Language as Mechanisms for Interaction: language and music parallelisms

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Single sentence structures emerging across participants, with intentions emerging through exchange

(1) Alex: We're going to
Hugh: to Burbage, to see Auntie Ann
Eliot: with the dogs?
Hugh: if you promise to control them.
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Speaker/hearer exchange roles across ALL syntactic dependencies:

(2) Ruth: I’m afraid I burned the kitchen ceiling.
    Michael: Did you burn
Developing utterances (together) in a dialogue context

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2. Ruth: I’m afraid I burned the kitchen ceiling.
   Michael: Did you burn

- Utterances may be multi-functional, indicating more than one speech-act:

9. Lawyer: Will you choose your son as the executor of your will or your...
   Client: My wife
What the dialogue data show about language

- Utterance understanding and planning are highly incremental
  - Fluent switch of roles in dialogue is not performance dysfluency
  - People interrupt and take over in a conversation as though they had been speaking all along
  - Speakers switch to parsing as though listening all along
  - Structure, content, context and intentions all evolve

- Strong parallelism with coordinated action (Pezzulo 2011) and with dynamics of improvisation in music (London 2004)

- What we need is a view of language as an embodied mechanism:
  - context-relative actions
  - incremental and expectation-driven
  - yielding progressive information growth
  - without invoking higher-order reasoning

- Dynamic Syntax (Cann et al 2005, Gregoromichelaki et al 2011)
Syntax as procedures for building interpretation

Underspecification + update are core syntax
Parsing and production as building representations of content
Tree growth is goal-driven and context-dependent.
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Underspecification + update are core syntax

Parsing and production as building representations of content

Tree growth is goal-driven and context-dependent.

Processing *Jo sneezed*

\[
\begin{align*}
?Ty(t), & \\
\downarrow & \\
Jo', & \\
\downarrow & \\
?\exists x. Tn(x) & \\
\end{align*}
\]

\[
\begin{aligned}
Sneeze'(Jo')(S_{PAST}) : t, & \\
\rightarrow & \\
S_{PAST} : e_s & \\
& \\
& \\
Sneeze' & \\
& \\
Jo' : e & \\
& \\
Sneeze'(
\)
\]

Words encode action sequences inducing semantic tree update.

?X are **requirements** for growth, ?Ty(t) proposition as goal;

Concepts decorate nodes: names are entity terms Ty(e); S_{PAST} event

Verbs induce propositional skeletons; ♦ is current node.
Defining what a tree is:
- A binary tree is a set of nodes (1 functor, 1 argument)
- Each node is defined in terms of its relation to the others.
- Complete tree has no expectations: 1 formula/type per node.
- Trees can be incomplete, always with update requirement:
  (i) Nodes may need a type – eg needing an entity type: ?Ty(e)
  (ii) Nodes may have a type but lack a fixed formula
       – eg pronouns: U : Ty(e), ?∃xFo(x)
  (iii) Nodes can be UNFIXED within emergent tree.
       ⟨↑∗⟩Tn(0) “the rootnode is somewhere above me”
       requirement: ?∃xTn(x)

All requirements induce expectations of update, driving growth of structure
All Actions (computational and lexical) are conditional, defined in a tree building language
Procedures for progressive tree growth: Actions all the way

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Underspecified structural relations (replacing “movement”):

The outset: building an “unfixed” node

\[ Tn(a), \ldots ?Ty(t), \quad \text{IF} \quad ?Ty(t), Tn(a) \]
\[ \quad \text{Tn(a)} \]
\[ \quad \text{Tn(a)} \]
\[ \quad \uparrow \ast \]
\[ \quad Tn(a) \]
\[ ?Ty(e), \quad \downarrow \downarrow \top \]
\[ ?\exists x Tn(x) \]

