Semantic primitives at the syntax-lexicon interface*

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comments welcome!

Abstract

A perennial debate regarding the interface between conceptual ontologies, the lexicon, the syntax, and the semantics concerns the extent to which different predicates are associated with different argument structure configurations. Understanding what components of meaning influence the syntax and how these notions should be formalized are notoriously difficult tasks. Focusing on the lexical roots that make up verbs, we propose a theory of the syntax-lexical semantics interface designed to make explicit the relationship between semantic primitives and syntactic/semantic composition. Framed in the assumptions of the Minimalist Program and Distributed Morphology, our proposal consists of two main components. The first is that semantic primitives, which are grounded in grammatically-relevant conceptual terms, are part of the denotation of different verb classes. The second holds that (verbal) roots have formal types. This theory is tested on the ontology of root/verb classes discussed by Levinson (2007, 2010, 2014). We show how the differences between three verb classes with respect to three different syntactic diagnostics can be explained using the tools above in a compositional semantics, with consequences for the interfaces between the lexicon, the syntax, and the semantics.

1 Introduction

An abiding question in the syntax-semantics interface is that of how to account for systematic patterns across verbs and their arguments. This question historically focuses on patterns in the verbal domain and whether well-known patterns like those in (1)–(3) are due to the syntax, the lexicon (constraining on the syntax) or the semantics.

(1) a. John ate a pizza.
     b. John ate.

(2) a. John devoured a pizza.
     b. *John devoured.

(3) a. *John dined (a) pizza.
     b. John dined on (a) pizza.
     c. John dined.

Much work in contemporary syntax implicitly assumes that patterns like these are accounted for, where explicit accounts either make reference to theta-roles (Gruber, 1965; Fillmore, 1968; Chomsky, 1981) or to Manner/Result Complementarity (Levin and Rappaport Hovav, 2005). The former encode the fact that certain verbs require certain complements; the latter are able to categorize verbs into classes, but such approaches do not formally explain why, for example, Manner verbs (like *ate*) do not require an internal argument.

This paper analyzes the contrasts between three verb classes in English: **Explicit Creation verbs**, **Change of State** verbs, and **Root Creation** verbs Levinson (2007, 2010, 2014). Our formal approach to the syntax-lexicon interface is compatible with contemporary assumptions about syntax and argument structure in the Minimalist program and Distributed Morphology, and informed by a long line of research in lexical semantics.

The verb classes of interest are distinguished with regard to three syntactic diagnostics.[1] The **No object** diagnostic—"obligatory theme" in Levinson (2014)—distinguishes Explicit Creation verbs from Change of State and Root Creation verbs such that verbs built with Explicit Creation roots are acceptable without an object, (4). Change of State and Root Creation verbs require an object.

(4) Diagnostic: No obligatory object (agentive reading)

     a. John baked (all day).   (Explicit Creation)
     b. *John cleared (all day).   (Change of State)
     c. *The kids piled (all day).   (Root Creation)

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[1]These generalizations are familiar from Levinson's work, but we have also confirmed them in an acceptability rating task (see OSF repository `https://osf.io/sf4bg/?view_only=e194d8ce05f141e29201ec31ea501d66` for details). In short, the task involved three verbs from each class, where each verb was tested once in each syntactic context. The judgments given throughout the paper reflect our experimental findings, which can be found in full online.

The **Pseudo-resultative** diagnostic distinguishes Root Creation verbs from the other two. The relevant reading for a pseudo-resultative predication is that the theme of the vP is interpreted as the material out of which a thing denoted by the verb (e.g., a braid) is created. The pseudo-resultative phrase modifies this created thing. In (5), subscripts indicate which elements are related in the resultative interpretation.

