Language: The tool for interaction - surfing uncertainty together

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The Dynamics of Dialogue Interactions

Dynamic Syntax: Tools for co-building interpretation/strings online

"core syntax" data as case study

Wellformedness Restrictions and Cross-Linguistic Universals?

Lexical/Computational Actions as Basis for Interaction

predicting sub-sentential dialogue interactivity

Entering the Clark world of cognition as surfing uncertainty

Language as the tool for surfing uncertainty together

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Developing utterances (together) in a dialogue context

- Single sentence structures emerging across participants

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Eliot: with the dogs?
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Lara (client): was a woman
Therapist: Yeah.
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(3) Carer: Old McDonald had a farm... On that farm he had a
Child: cow.

The challenge for linguists

- Speaker/hearer exchange roles across ALL syntactic/semantic dependencies:

  (4) Ruth: I'm afraid I burned the kitchen ceiling.
  Michael: Did you burn
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(7) A: That niece of yours we promised we wouldn't ...
B: abandon?
A: Dolma, yes, she has to be met at Gatwick.

Recognising intended proposition/speech-act not necessary for communicative success: interaction essential

- Interruptions/extensions possible before intended proposition fixed:

(8) A. They X-rayed me, and took a urine sample, took a blood sample. Er, the doctor

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(12) Teacher: And your name is ...
Child : Mary

What the dialogue data show about language

- Utterance understanding and planning are highly incremental
  - Fluent switch of roles in dialogue is not performance dysfluency
  - Mind-reading not necessary for successful communication
  - Structure, content, context and intentions all evolve
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- Strong parallelism with coordinated action as embodied representations (Pezzulo 2011, Clark 2016.....)
  - action-oriented predictive processing
  - action and perception both involve low-level procedural mechanisms rather than cross-modal higher order inference
- Our grammars ought to capture them
  - The phenomenon is universal
  - All dependencies can be distributed across a dialogue
  - If dialogue ignored, NO syntactic/semantic dependency will be fully characterised
  - Sole data to which the small child is exposed

What is needed in the grammar

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- A view of language as a set of mechanisms for processing:
  - context-relative (situated) actions
  - prediction-driven
  - incremental
  - progressively accumulating expression of information
    yet allowing local revisions
  - the outcome of each step always extendable
    no pre-condition of mind-reading/higher-order reasoning
- *Dynamic Syntax* captures dialogue data naturally.

Kempson et al 2001, Cann et al 2005, Purver et al 2006, Gregoromichelaki 2011, etc.

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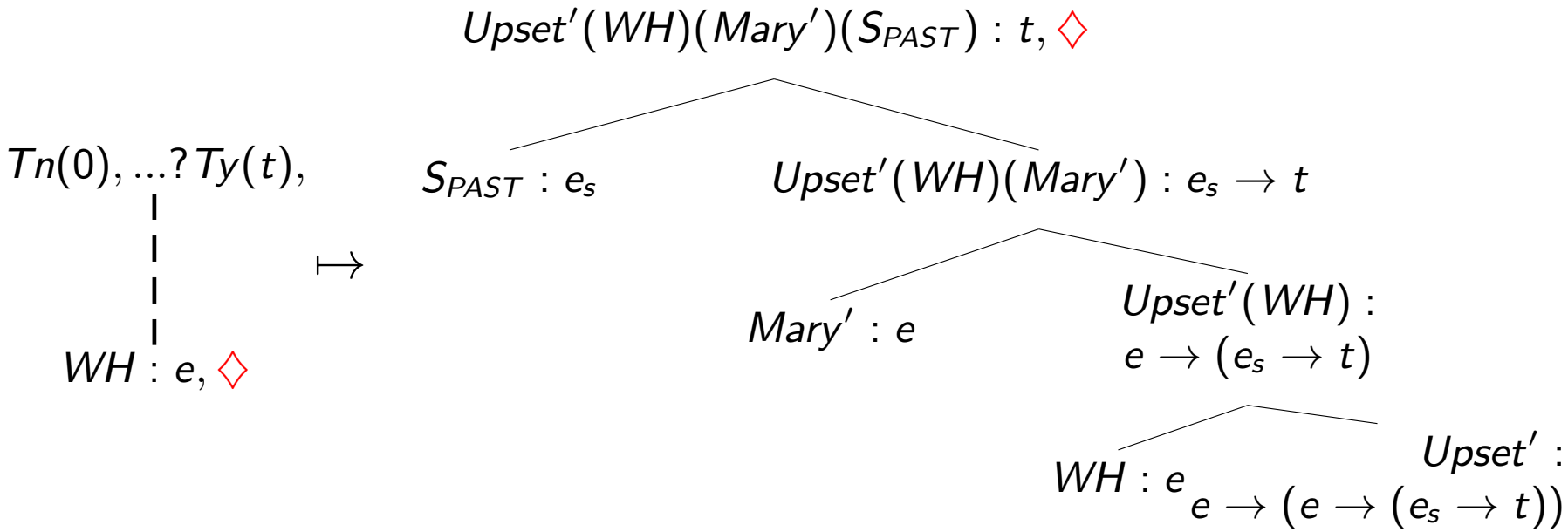
"Syntax": procedures for building meaning representations

Underspecification+update are core "syntax"
Building representations of content as goal-driven
context-dependent, tree-growth from word-sequence
Producing/parsing (13) *Who did Mary upset?* [*WH*, Aux inversion]



Words encode action sequences inducing semantic tree update. NPs map to type e (epsilon) terms; propositions type t; S_{PAST} event term $Ty(e_s)$; predicates $e \rightarrow (e_s \rightarrow t)$; $?Ty(t)$ proposition as goal; $\Diamond$ is current node.

Logic of Finite Trees: Blackburn & Meyer-Viol 1994

from the point of view of treenode n, $Tn(n)$:

$\langle\downarrow_0\rangle X$	X holds at argument daughter of Tn(n).
$\langle\downarrow_1\rangle X$	X holds at functor daughter of Tn(n).
$\langle\uparrow\rangle X$	X holds at mother of Tn(n).
$\langle\downarrow_*\rangle X$	Tn(n) dominates X. ["Somewhere below is X"]
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Requirements for Growth: $?X$ for any X. All underspecifications have requirement for update: $?Ty(t), ?Ty(e), ?\exists x Tn(x)$, etc

Underspecifications of content:

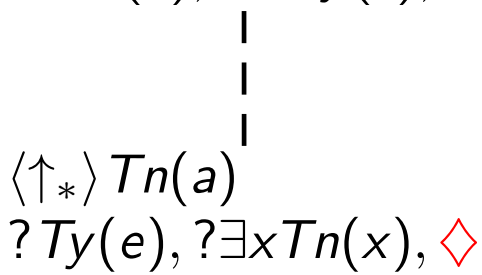
- PRONOUNS - **U** : $e, ?\exists x Fo(x)$ [**U** a metavariable]
- AUXILIARY - **U** : $e_s \rightarrow t, ?\exists x Fo(x)$

Procedures for progressive tree growth: Actions all the way

Computational and Lexical Actions are conditional, defined in a tree building language with predicates make(), go(), put(): $\texttt{make}(\langle\downarrow_0\rangle)$, $\texttt{go}(\langle\downarrow_0\rangle)\texttt{put}(?Ty(e))$