ELSE

Abort

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\[ \quad \text{THEN} \quad \text{IF} \quad \langle \downarrow \rangle \langle \downarrow *) \top \]
\[ \quad \text{THEN} \quad \text{ELSE} \quad \text{Abort} \]
\[ \langle \uparrow * \rangle Tn(a) \]
\[ ? Ty(e), \quad \text{ELSE} \quad \text{Abort} \]
\[ ? \exists x Tn(x), \quad \text{ELSE} \quad \text{Abort} \]

- Lexical specifications also define macros of actions, inducing partial trees eg verbs induce skeletal templates

- Subtrees can then be unified to form composite complete trees

- Mechanisms apply equally for both speakers and hearers
Opening with an unfixed node to process _Jo sneezed_

\[ Tn(0), \ldots ?Ty(t), \diamond \]

\[ \langle \uparrow \ast \rangle Tn(0) \]

\[ Jo', \]

\[ \exists x Tn(x) \]
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\[
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\[
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\]

\[
Jo
\]

\[
?\exists x Tn(x)
\]

\[
SPAST
\]

\[
?Ty(e_s \rightarrow t)
\]

\[
?Ty(e), Sneeze'
\]
Completing the tree

- Compiling interpretation for *Jo sneezed* ?

\[ Sneeze'(Jo')(S_{PAST}) : t, \Diamond \]

\[ S_{PAST} : e_s \quad \text{Sneeze'}(Jo') \]

\[ Jo' : e \quad \text{Sneeze'} \]
Completing the tree

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\[
\text{Sneeze}'(\text{Jo}') (\text{S}_{\text{PAST}}) : t, \text{◊}
\]

\[
\text{S}_{\text{PAST}} : e_s \quad \text{Sneeze}'(\text{Jo}')
\]

\[
\text{Jo'} : e \quad \text{Sneeze'}
\]

- Constraint on tree-building process

Only one unfixed relation of a type at a time because **ALL** nodes are uniquely identified by tree position 
This allows a node relation to be built more than once, but this will **NEVER** result in more than one such node
Incremental licensing allows take-over with new goal: 
\[ \text{Burn}(\text{Ruth})(\text{Ruth})(S_{PAST}) \]

**Michael**: Did you burn... **Ruth**: myself?

Role-shift licensed across all dependencies because interlocutors mirror each other’s processing

Choices are made relative to one’s own context, not by reading the other person’s mind
Interactive exchange is an effect of language processing, not requiring externally imposed higher-order inference.

The dynamic of the exchange mimics music directly, and coordinated action more generally.

But are the dynamics the same in kind?

The test is whether the dynamics of music displays similar structural constraints.
Music and language processing

- If the answer is yes, then general structure building mechanisms should be common to both.
  - Is the notion of structural underspecification as a structure building mechanism relevant for polyrhythmic processing?
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- Is the notion of structural underspecification as a structure building mechanism relevant for polyrhythmic processing?
  - In what follows, we present some preliminary thoughts (rather naive) on how such a restriction can be traced when looking at polyrhythm processing.
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Somewhat more formally: ‘a polyrhythm refers to any two or more separate rhythmic streams in the musical texture whose periodicities are noninteger multiples’ (London 2004)
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Ways of polyrhythmic processing

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      ▶ Relevant factors include presentation rate (tempo), frequency separation (the pitch difference of the two rhythms) and attentional behaviour (see for example Jones 1976; Beauvillain, 1983; Bregman, 1990; Moealants, 2005 and Fidali et al., 2011 for a summary)
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- Is the inability to tap along might be due to motor limitations and not perceptual ones?
  - Evidence suggests that the same effects are present in the case of processing only (Klapp et al. 1985)
Segregation

