Language as Mechanisms for Interaction: language and music parallelisms

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Developing utterances (together) in a dialogue context

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

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Hugh: to Burbage, to see Auntie Ann

Eliot: with the dogs?

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- 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

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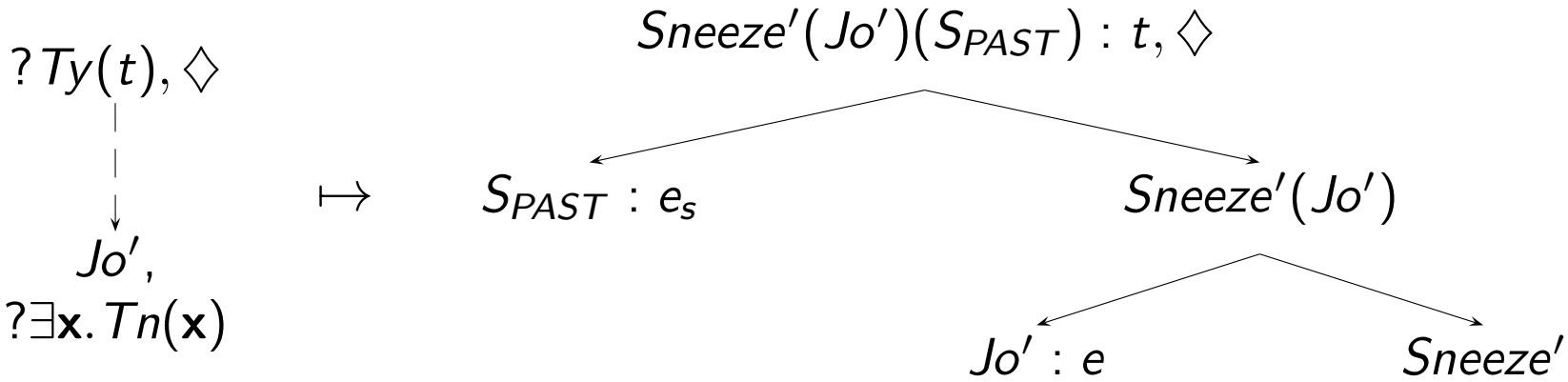
Processing *Jo sneezed*



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.

Language for Trees and Dynamics of Growth

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: $\mathbf{U} : Ty(e), ?\exists x Fo(x)$
  - (iii) Nodes can be UNFIXED within emergent tree.
    $\langle\uparrow_*\rangle Tn(0)$ "the rootnode is somewhere above me"
    requirement: $?\exists x Tn(x)$

  All requirements induce expectations of update,
  driving growth of structure

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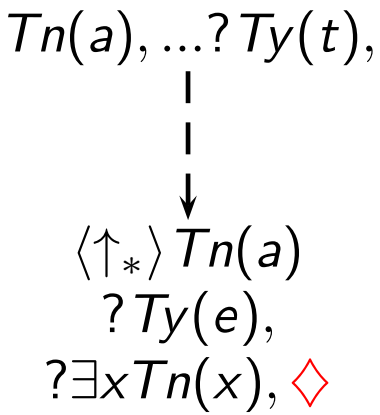

IF		$?Ty(t), Tn(a)$	
THEN	IF		$\langle\downarrow\rangle\langle\downarrow_*\rangle\top$
	THEN		Abort
	ELSE		$\texttt{make}(\langle\downarrow_*\rangle); \texttt{go}(\langle\downarrow_*\rangle);$ $\texttt{put}(\langle\uparrow_*\rangle Tn(a), ?Ty(e),$ $?\exists x Tn(x))$
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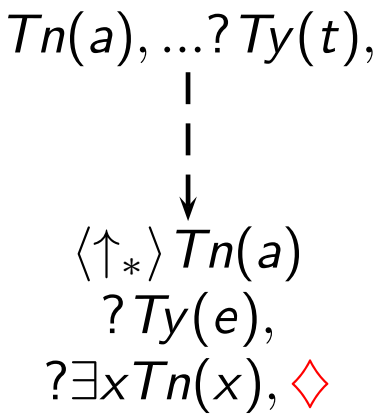