Underspecified structural relations "(Local)*Adjunction":

The outset: building an "unfixed" node (long distance dependency)



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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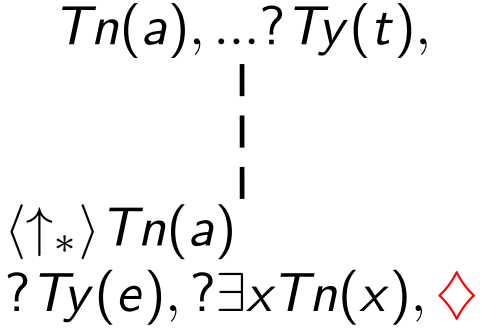

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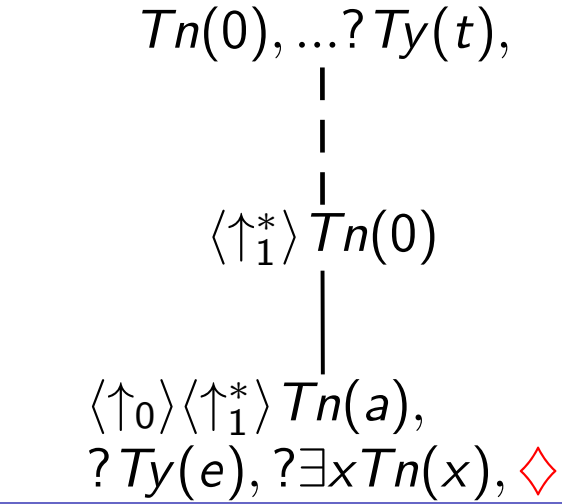
Building a locally unfixed node (local word order variation)



IF	$?Ty(t), Tn(a)$
THEN	$\texttt{make}(\langle\downarrow_1^*\rangle);\texttt{go}(\langle\downarrow_1^*\rangle);$ $\texttt{make}(\langle\downarrow_0\rangle);\texttt{go}(\langle\downarrow_0\rangle)$ $\texttt{put}(\langle\uparrow_0\rangle\langle\uparrow_1^*\rangle Tn(a), ?Ty(e)$ $?\exists x Tn(x))$
ELSE	Abort

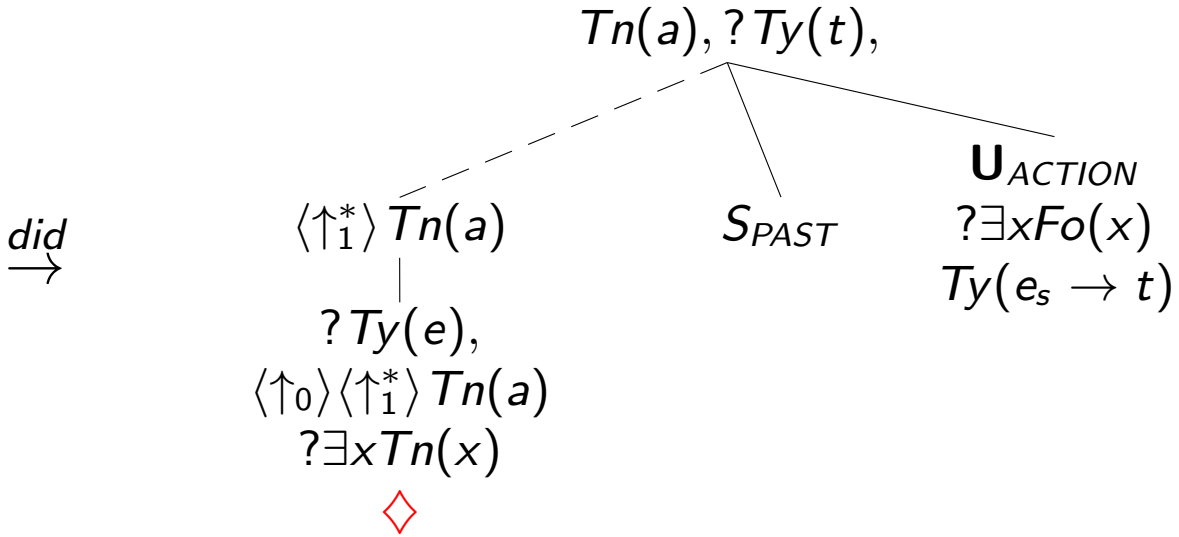
Structural Constraint on the Growth Process

- The position of a node in a tree is uniquely identified by its relation to others

  The making of a tree relation can be reiterated, but any such repetition cannot create a distinct node
- This constraint applies to all trees at every stage of the tree growth
- Hence the restriction of only one unfixed relation of a type at a time
- The effect is that though some tree-relations can be constructed more than once, the result will not be structurally distinguishable

What do words do for us? Auxiliaries (English)

Auxiliaries induce complex tree growth: they can't follow verbs, can occur initially, project tense, syntactic-subject, propositional template



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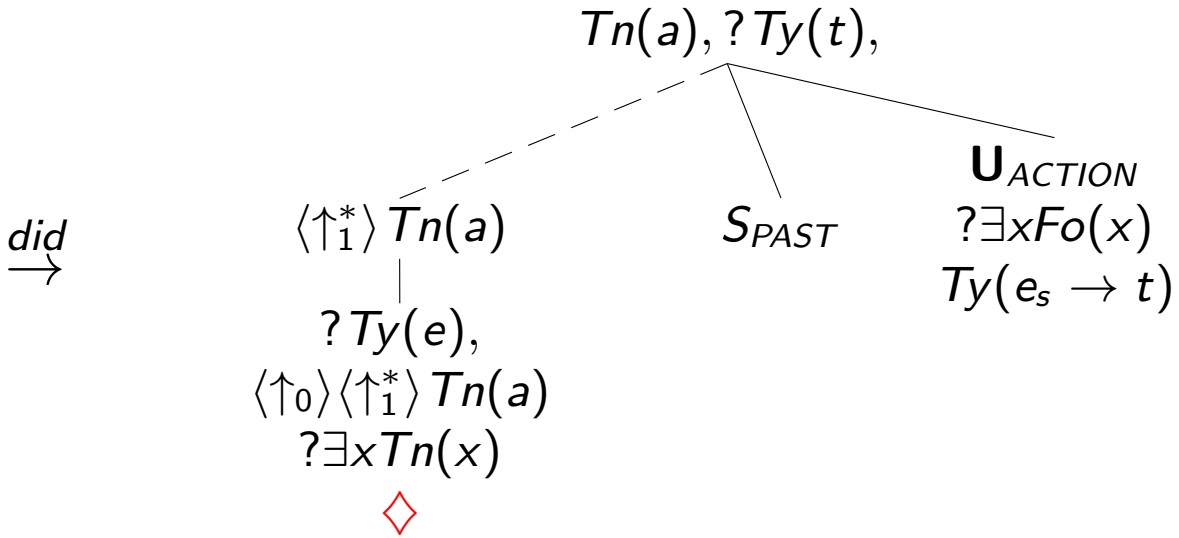