(5)   Diagnostic: Pseudo-resultative
    a.   John baked [the cake]$_i$ cripsy$_i$.   (Explicit Creation)
    b.   John cleared [the table]$_i$ clean$_i$.   (Change of State)
    c.   #Lisa braided$_i$ [her hair] tight$_i$.   (Root Creation)

The **Double object** construction is possible with Explicit Creation verbs and in some cases with Change of State verbs (when a transfer-of-possession reading is available). But double objects are not possible with Root Creation verbs (6):

(6)   Double object diagnostic
    a.   John baked his mom a cake.   (Explicit Creation)
    b.   John opened his mom a beer.   (Change-of-state)
    c.   *John piled his mom some cushions.   (Root Creation)

In contemporary approaches to argument structure, questions of the division of labor between the syntax and the semantics illustrated in the data above can be put in Embick's (2009) framing (foreshadowed in Marantz 1997), in terms of (verbal) roots: What is needed is a theory of what meanings roots have inherently, and a theory of what types of syntactic environments different roots are compatible with. This paper presents a way of sorting out these questions in a way that makes precise the division of labor between the syntax and different aspects of the semantics in the verbal domain. Concretely, we show how semantic primitives encoded within root denotations lead to syntactic effects. Our approach thus aims to synthesize work in lexical semantics with mainstream generative syntax.

The paper is structured as follows: Section 2 presents additional some background and technical details on the two assumptions that are central to our approach: the assumption that roots have formal semantic types, and the notion that some aspects of root-meaning are grammatically-privileged. Section 3 illustrates the system in simple transitive contexts. Sections 4-6 then derive the results of the three syntactic diagnostics for our three verb classes. In Section 7 we contrast our approach with an alternative theory of the syntax-lexicon interface, an approach that we call the hybrid, type-driven approach. Section 8 concludes.

2   Assumptions and background

In this section we expand on the background to our study (Section 2.1), sketch our assumptions and proposal (Section 2.2), and preview our analysis of the verb

classes and alternations introduced above (Section 2.3).

2.1   The syntax-lexicon interface

Our introduction demonstrated a number of cases where the lexicon influences the syntax. How should this phenomenon be analyzed in contemporary Minimalist syntax? It seems to us that there are three possible approaches. Our own view is that the syntax is free to generate syntactically well-formed structures, but lexical *roots* can impose semantic constraints at Logical Form (LF). In this way, the interfaces can be said to not only interpret but also "filter" the output of the syntax (Marantz, 2013; Wood, 2015; Wood and Marantz, 2017; Myler, 2017; Kastner, 2020).

A contrasting approach would deny any involvement of lexical semantics in the grammar. On this view, all roots are compatible with all (well-formed) syntactic structures. Therefore, the fact that e.g. (3a) is unacceptable has to do with extreme semantic anomaly or perhaps simply our lack of imagination in our ability to conceive of an event that could be described as "devouring" without including the thing that is devoured. This view might be exemplified by approaches that assume Exo-Skeletal models of the grammar (Borer, 2005a,b; Acedo-Matellán and Mateu, 2014). In such approaches, components of meaning that in our system are associated with root denotations are located on functional heads in the syntax.

The third approach might hypothesize that root classes are categorized by formal semantic *type*, but root denotations are relatively impoverished in their lexical semantic content; such content is instead encoded in silent functional heads in the syntax, as in Exo-skeletal approaches. In this approach, developed by Levinson (2007, 2010, 2014), roots and verbalizing heads have highly articulated formal semantic types such that there is nearly a one-to-one correspondence between root classes and functional verbalizing heads. In contrast to Exo-centric approaches in which root distribution is more free, this system is constrained by a tight mapping of roots to verbalizing heads. Because of this tight mapping, syntactic unacceptability is always analyzed as a formal semantic type clash. We refer to this approach as "the hybrid type-driven view" ("the hybrid view," for short) and discuss it in further depth in Section 7.

