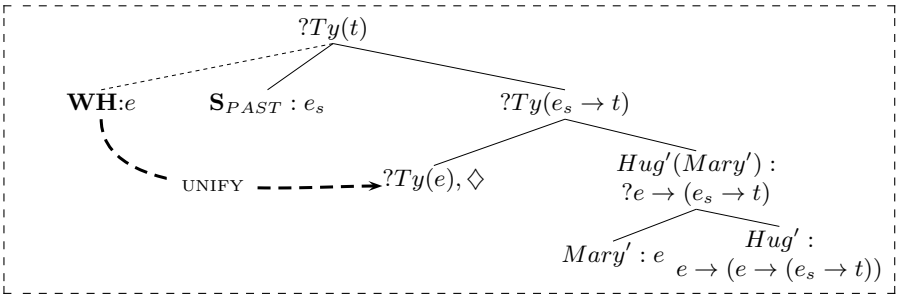
former (minimally) leads to the prediction of a left daughter of type e_s and a right daughter of type $(e_s \rightarrow t)$ whereas the latter leads to the prediction of e and $(e \rightarrow (e_s \rightarrow t))$. As such the types constitute subpersonal mechanisms, however, they can be brought to consciousness by processes of reification for e.g., explicit planning, theory construction, or teaching.

Given affordance competition, agents select their next actions based on possibilities (probabilistically) grounded on these types (functioning as 'outcome indicators' Bickhard and Richie, 1983) so that the types might be reinforced (verified) or abandoned (fail) in the next steps. As long as they remain live possibilities, types do not passively represent the world but keep triggering flows of predictions for further possible (mental or physical) action opportunities. These predictions, in the case of verbal dialogue, concern either participant extending or "repairing" the DAG node elements, thus coordinating behaviour with selected aspects of the environment and each other.

Returning to the processing stage in (18), we see the pointer $\Diamond$ at a predicted argument node. This implements the word-order restriction in English that the object follows the verb. In NLs with explicit morphological case, like Greek in (9), it is the case morpheme that induces the embedding of the noun content under a particular role assignment in the emergent conceptual structure. For English, at the stage shown in (18), *Mary* can be processed to initiate the tracking of a contextually-identifiable individual ($Mary'$) at the argument node internal to the predicate (for the view that such entity concepts are tracking abilities allowing the accumulation of knowledge about individuals, see Millikan, 2000). After this step, everything is in place for the structural underspecification to be resolved, namely, the node annotated by *who* can now unify with the subject node of the predicate, resulting in an ICS that includes the minimal content of an utterance of *Who hugged Mary?* imposed as a goal ($?Q_{\mathbf{WH}}$) for the next action steps (either by the speaker or the hearer):

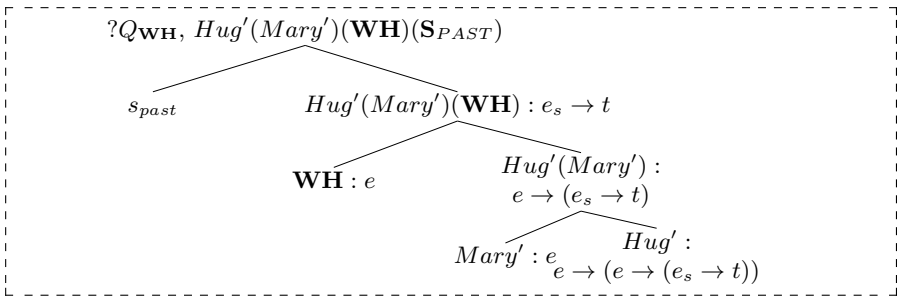
(19)

...*Mary*...`unification macro`...
$\longrightarrow$



(20)

...`tree-completion macros`...
$\longrightarrow$



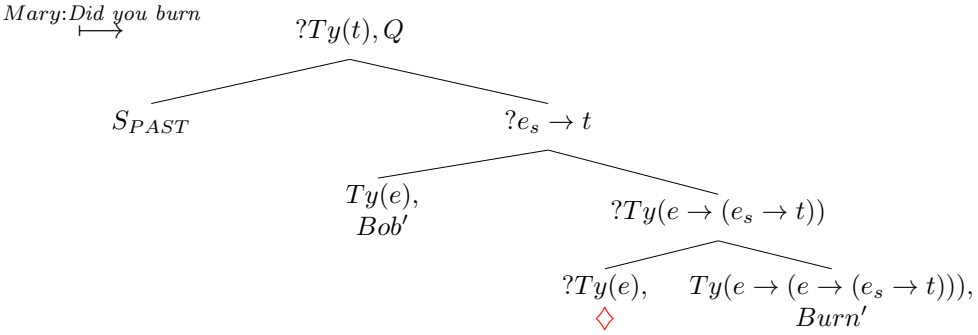
The DS model assumes tight interlinking of NL perception and action: the predictions generating the sequence of trees above are equally deployed in comprehension and production. *Comprehension* involves the generation of predictions/goals and awaiting input to satisfy them, while *production* involves the deployment of action (verbalising) by the predictor themselves in order to satisfy their predicted goals. By imposing top-down predictive and goal-directed processing at all comprehension/production stages, interlocutor feedback is constantly anticipated and seamlessly

integrated in the ICS (Gargett et al., 2009; Gregoromichelaki et al., 2009; Purver et al., 2010; Eshghi et al., 2015) either via LINKing simple proposition-like structures such as (20) or locally LINKed structures of any type (e.g. adjunct processing, see (4a)) incrementally extending the node of a tree in the ICS. For this reason, maintaining even abandoned options as required for the explicit modelling of conversational phenomena like "fragment" clarifications, self/other-corrections, etc. but also, quotation, code-switching, humorous effects and puns (Hough, 2015; Gregoromichelaki, 2017) is not problematic. Moreover, given the modelling of word-by-word incrementality, at any point, either interlocutor can take over to realise the currently predicted goals in the ICS. This can be illustrated in the sharing of the dependency constrained by the locality definitive of reflexive anaphors:

(21) Mary: Did you burn Bob: myself? No.