IF	$Tn(a)?Ty(t)$		
THEN	IF	$\downarrow \top$	THEN Abort
	ELSE	IF	$\langle\downarrow^1_*\rangle\langle\downarrow_0\rangle\bot$
		THEN	$\texttt{put}(Q);\texttt{make}(\langle\downarrow_0\rangle) : \texttt{go}(\langle\downarrow_0\rangle);$ $\texttt{put}(Ty(e_s), Fo(\mathbf{S}_{PAST}), ?\exists x Fo(x));\texttt{go}(\langle\uparrow_0\rangle);\texttt{make}(\langle\downarrow_1\rangle);$ $\texttt{go}(\langle\downarrow_1\rangle);\texttt{put}(Fo(\mathbf{U}), Ty(e_s \rightarrow t));\texttt{go}(\langle\uparrow_1\rangle);$ $\texttt{make}(\langle\downarrow^1_*\rangle\langle\downarrow_0\rangle);\texttt{go}(\langle\downarrow^1_*\rangle\langle\downarrow_0\rangle);\texttt{put}(?Ty(e), ?\exists x Tn(x))$
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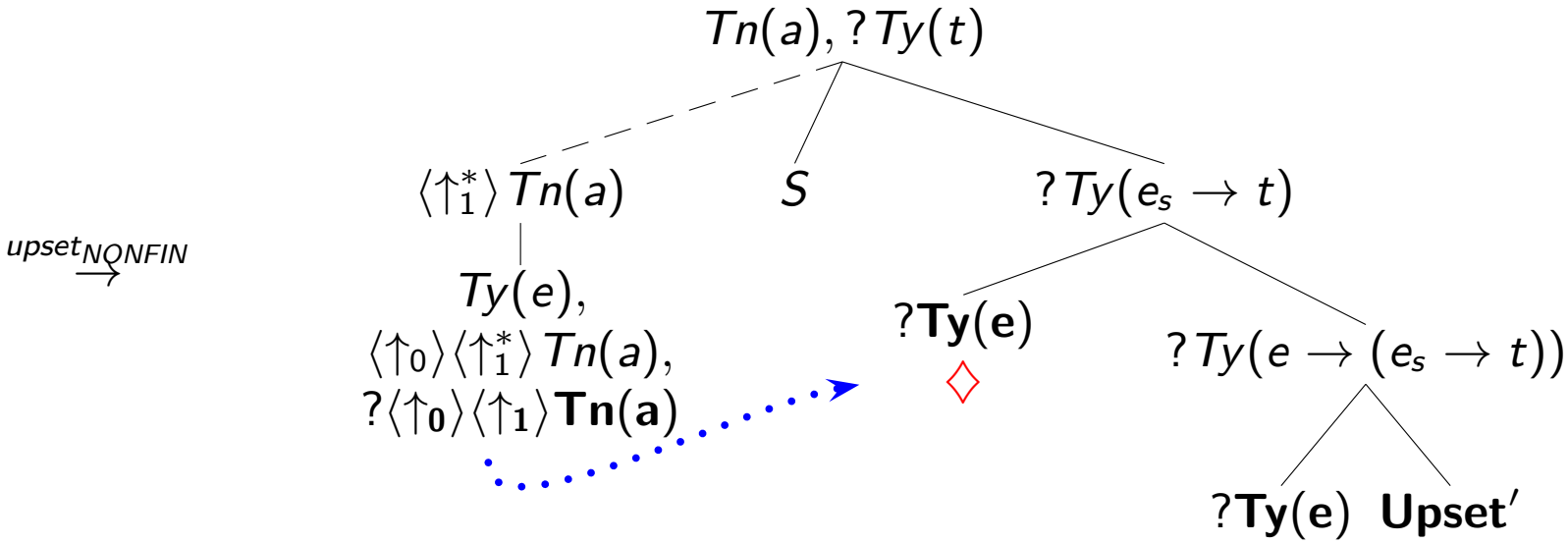
Verbs projecting full propositional skeletal template



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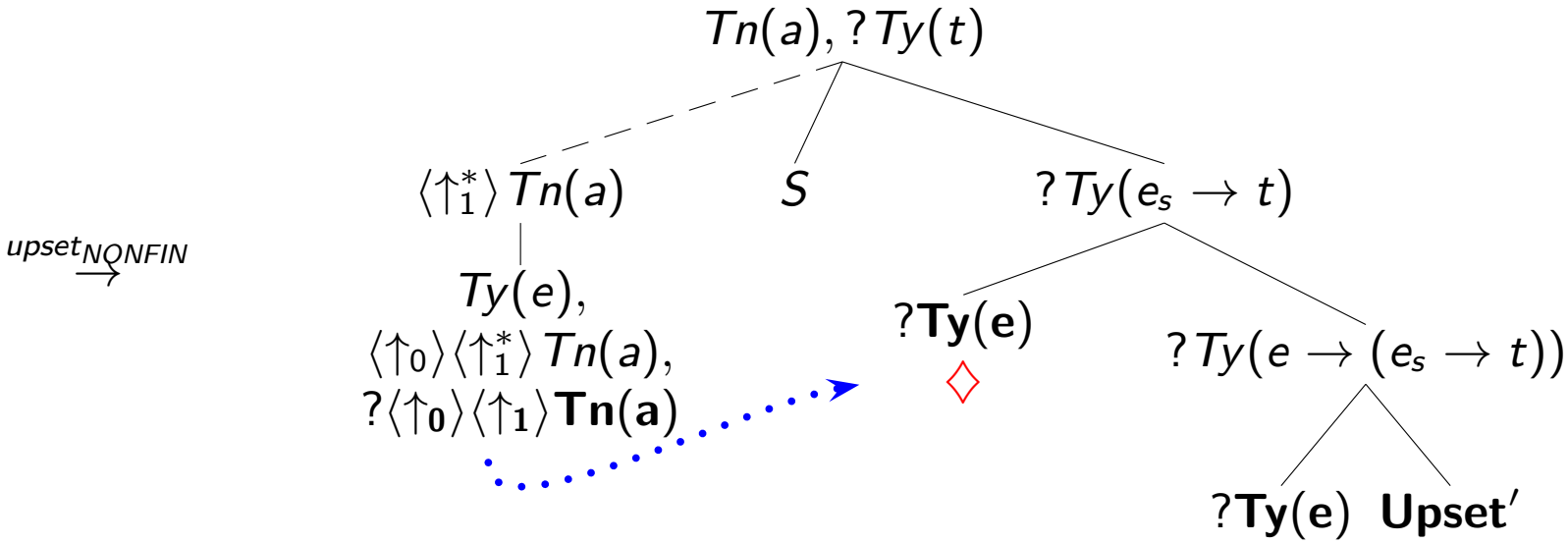

Verbs can't occur initially (imperatives apart), they need some locally projected term, which in a nonpassive form they fix as the logical subject, they overlay the structure provided by the auxiliary and expand it:

IF	$Tn(a)?Ty(t)$	
THEN	IF	$\langle\downarrow_*^1\rangle\langle\downarrow_0\rangle\top$
	THEN	$\texttt{go}(\langle\downarrow_*^1\rangle\langle\downarrow_0\rangle); \texttt{put}(?\langle\uparrow_0\rangle\langle\uparrow_1\rangle Tn(0)); \texttt{go}(\langle\uparrow_0\rangle\langle\uparrow_*^1\rangle Tn(a));$ $\texttt{make}(\langle\downarrow_0\rangle) : \texttt{go}(\langle\downarrow_0\rangle); \texttt{put}(Ty(e_s), Fo(S), ?\exists x Fo(x)); \texttt{go}(\langle\uparrow_0\rangle)$ $\texttt{make}(\langle\downarrow_1\rangle); \texttt{go}(\langle\downarrow_1\rangle); \texttt{put}(?Ty(e_s \rightarrow t)); \texttt{make}(\langle\downarrow_0\rangle); \texttt{go}(\langle\downarrow_0\rangle);$ $\texttt{put}(?Ty(e)); \texttt{go}(\langle\uparrow_0\rangle); \texttt{make}(\langle\downarrow_1\rangle); \texttt{go}(\langle\downarrow_1\rangle); \texttt{put}(?Ty(e \rightarrow (e_s \rightarrow t)));$ $\texttt{make}(\langle\downarrow_0\rangle); \texttt{go}(\langle\downarrow_0\rangle); \texttt{put}(?Ty(e)); \texttt{go}(\langle\uparrow_0\rangle); \texttt{make}(\langle\downarrow_1\rangle); \texttt{go}(\langle\downarrow_1\rangle);$ $\texttt{put}(Fo(\text{Upset'}), Ty(e \rightarrow (e \rightarrow ((e_s \rightarrow t))))); \texttt{go}(\langle\uparrow_1\rangle\langle\uparrow_1\rangle)\texttt{go}(\langle\downarrow_0\rangle);$
	ELSE	Abort
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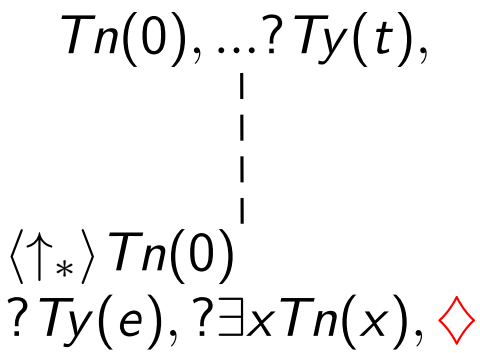
Structural Underspecification + update (discontinuity)

- Processing (13) *Who did Mary upset ?*

  Opening with just a simple unfixed node



Structural Underspecification + incremental update

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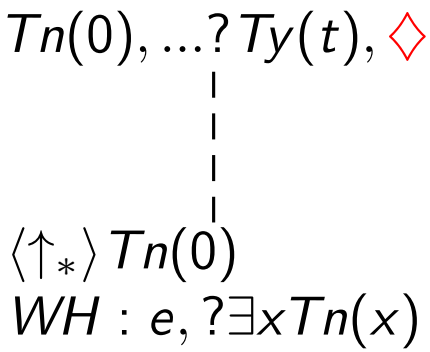
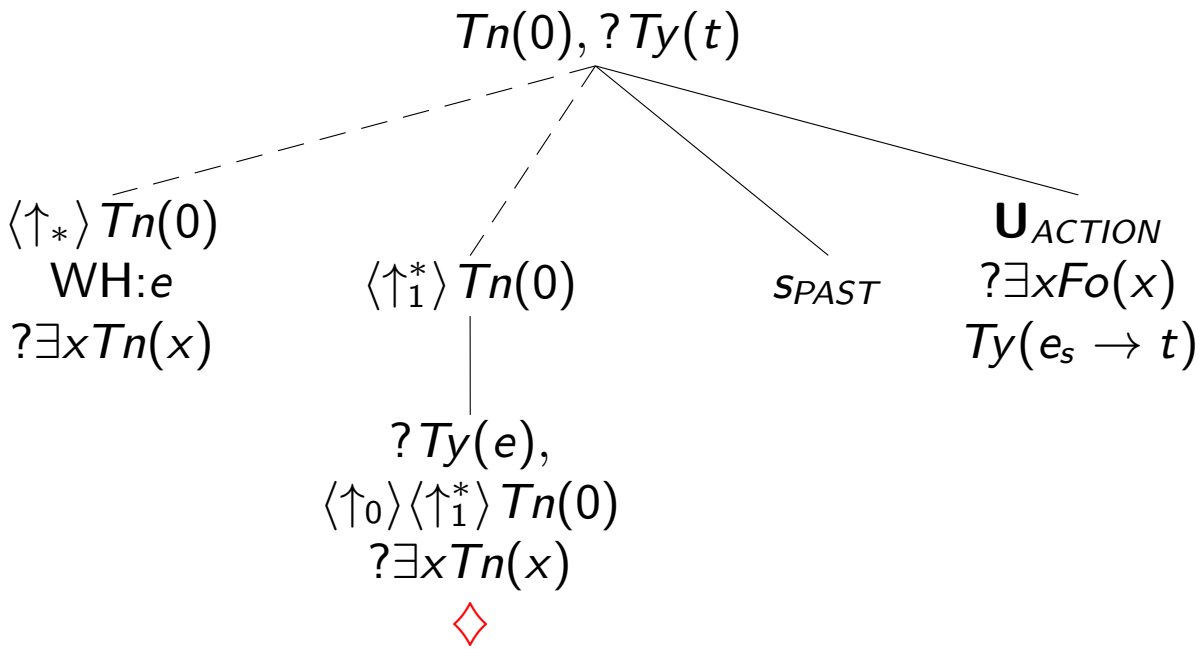


Structural Underspecification + incremental update

- Processing *Who did Mary upset?*
- Auxiliary projects propositional template with one internal locally unfixed term-node



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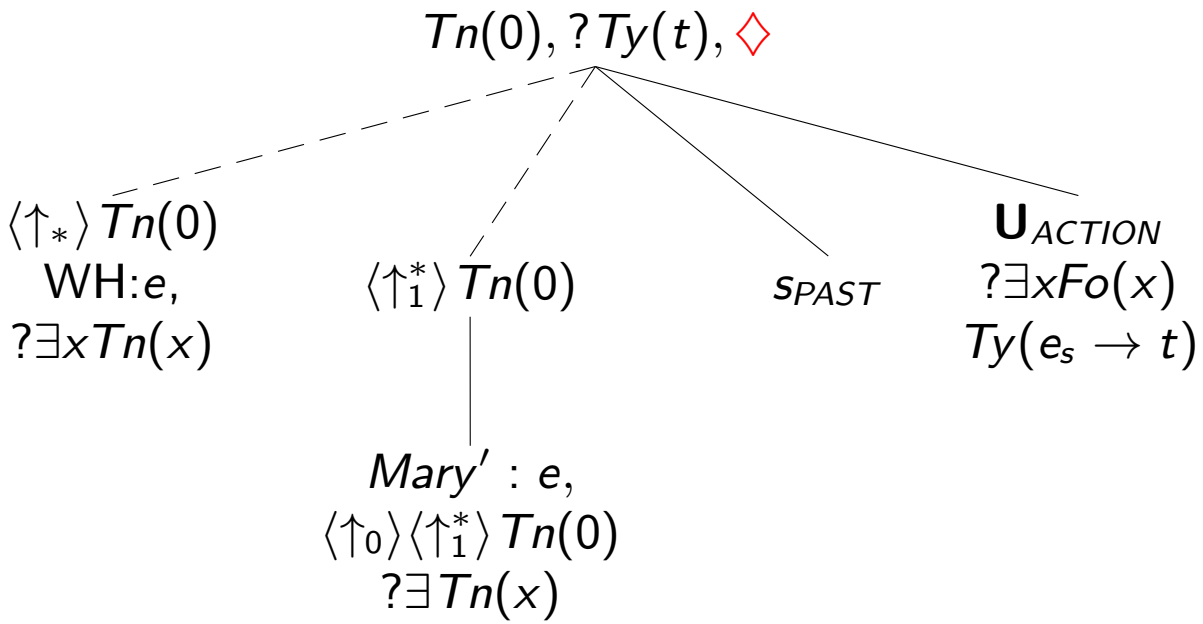