- The two rhythms are kept distinct
  - Seems to be easier in terms of processing
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  - Seem to be easier in terms of processing
    - The reason for this might be the fact that subjects in these cases process only one of the two rhythms. As Bregman (1990) puts it: “The task of trying to hear two streams (you can actually pay attention to only one at a time) is much easier [than integration]”. 
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  - The subjects pay attention to one of the rhythms and entrain to its rhythm while treating the other as ‘noise’ (London, 2004: 50)
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The two rhythms are integrated, i.e. processed or produced as one complex rhythm.
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  - The example below shows an 3:2 polyrhythm
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![Musical notation example](image)
What counts as an underspecified rhythm?
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A rhythm that has not yet been defined in relation to a metric context or in relation to another rhythm that has received its interpretation in reference to a metric context.
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Looking for evidence

Let us assume that we have an empty metric context, in the sense that the metric context has not yet been decided given that no harmony, melody or any kind of musical layer is salient in the musical context (however this is defined)
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  - In such an environment, let us imagine a sequence of isochronous rhythmic units with an inherent accent every three units.
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This rhythm is potentially underspecified since it can be given a number of interpretations, given the absence of any rhythmic/musical context.
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Some of these interpretations:

\[
\begin{align*}
4/4 & : \quad \boxed{\text{\longunder{3,\,3,\,3,\,3}}} \\
6/8 & : \quad \boxed{\text{\longunder{3,\,3,\,3,\,3}}} \\
\end{align*}
\]
Some more interpretations
Some more interpretations
Some more interpretations
Fixing the relation

In case the metrical context has been established the relation can be further specified, having the ability to potentially take any of the interpretations (or more) we have discussed (the metrical context provides the ground in a figure-ground relationship according to London, 2004).
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The issue arises when prior to the fixing of the underspecified relation we have another underspecified rhythm at play.
Let us imagine a five note rhythmic unit on top of the already existing three note one, the 5 unit rhythm extending over the same time interval as the 3 beat rhythm.
Two underspecified relations - polyrhythms out of context

- Let us imagine a five note rhythmic unit on top of the already existing three note one, the 5 unit rhythm extending over the same time interval as the 3 beat rhythm.
- Now, if this is also underspecified, then we would expect (if there is such restriction on underspecification) both relations to collapse and processing to be impossible.
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In effect we do have a polyrhythm going with no established metrical context.
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a. Extract a composite pattern out of all the streams and then match it to a suitable metric framework.

b. Focus on one stream while treating the other as ‘noise’.

(London, 2004)

The question is what happens when no such metric context has been established? In this case, in both options, the processed rhythms are underspecified with respect to a not-yet-established metrical context.
Two underspecified relations - the case of integration

- The case of integration involves a composite underspecified rhythm pattern
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\[ MC, Tn(a) \]

\[ \langle \uparrow * \rangle Tn(a), (3, 5) \]
The case of segregation

- Two distinct rhythms
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  - However, only one seems to be parsed, the rest is heard as ‘noise’. Thus, again only one underspecified relation is at play
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  - However, only one seems to be parsed, the rest is heard as ‘noise’. Thus, again only one underspecified relation is at play
    a. Segregation: hearing the 3 note unit
      \[ MC, Tn(a) \]
      \[ \langle \uparrow \ast \rangle Tn(a), (3) \]
b. Segregation: hearing the 5 note unit

$$MC, Tn(a)$$

\[\langle \uparrow \ast \rangle Tn(a), (5)\]
The need for experimental evidence

- The experimental evidence can be explained via the assumption that underspecification is also relevant for polyrhythmic processing
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The former does not necessarily imply the latter.
The need for experimental evidence

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However, we must be cautious here: compatibility with the data and the existence of the constraint are too separate issues.

The former does not necessarily imply the latter.

More evidence is needed in order to determine whether such a constraint is indeed operative in polyrhythmic processing.

We need experiments designed specifically for this purpose.
Reflections on language-music correlations

▶ Analysis of language as mechanisms for interactive growth
  - structural growth reflecting real-time
  - domain-independent
  - context- and expectation- driven

▶ New perspective on modelling rhythmic processing in music
  - progressive establishing of dependencies
  - composite units storable as individuated chunks
  - intrinsic potential for interaction in real time

▶ New horizons for analysing music and language as tightly correlated