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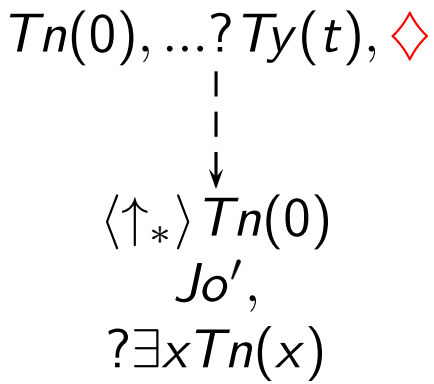
- Lexical specifications also define macros of actions, inducing partial trees eg verbs induce skeletal templates
- Subtrees can then be unified to form composite complete trees
- Mechanisms apply equally for both speakers and hearers

Structural Underspecification + incremental update

- Opening with an unfixed node to process *Jo sneezed*



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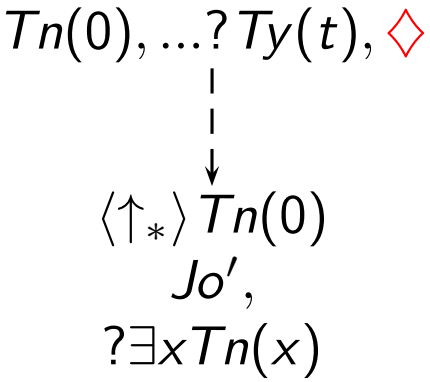
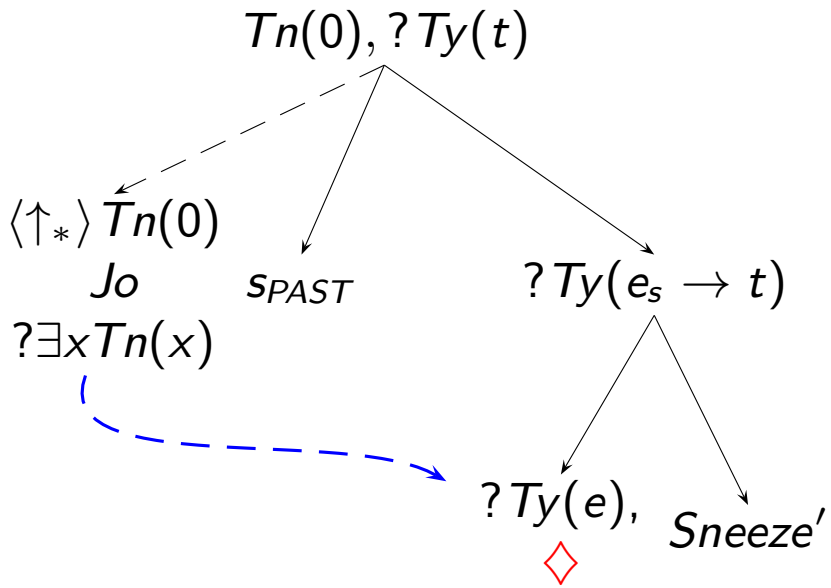
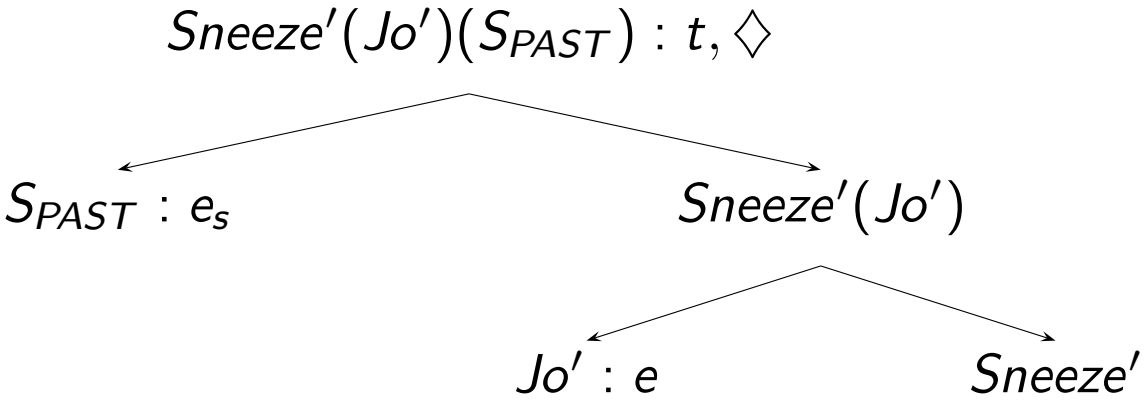