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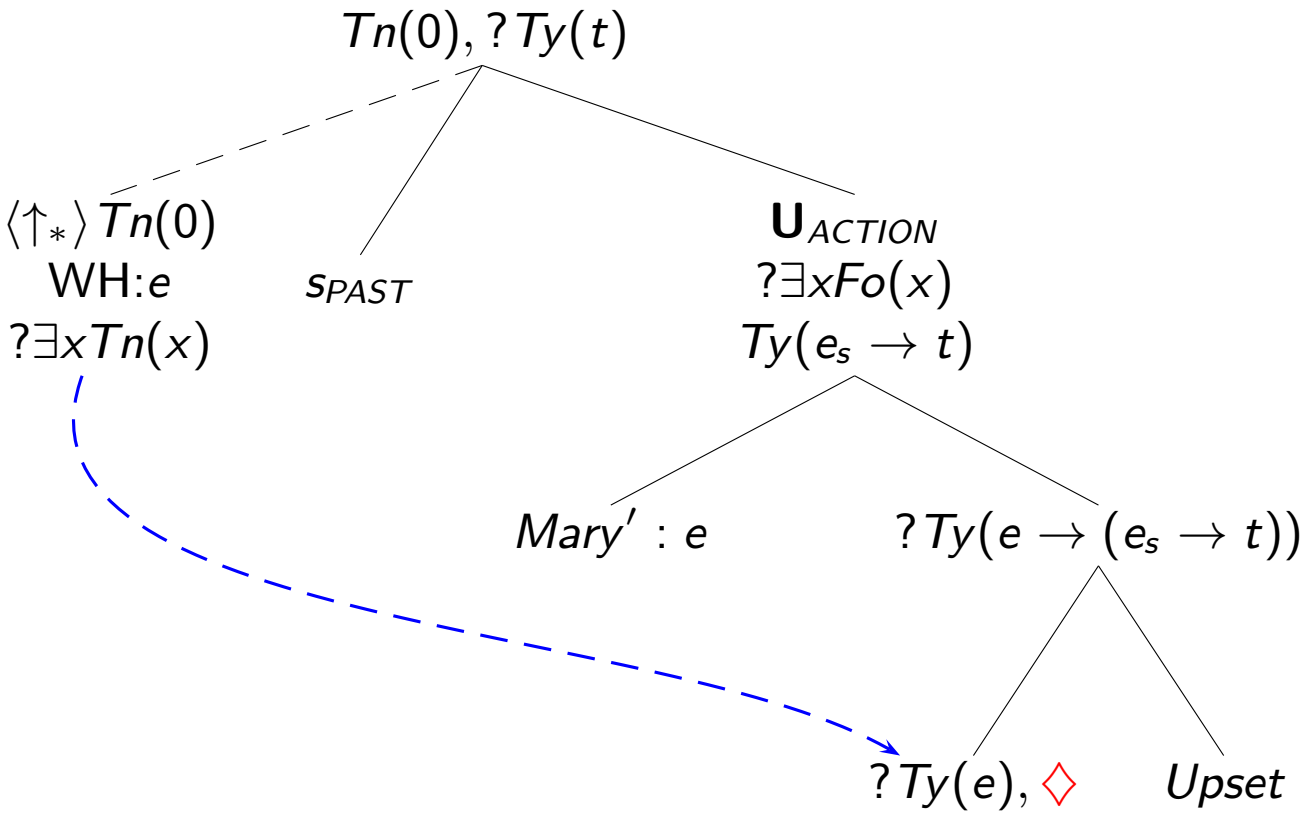
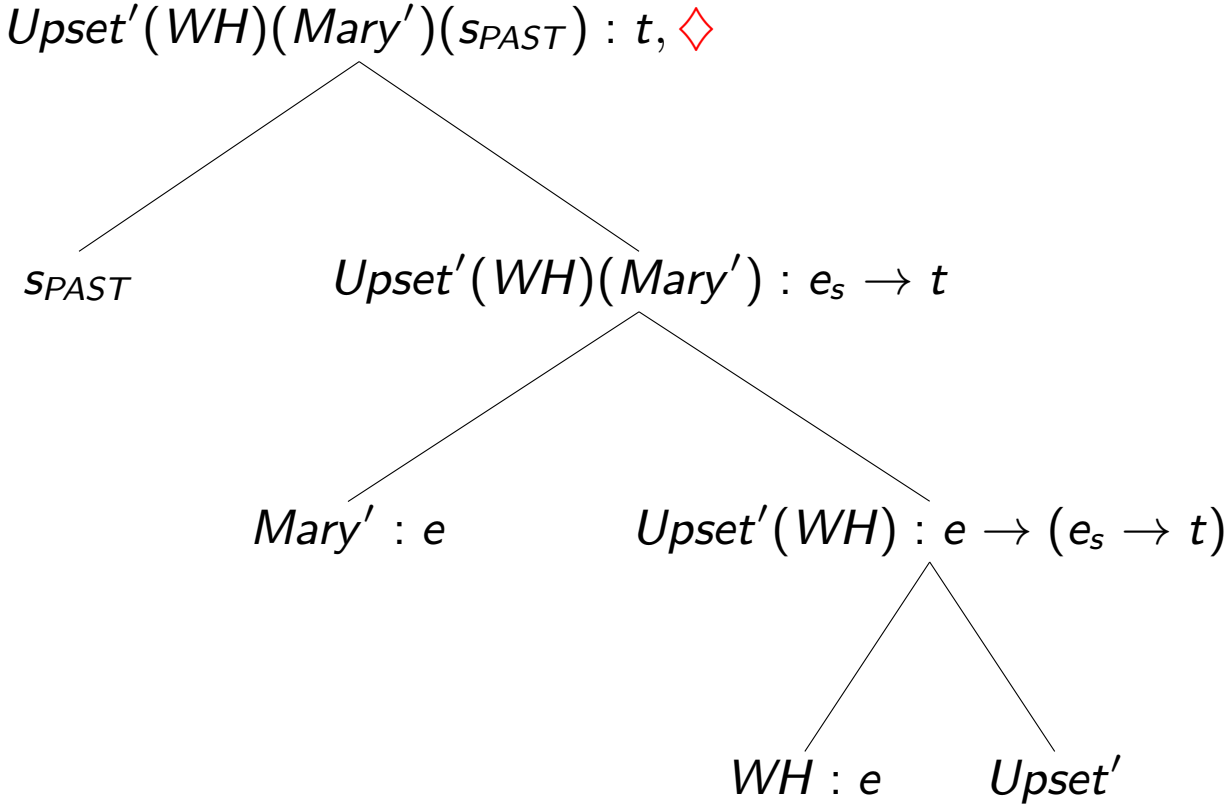