2.2   Architectural assumptions

The approach we defend here shares with Exo-skeletal approaches the notion of the independence of syntax—the vP structures that are available to the grammar are fully independent from the lexical semantic content of roots. It also builds on insights from the hybrid view in invoking semantically typed roots, but crucially draws on the idea that root denotations include "grammatically-privileged" conceptual terms (Levin, 2017; Rappaport Hovav, 2017). The system therefore allows for vPs that are structurally well-formed but unacceptable due to a mismatch be-

tween lexical semantic content and the syntactic environment in which a root finds itself.

As our general frameworks for syntactic structure-building and semantic composition we adopt the basic assumptions of the Minimalist Program (Chomsky, 1995) and the combinatoric operations of Heim and Kratzer (1998). Our approach to argument structure is situated within root-centric views of syntax-centric morphology, specifically Distributed Morphology (Halle and Marantz, 1993).

Our approach starts with two assumptions about the components of root meaning: the first assumption is that semantic primitives, grounded in grammatically-relevant conceptual terms, are part of the denotation of different verb classes (7a). The second assumptions maintains that (verbal) roots accordingly have formal semantic types and are limited to the types given in (7b).

(7)   **Two formal components of root meaning**

      a.   Semantic primitives that are grounded in grammatically-relevant conceptual terms are part of the denotations of different verb classes.

      b.   Verbal roots have formal semantic types. These types are limited to $\langle s, t \rangle$ and $\langle e, \langle s, t \rangle \rangle$.[2]

The goal of this system is to make explicit what elements of root denotations are syntactically relevant to argument structure alternations and syntactic acceptability. The main theoretical claim is that roots encode two components of meaning, above and beyond whatever components are not part of the formal grammar and can be said to be part of the Encyclopedia (Harley and Noyer, 2000; Harley, 2014)—e.g., the conceptual differences between same-class roots such as $\sqrt{\text{break}}$ and $\sqrt{\text{open}}$. We flesh out these two components next.

2.2.1   Component A: Root-specific semantic primitives

The first component of the system is the claim that the denotation of verb classes involves grammatically-relevant semantic primitives. Not all components of meaning have grammatical effects, of course, but some do and can be said to be "grammatically privileged" (Levin, 2017; Rappaport Hovav, 2017; Irwin, 2019). The role of root content—and its relevance for the syntax—has received little formal attention from syntacticians working in the Minimalist Program, although precursors to it can be found in work on lexical semantics, from Levin and Hovav (1991) to (Beavers and Koontz-Garboden, 2020).

In the lexical semantics literature, the dominant proposal that has been of interest to syntacticians starts with Rappaport Hovav and Levin (1998), who divides verbs into those containing the primitive Manner, and those containing Result (Levin and Rappaport Hovav, 2005; Beavers and Koontz-Garboden, 2012).[3] One

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[2]We use the following conventional variables for formal semantic types: e ranges over individuals; s ranges over eventualities (both events and states); t ranges over truth values. We use e as the type of all nominal arguments for simplicity.

[3]Theories of lexical semantics like those of Lieber (2004) and Pustejovsky (1995, 2013) propose

candidate for such components of meaning in these lines of research includes Manner and Result; other work proposes that predicates such as BECOME() are part of the denotation of certain verb/root classes (Beavers and Koontz-Garboden, 2020).

So although (A) is not controversial, there is much debate about the nature and granularity of such primitives. Possible candidates for syntactically-relevant primitives have included types of reflexivity (Schäfer, 2008; Alexiadou, 2015; Alexiadou et al., 2015; Spathas et al., 2015; Kastner, 2017); scales of causation (Marantz, 1997; Alexiadou et al., 2006, 2015); telicity and scalar change (Folli, 2001; Zubizarreta and Oh, 2007; Kelly, 2013; Rappaport Hovav, 2014; Beavers and Koontz-Garboden, 2017; Melchin, 2019); animacy (Sorace, 2000; Jerro, 2020); alienable/inalienable possession (Myler, 2016; Irwin, 2019); verbs as denoting events, states or entities (Harley, 2005; Roßdeutscher, 2014), contact at a point or a region (Levin, 2017), metaphorical uses (Meir, 2010), force (Copley, 2019), ingestion (Jerro, 2019) and lexical verbs vs. light verbs (Ramchand, 2014). What is most concerning from an architectural perspective is that these primitives are often encoded outside of the formal system, rendering their effects difficult to test.