Completing the tree

- Compiling interpretation for *Jo sneezed* ?



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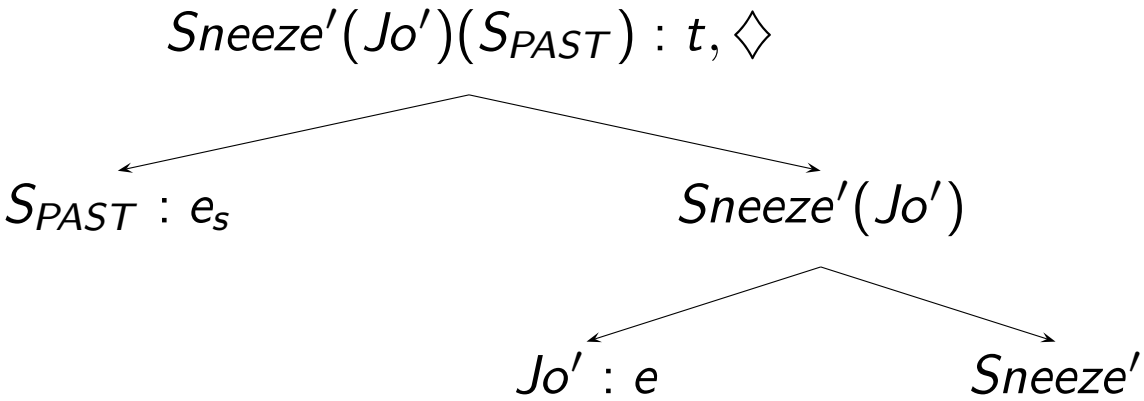


- **Constraint on tree-building process**

  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

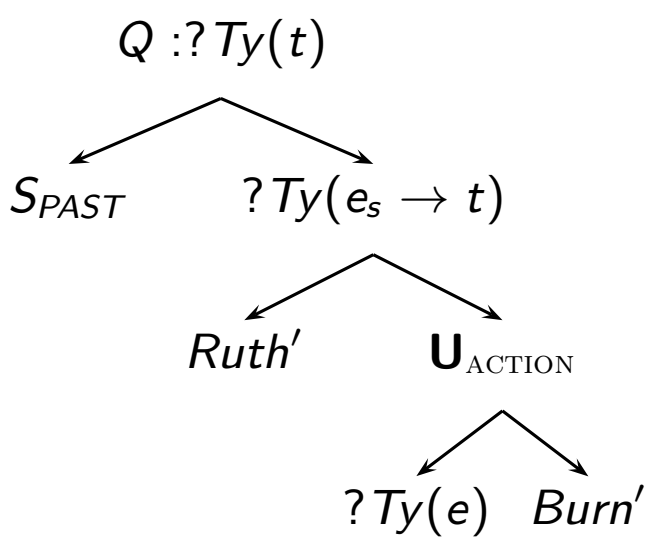
Compound utterances: interactive structure building