Structure Underspecification + update

- Completing the processing of *Who did Mary upset ?*



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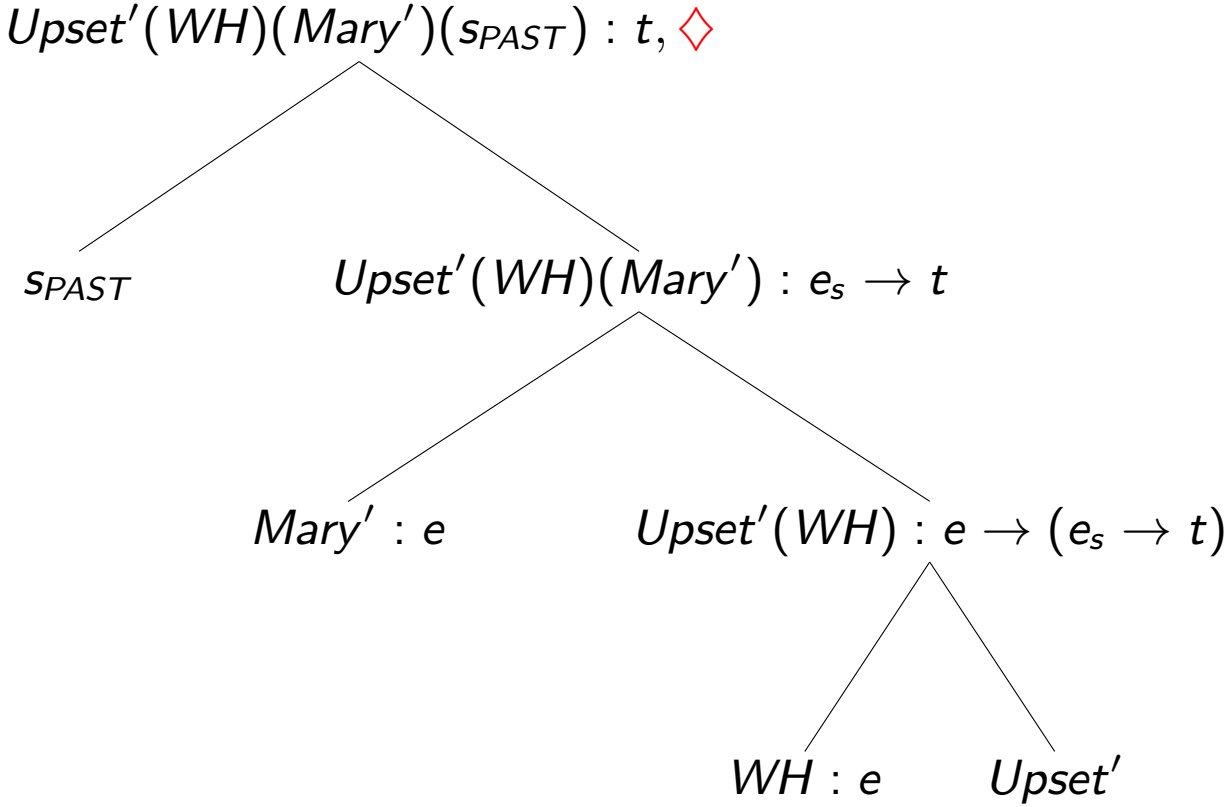

- Production equally follows these action sequences (thanks M.Stone, M. Purver), with attendant richer *goal tree* as a subsumption check so parsing/production operate in tandem

No possible derivation sequence = ungrammaticality

(14) *Did who Mary upset?

Ungrammatical

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(a) *Adjunction is precluded following the processing of the auxiliary by the presence of an event term node and event predicate, so WH can only be construed as decorating a locally unfixed node;
(b) But then Mary cannot be processed as a reconstruction of a locally unfixed node, as this would collapse with the WH-decorated node, which is precluded by consistency check and locality constraint on WH. Even it could, no decoration could then be provided for the object node. QED

Predictions of (non)-availability of ambiguities

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- Hence the projection of Who as decorating an unfixed node with Mary decorating the locally unfixed node is the only possible sequence of actions, and *Who did Mary upset?* is unambiguous.

Cross-language variation: Japanese Word order

Constituent order in Verb-final languages is free except for final verb

(16)

supai-ni,	shorui-o,	jaanarisuto-ga	watashita
spy-IO	document-DO	journalist-SUBJECT	hand-PAST

To the spy the journalist handed the document

Case serves to locally enrich a node initially locally unfixed, hence not precluded by the constraint debarring multiple unfixed nodes at any one time.

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Constituent order in Verb-final languages is free except for final verb

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supai-ni,	shorui-o,	jaanarisuto-ga	watashita
spy-IO	document-DO	journalist-SUBJECT	hand-PAST

To the spy the journalist handed the document

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Multiple long-distance dependency? Yes, but subject to a rigid locality restriction on the two left-peripheral elements, explicable as *Adjunction feeding Local*Adjunction applying as in simple clause:

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The police said that the journalist handed the document to the spy

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- Romance clitic clusters present a parallel cross-linguistic morphosyntactic puzzle, seen as calcified reflexes of Latin constituent-ordering preferences similarly constrained (Chatzikyriakidis & Kempson 2012 on clitic-cluster paradigm gaps French **On me lui présentera*, Spanish **Le me h'a dado*)

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Towards split utterances: context/content updates

- Partial trees as initial input and putative output:
  - speakers can start out with only partial thought in mind (partial trees as goal)
  - speakers can intervene with some partial contribution to this emergent structure (partial trees in context and goal)
  - context for parsing and production includes:
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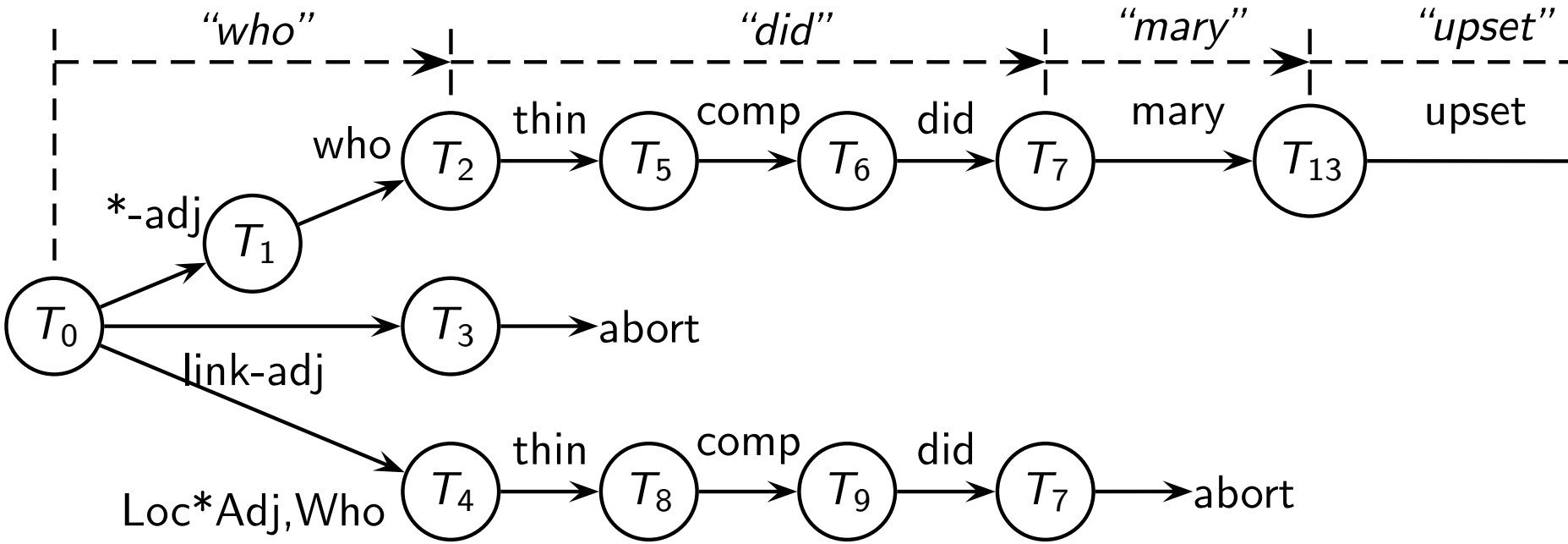
- Hence structure, content, and context all evolve.
- The dynamics of narrowing down derivational choices mapping onto TTR now interfacing with Cooper et al 2015