2.2.2 Component B: Semantic types for roots

Component (B) constrains formal semantic types of verbal roots in the syntax, thus capturing the distinction between core and non-core arguments to verbs (Levin, 1999). The idea that roots have formal semantic types has received somewhat limited attention, although it has been recently revisited by Coon (2019) and Henderson (2019) Chuj and Kaqchikel, respectively. This idea has been applied to argument structure by Levinson (2007)— building on a proposal in Harley (2005)—in the hybrid account to be contrasted with our own proposal.

In all approaches to roots, it should be emphasized that roots lack syntactic *category* even if they have a specific semantic *type*. These developments in the literature, together with the root-based architecture of DM, are why frame our discussion in terms of roots rather than verbs. But because our analysis focuses exclusively on verbs, the insights here can be implemented equally in more lexically-oriented frameworks. In Section 8 we return to the implications of our approach for cross-categorial issues.

2.3 Building verb classes

This section derives the three verb classes under consideration. We assume that verb phrases come in two forms: a vP either has an internal argument or it does not—and this is a property of the verbalizing head. Accordingly, the verbalizing head v can have one of the two denotations in (8), which we will soon see in action:

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detailed accounts of lexical semantics which are not focused on syntactic differences but are still part of this larger conversation. In a typical contrast like *the rock fell* vs. **the rock died*, what matters is which predicates are possible with which arguments once the syntax is factored out.

(8) $\llbracket v \rrbracket =$

    a. $\lambda x \lambda e.\text{Theme}(x,e)$ ("transitive", type $\langle e, \langle s, t \rangle \rangle$)

    b. $\lambda P.P$ ("intransitive", type $\langle s, t \rangle$)

The transitive variant (8a) introduces a Theme role in the semantics and (8b) does not. One reason to allow this freedom is because unergative verbs and even some unaccusative verbs allow transitive structures in certain cases, most notably with cognate objects (Nakajima, 2006; Oltra-Massuet, 2014). In other words, a transitive variant of the verb is in principle always possible unless ruled out in the semantics. For many of the derivations below, we also need a denotation for agentive Voice (Kratzer, 1996; Pylkkänen, 2008); this is given in (9).

(9) $\llbracket \text{Voice} \rrbracket = \lambda x \lambda e.\text{Agent}(x,e)$

Roots are always adjuncts (syntactically) and modifiers (semantically) of v (Marantz, 2013). Semantically, therefore, roots can combine with v only through the operations of EVENT IDENTIFICATION or PREDICATE COMPOSITION. We will see that this assumption distinguishes our approach from Exo-centric approaches and the hybrid approach —theories in which roots can variously serve as functions, arguments, and adjuncts.

    Turning to roots themselves, recall formal component (B), according to which verbal roots are of two formal semantic types: $\langle s, t \rangle$ or $\langle e, \langle s, t \rangle \rangle$. This division of labor between root and v means that there may be more than one source for the transitivity of a verb phrase. In other words, a vP might be transitive because it is built from a root that requires an argument (root is type $\langle e, \langle s, t \rangle \rangle$). On the other hand, vP might be transitive because it is built with a verbalizer that requires an argument (v is type $\langle e, \langle s, t \rangle \rangle$). This assumption helps understand "weakly transitive" verbs like *eat* with an optional internal argument; as discussed earlier, other approaches do not provide formal mechanisms to encode optional transitivity.

    Considering the relevant verb classes, Table 1 gives the formal semantic type for each root class along with the denotation for an example verb in each class.