Incremental licensing allows take-over with new goal:

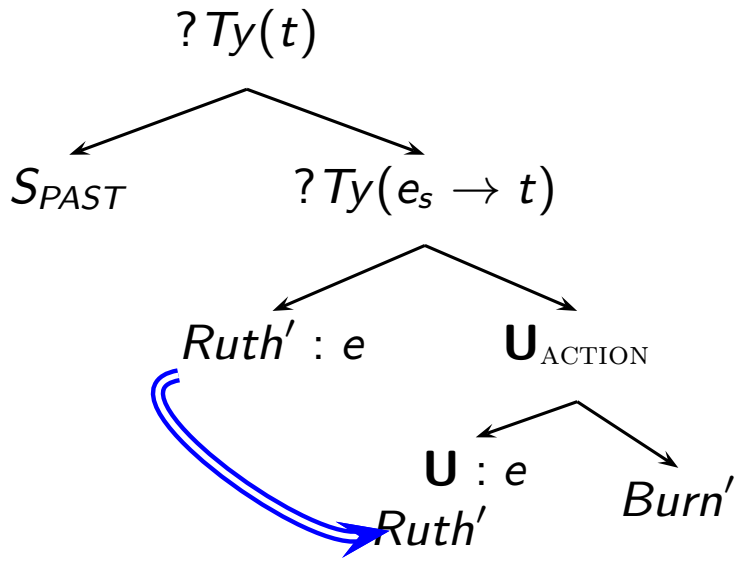
$Burn(Ruth)(Ruth)(S_{PAST})$

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

SHARED CONTEXT AT SHIFT



TEST/PARSE TREE AT SHIFT



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

Structure building that extends context yields interaction

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.
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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 polythythm processing

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- Informally: More than one rhythm going at the same time.
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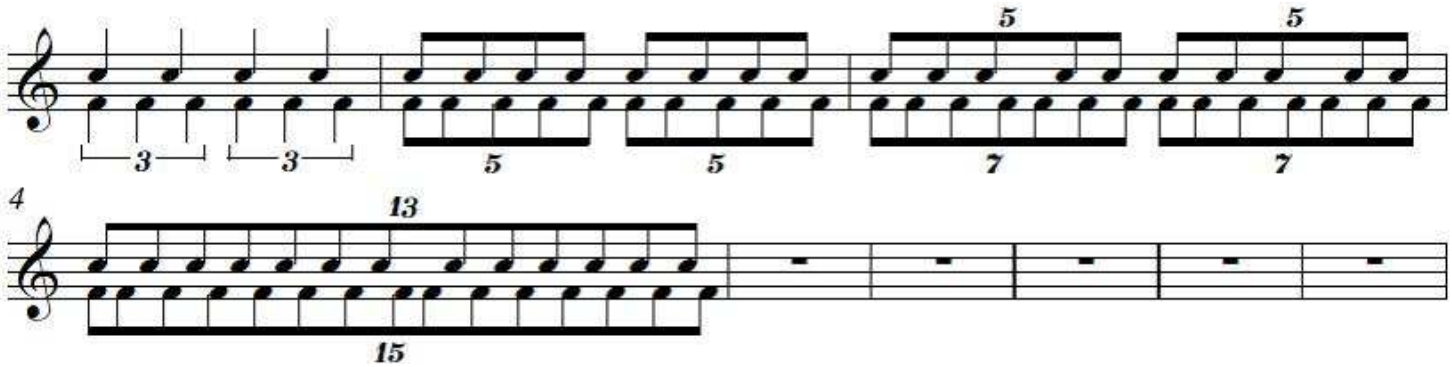