Hough & Purver 2014

- Parsing/generation context: a Directed Acyclic Graph
- DAG illustrates parsing/generation states: partial trees (nodes), licensed actions (edges), and words (higher-level edges)
- word edge arches over smaller parsing action edges it triggers

(Purver et al 2006, Cann et al 2007, Cann et al 2009, Sato 2011, Hough and Purver 2013, Eshghi et al 2013, Purver et al 2014, Hough 2015)

Capturing The Flow of DS derivational choices



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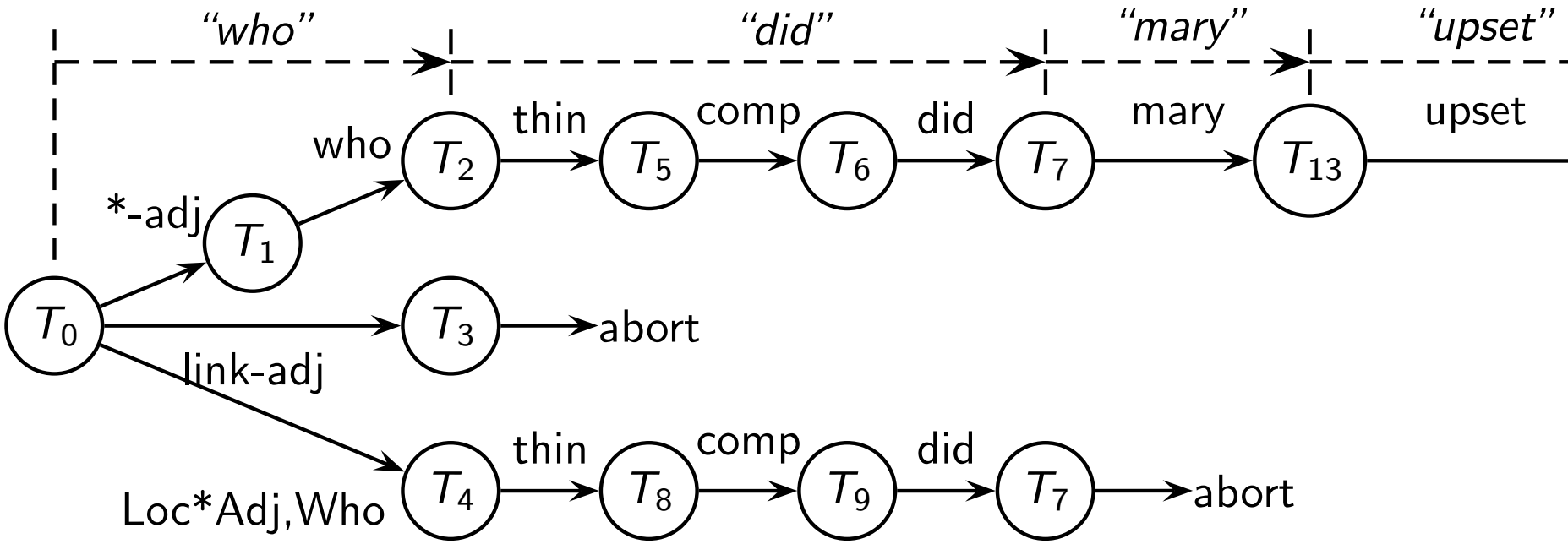

- Local backtracking in face of inconsistency to first compatible point in path expresses the fine-grained incrementality needed for:

(18) The yell- uh purple square.

Brennan and Schober 2001, Hough and Purver 2014

Compound utterances: interactive structure building

Hearer's prediction of upcoming input leads to lexical access; incremental licensing allows take-over with new goal:

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

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

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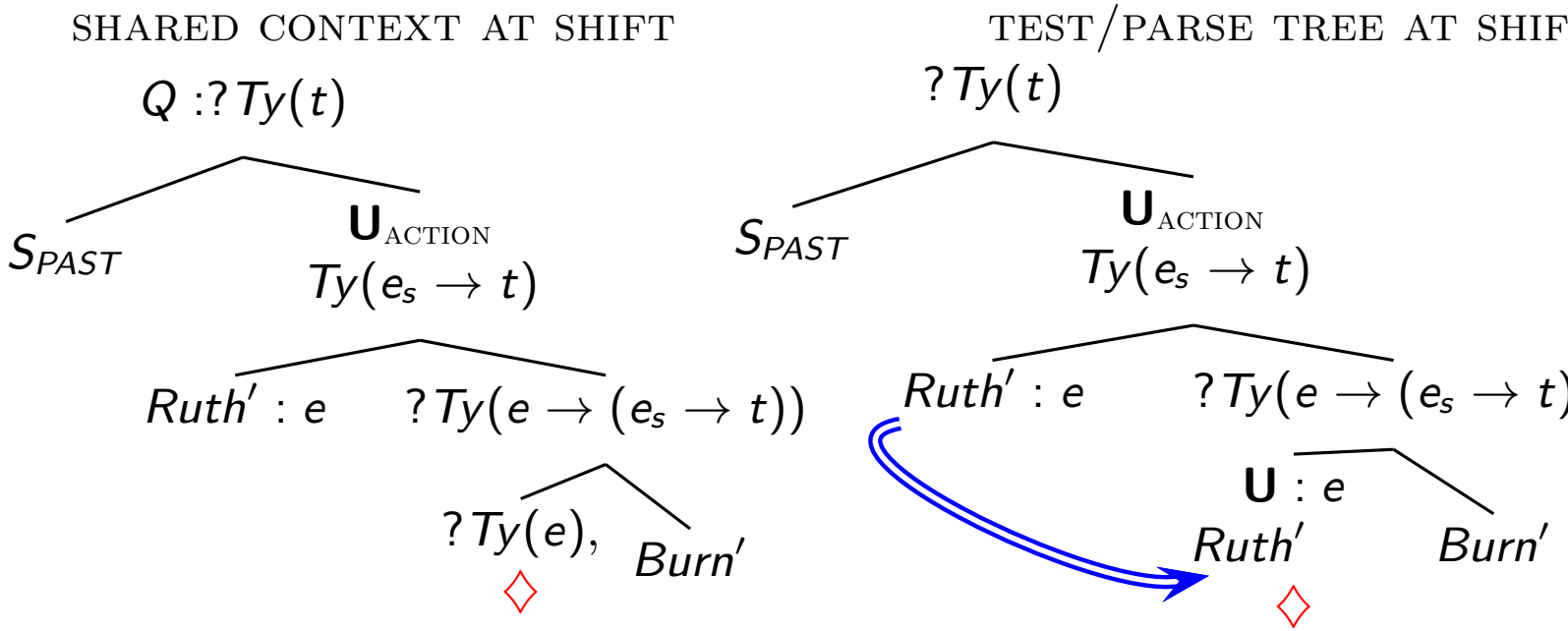