Class of root	Semantic type	Example denotation
Explicit Creation (*bake, build*)	$\langle s, t \rangle$	$\llbracket \text{bake} \rrbracket = \lambda e.\text{bake}(e)$
Change of State (*open, break*)	$\langle e, \langle s, t \rangle \rangle$	$\llbracket \text{open} \rrbracket = \lambda x.\lambda e.\text{open}(e) \ \& \ \text{Theme}(x,e)$
Root Creation (*pile, braid*)	$\langle e, \langle s, t \rangle \rangle$	$\llbracket \text{pile} \rrbracket = \lambda x.\lambda e.\exists y. \text{ LUMP}(y) \ \& \ \text{pile}(e)$
		$\& \ \text{Theme}(x,e) \ \& \ \text{MADE-OF}()$

Table 1: Root classes, types, and example verb denotations.

The denotations for Explicit Creation and COS verbs are in Table 1 are somewhat unremarkable, but note the denotation of $\sqrt{\text{pile}}$. This denotation contains two semantic primitives, LUMP and MADE-OF, which we will show are implicated in the acceptability tests that distinguish these verb classes.

The patterns to be accounted for are summarized in Table 2, which essentially reproduces that of Levinson (2014:210). The checkmark under "No object" for Explicit Creation verbs indicates that these verbs do not require an object to form an acceptable vP.

Verb (from root)	No object	Pseudo-resultative	Double object
Explicit Creation	✓	✗	✓
Change of State	✗	✗	✓
Root Creation	✗	✓	✗

Table 2: Verb class patterns (see also Levinson 2014, Table 10.1).

Before we turn to the analyses that derive Table 2, we will provide basic derivations for transitive clauses in Section 3. But a note on the patterns to be explained is in place first.

The explicit discussion of syntactic and semantic factors allows us to identify several sources of sentence unacceptability. Some sources of unacceptability might be considered "narrowly" syntactic: failed licensing, failed feature checking, movement violations, and so on. These are not of direct interest in this paper. On the other hand, a structure might be well-formed syntactically but contain different semantic problems: a formal type clash, a failure in binding or scope-taking, an unsaturated predicate (leading to uninterpretability), an incompatibility between lexical semantic representation in a particular syntactic structure. This paper will focus on the two last sources of unacceptability, both of them semantic. In this paper, we take sentence unacceptability as the data to be explained. This is noteworthy because much work on lexical semantics focuses on entailments; that work takes the relationships between propositions as the data to be explained. Although both sources of data are important, our interest in the role of lexical semantic information in explicit syntactic structures leads us to take acceptability as the primary source of data here.

3 Baseline: Transitive and intransitive vPs

This section presents the basic patterns for transitive and intransitive vPs in the three root classes, showing the most unmarked contexts in which these verbs normally occur. Each root class is addressed in turn.

3.1 Explicit Creation vPs

Explicit Creation verbs like *bake*, *build* and *cook* typically name an activity in which something is created. They can clearly occur in unergative vPs, although including an adverbial often improves the sentence overall (10).
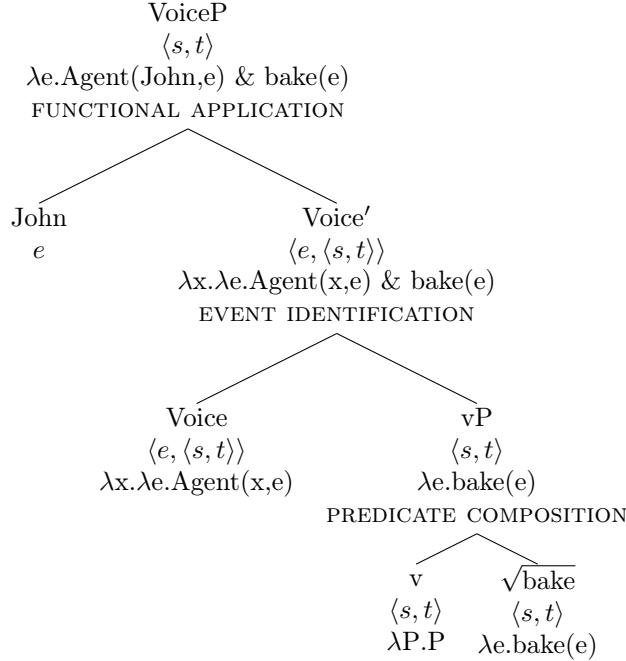
(10)   John was baking (all day).