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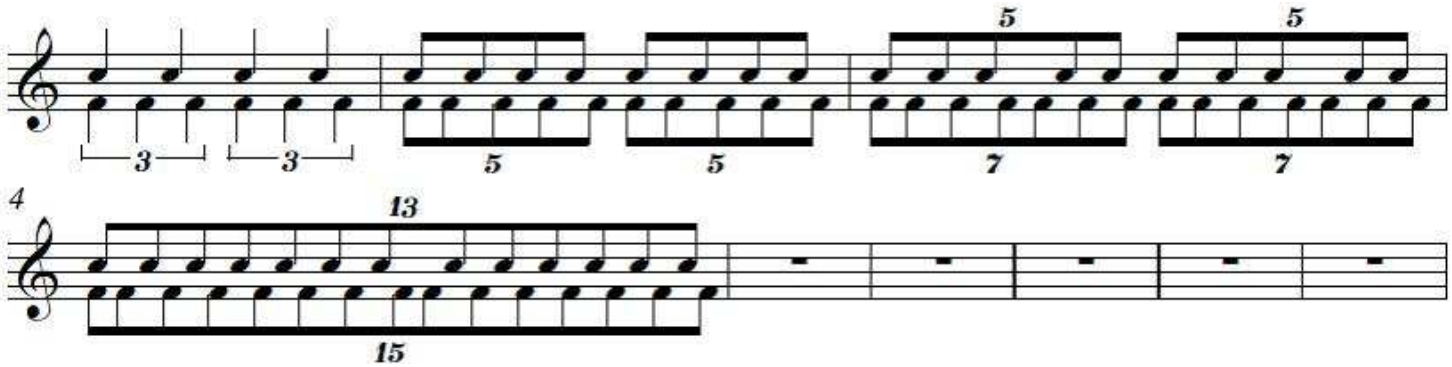

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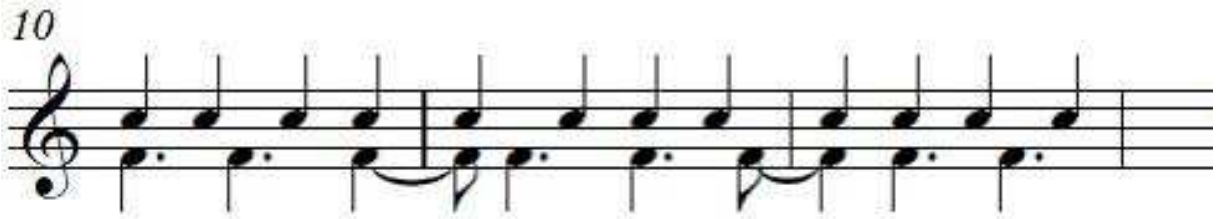

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     - Evidence suggests that the same effects are present in the case of processing only (Klapp et al. 1985)

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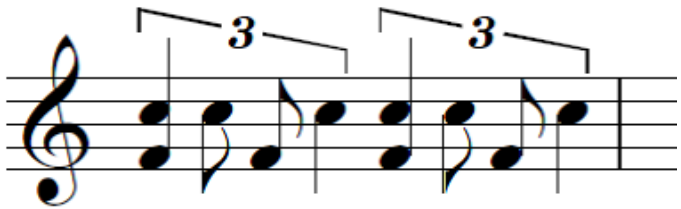

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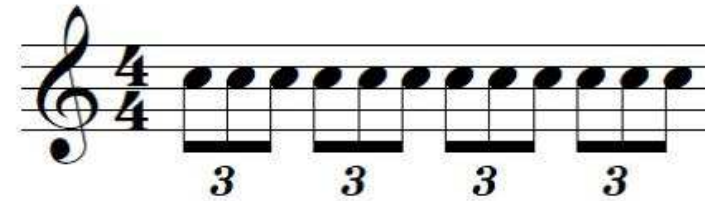