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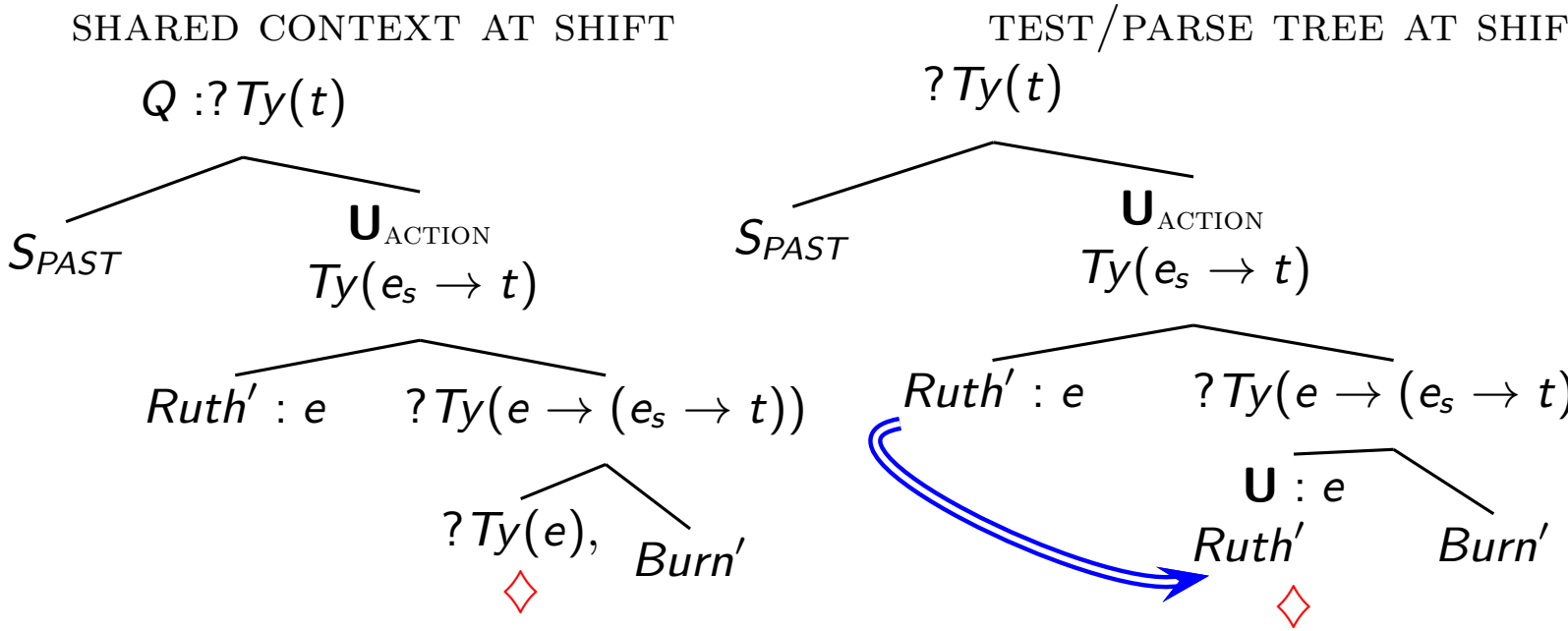

Speakers and hearers mirror each other's emergent structures, so role-shift licensed across all dependencies because each using own context

Structure building that extends/revises context yields interaction

- Resolving dependencies across role-switch is because

  parties are building up structure relative to own context and predictions

  - interactive exchange through complementary-actions coordination
- higher order mind-reading unnecessary

  - other-person perspective not calculated as metarepresentation

  [Gregoromichelaki et al 2011]
- DAG is a mechanism for self- and other-correction, clarifications, checking predictions against input, back-tracking in the face of inconsistency (prediction errors)

  [Hough 2015, Hough and Purver 2014]

Action-based Grammar

- A non-representationalist view of "syntax"
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  - Local/universal grammar-defined procedures induce interaction/coordination effects
- No necessary intention recognition or mind reading
  - parsing/production use the same processes: no separate parsing/production modules related solely via central reasoning
  - Syntax an embodied skill consisting of coupled interlocutor actions for incremental predictive processing in context.
- With grammars defined as mechanisms for information/action coordination, languages are tools evolved for interaction.

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constructing an adequate match of the world: Clark 2016

- Perception as action: constructing/guessing a representation of what is anticipated replaces bottom up flow of information: a generative probabilistic model with prediction errors as driving force.
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- Affordance competition hypothesis. Brain specifies in parallel several potential actions, which compete against each for further processing until all but one winnowed out
- The system is self-organising, learning from own guess filtered by progressive ongoing flow of input stimuli

what language contributes - the Clark view

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- Invokes as an advantage of language its boosting of intelligence
- Co-construction in dialogue limited to seeking to match other's expectations (citing Pickering and Garrod's efference-copy view of parsing/production)
- language enables top-level "script sharing" "brain-to-brain coupling" and "collective negotiation of shared representational spaces"
(citing Frith, the proto-Gricean, "shared brain" view" 2006)

What the Clark application to language misses

- It is too strong
  - Dialogue coordination seen as constructing representations to match other's expectations (retaining mind-reading view (Tylen et al 2010, Friston & Frith 2014))
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- What the Clark PP perspective lacks is the view of language as evolved for interaction

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- built in self- and other-correction yields step-wise weeding out of options (Eshghi et al IWCS 2015)

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  - emergent evidence shows time-critical, highly local, and strictly incremental perspective crucial to minimizing search space (Hough & Purver 2014a)
  - prediction and twinned generation of unfolding actions deliver fragments of information "just in time for use", with individual language restrictions on word ordering and the obligatory online incremental processing optimizing such cost-benefit factors (Hough 2015)

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  - With reiteration, we get routinisation of sequences as cued by intonation/consonant-cluster patterns etc, with low-level prosodic constraints leading to separate listing of macros relative to a given "name" - eg clitic clusters)

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  - Group effects are emergent (without invoking normativity as an externally imposed pressure) (Bickard 2009)
- language enables us to surf uncertainty together, even though doing our own thing (no social brain hypothesis).

What we no longer need to invoke

- What is left behind (following Shieber & Lappin 2007):
  - a rich set of unexplained innates
  - a sudden switch explanation for how language evolved
  - language evolution as in principle different in kind from historical change

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- The explanation: strongly functionalist but not circular
- The final hope: seeing language as intrinsically a tool for interacting in real time opens up the chance of an explanation of why and how the language capacity developed, inexorably.

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