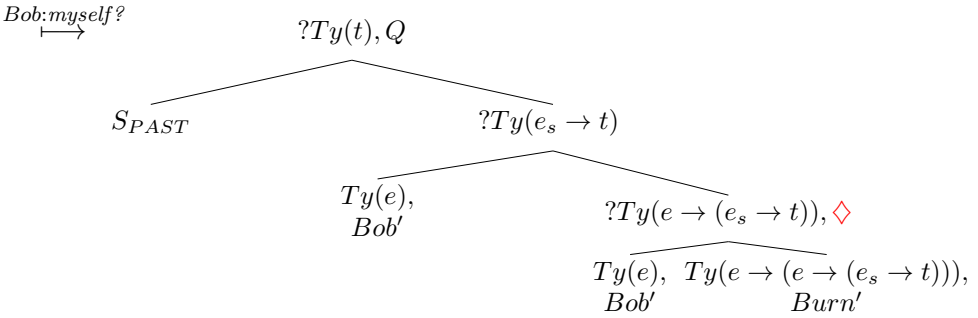
As shown in (21), Mary starts a query involving an indexical metavariable contributed by *you* that is resolved by reference to the $Hearer'$ contextual parameter currently occupied by Bob':

(22)



With the ICS tracking the speaker/hearer roles as they shift subsententially, these roles are reset in the next step when Bob takes over the utterance. *Myself* is then uttered. Being a pronominal, it contributes a metavariable and, being a reflexive indexical, it imposes the restriction that the entity to substitute that metavariable needs to be a co-argument that bears the $Speaker'$ role. At this point in time, the only such available entity in context is again Bob' which is duly selected as the substituent of the metavariable:

(23)



As a result, binding of the reflexive is semantically appropriate, and locality is respected even though joining the string as a single sentence would be ungrammatical according to any other syntactic/semantic framework.This successful result relies on (a) the lack of a syntactic level of representation (cf. Auer, 2014), and (b) the subsentential licensing of contextual dependencies. In combination, these design features render the fact that the utterance constitutes a joint action irrelevant for the wellformedness of the sequence of actions constituting the string production. This means that coordination among interlocutors here can be seen, not as propositional inferential activity, but as the outcome of the fact that the grammar consists of a set of licensed complementary actions that speakers/hearers perform in synchrony (Gregoromichelaki et al., 2011, 2013a;

Gregoromichelaki and Kempson, 2016). Due to subsentential step-by-step licensing, speakers are not required to plan propositional units, so hearers do not need to reason about propositional intentions. Given that parsing/production are predictive activities, a current goal in the ICS may be satisfied by a current hearer, so that it yields the retrieval/provision of conceptual information that matches satisfactorily the original speaker's goals, as in (3), (6), deflects the original speaker's action (5), or can be judged to require some adjustment that can be seamlessly and immediately provided by feedback extending/modifying the ensuing ICS (2e), (10).

3 Conclusion

The action dynamics of DS, and its emphasis on underspecification and update for both NL resources and context specifications, reflect the formalism's fundamental mechanism of cross-modal predictivity. This allows for parsimonious modelling of NL data and accommodates now commonly accepted psycholinguistic evidence of prediction from standard sentence processing studies (Altmann and Kamide, 1999; Trueswell and Tanenhaus, 2005, a.o.). Further than this though, the articulation of DS as a formalism is designed to model current corpus-derived and experimental dialogue data. The phenomena encountered in such data, characterised as "ellipsis" or "fragments" in other formalisms, do not support the claim in most formal frameworks that a level of syntactic analysis based on sentential/phrasal units is required for licensing, neither the semantic/pragmatic assumption that whole propositions are the basis of joint action and inference. For example, data showing the plasticity of NL resources, as in section 1.5, do not usually ensue as the outcome of sentential/propositional exchanges but through the reciprocity of physical and verbal actions (Mills and Gregoromichelaki, 2010). Additionally, such data shows that "wellformedness" is a context dependent and incrementally assessed notion, for example, responses to truncated turns depend on how predictable the continuation is (Howes et al., 2011, 2012): extremely predictable continuations do not even need to be articulated by either party in order to be taken unproblematically as part of the interpretation of what has been said, and continuations that are predictable in terms of structure but not content prompt dialogue participants to provide multi-functional utterances, merging the performance of multiple speech acts, for example, serving both as continuations and offering feedback as clarification requests. DS processing can model all these options since there is no notion of wellformedness defined over sentence-proposition mappings, neither encoded meta-level speech-act characterisations, only systematicity/productivity of procedures for incremental processing. Therefore, unlike non-incremental formalisms where explanation for these phenomena has to either be devolved to a parser external to the grammar (Kobele, 2016) or be attributed to performance "errors", for DS, non-sentential (NSU, "fragmentary") linguistic input/output, "repair" processes, as well as shared or abandoned utterances are not modelled as a problem for the interlocutors. Instead, processing that continually aims to build upon partial chunks of information is basic, constantly in progress, and constitutes the purpose of interaction which is to modify the interlocutors' cognitive and physical environments, a key feature for learning and adaptation purposes.

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