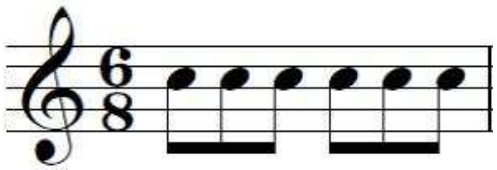

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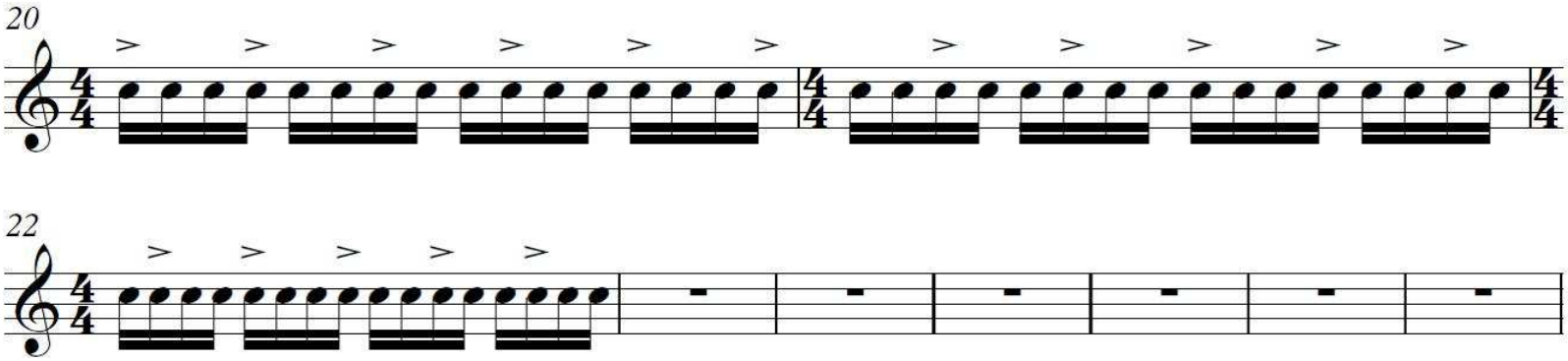

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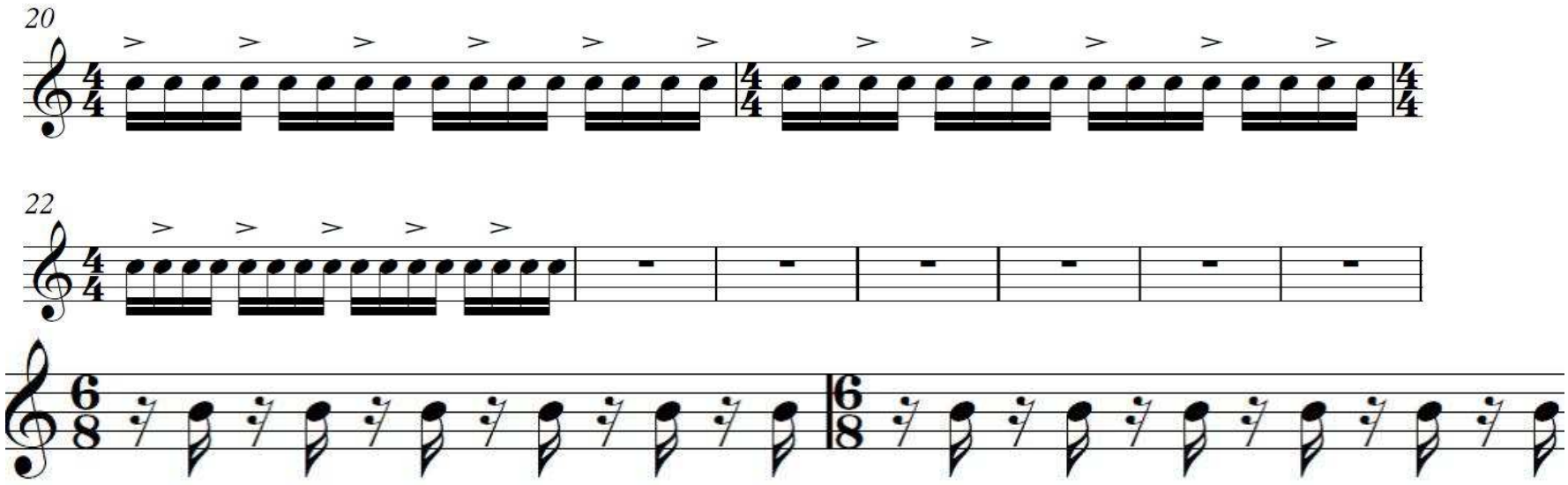

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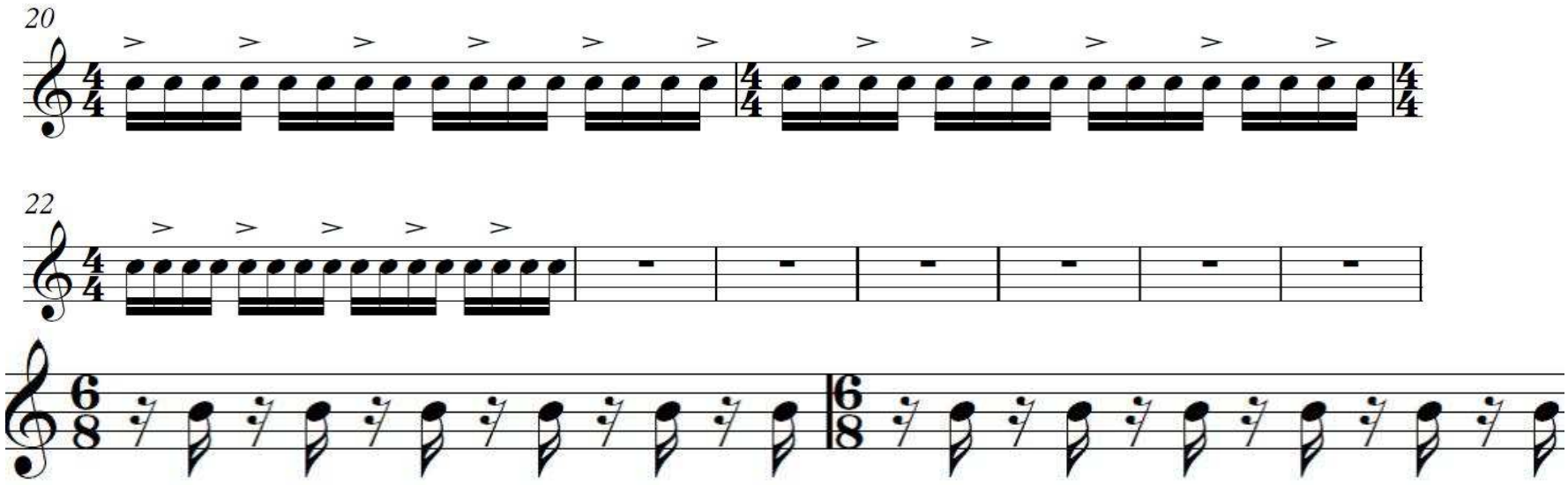

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- The issue arises when prior to the fixing of the underspecified relation we have another underspecifed rhythm at play

Two underspecified relations - polyrhythms out of context

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  - In effect we do have a polyrhythm going with no established metrical context.

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Two underspecified relations - polyrhythms out of context

- The experimental evidence suggests that the two ways to parse polyrhythms (integration and segregation) amount to the following two strategies
  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

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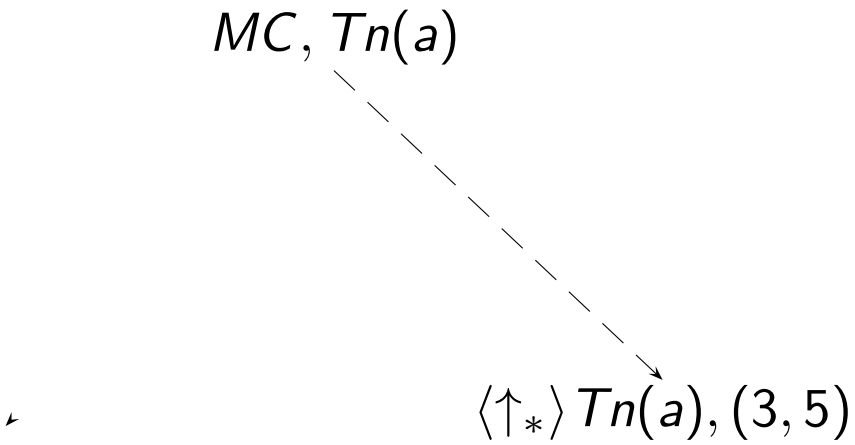

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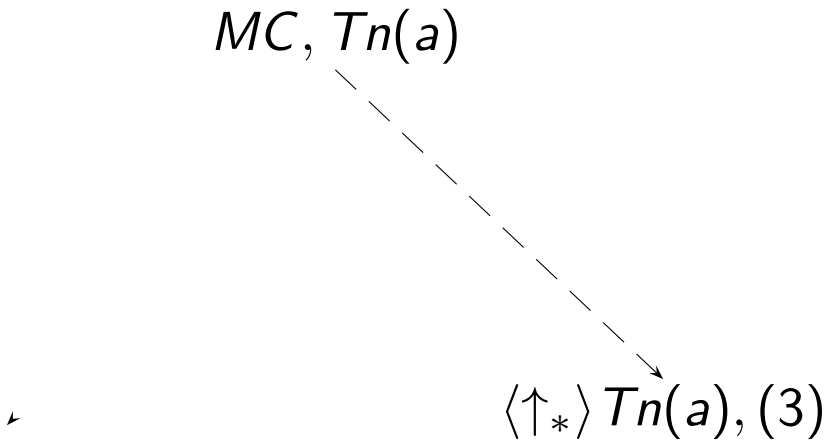

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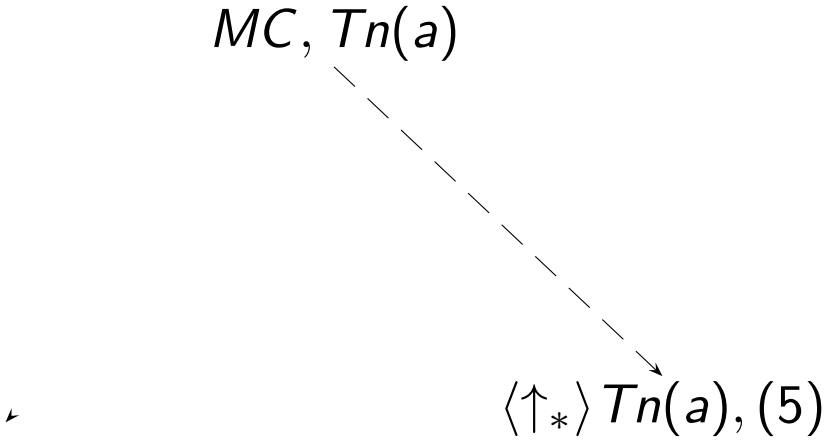
b. Segregation: hearing the 5 note unit



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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

Cann, R. et al. 2005 *The Dynamics of Language* Kluwer.

Gregoromichelaki, E. et al. 2011. Incrementality and intention-recognition in utterance processing. *Dialogue and Discourse* 2.

London, J. 2004 *Hearing in Time: Psychological Aspects of Musical Meter* OUP

Orwin, M, et al 2013. *Language, Music and Interaction*. College Publications

Pezzulo, G. 2011 Shared representations as coordination tools for interaction. *Review of Philosophy and Psychology*, 2(2):303?333.

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