In terms of argument structure, there is no theme involved in this event (see additional discussion in Section 4.1). On our analysis, the root is of type $\langle s, t \rangle$ and does not introduce a theme. When verbs like *bake* are transitive, the theme comes from the verbalizing head. An example denotation of an Explicit Creation verb is given in (11).

(11) $[\![\sqrt{\text{bake}}]\!] = \lambda e.\text{bake}(e)$

The derivation of (10) in our system is shown in (12). Each node in the syntactic structure is annotated with the semantic computation that led to the node and the semantic type of the node. Event variables are given as type e in the lambda formulas, and events are shown as type s in lines that indicate the formal semantic types (The distinction between dynamic and stative events is not necessary in our approach, contra e.g., Levinson 2010.)

(12)   John baked (all day yesterday).

$$
\begin{array}{c}
\text{VoiceP} \\
\langle s, t \rangle \\
\lambda e.\text{Agent(John,e)} \ \& \ \text{bake}(e) \\
\text{FUNCTIONAL APPLICATION}
\end{array}
$$

- John, e
- Voice$'$, $\langle e, \langle s, t \rangle \rangle$, $\lambda x.\lambda e.\text{Agent(x,e)} \ \& \ \text{bake}(e)$, EVENT IDENTIFICATION
  - Voice, $\langle e, \langle s, t \rangle \rangle$, $\lambda x.\lambda e.\text{Agent(x,e)}$
  - vP, $\langle s, t \rangle$, $\lambda e.\text{bake}(e)$, PREDICATE COMPOSITION
    - v, $\langle s, t \rangle$, $\lambda P.P$
    - $\sqrt{\text{bake}}$, $\langle s, t \rangle$, $\lambda e.\text{bake}(e)$

Explicit Creation verbs like *bake* can clearly also occur in transitive vPs. Transitive vPs with Explicit Creation verbs come about when the transitive variant of v is merged, as in (13). The only difference between the intransitive structure (12) and the transitive structure (13) is that the intransitive vP is headed by $v_{\langle s,t \rangle}$ (without a THEME() predicate) and the transitive vP is headed by $v_{\langle e, \langle s,t \rangle \rangle}$ (with a THEME() predicate). The root here does not require a theme but the verbalizer might. We leave out discussion of anticausatives (as in, *the cookies baked in the oven*) since for these the Voice layer is simply not merged (Alexiadou et al., 2015).

(13)   John baked a cake.

VoiceP
$\langle s,t \rangle$
λe.Agent(John,e) & bake(a cake,e)
FUNCTIONAL APPLICATION

John
e

Voice′
$\langle e, \langle s,t \rangle \rangle$
λx.λe.Agent(x,e) & bake(e) & Theme(a cake, e)
EVENT IDENTIFICATION

Voice
$\langle e, \langle s,t \rangle \rangle$
λx.λe.Agent(x,e)

vP
$\langle s,t \rangle$
λe.bake(e) & Theme(a cake, e)
FUNCTIONAL APPLICATION

v
$\langle e, \langle s,t \rangle \rangle$
λx.λe.bake(e) & Theme(x,e)
EVENT IDENTIFICATION

DP
a cake
e

v
$\langle e, \langle s,t \rangle \rangle$
λxλe.Theme(x,e)

√bake
$\langle s,t \rangle$
λe.bake(e)
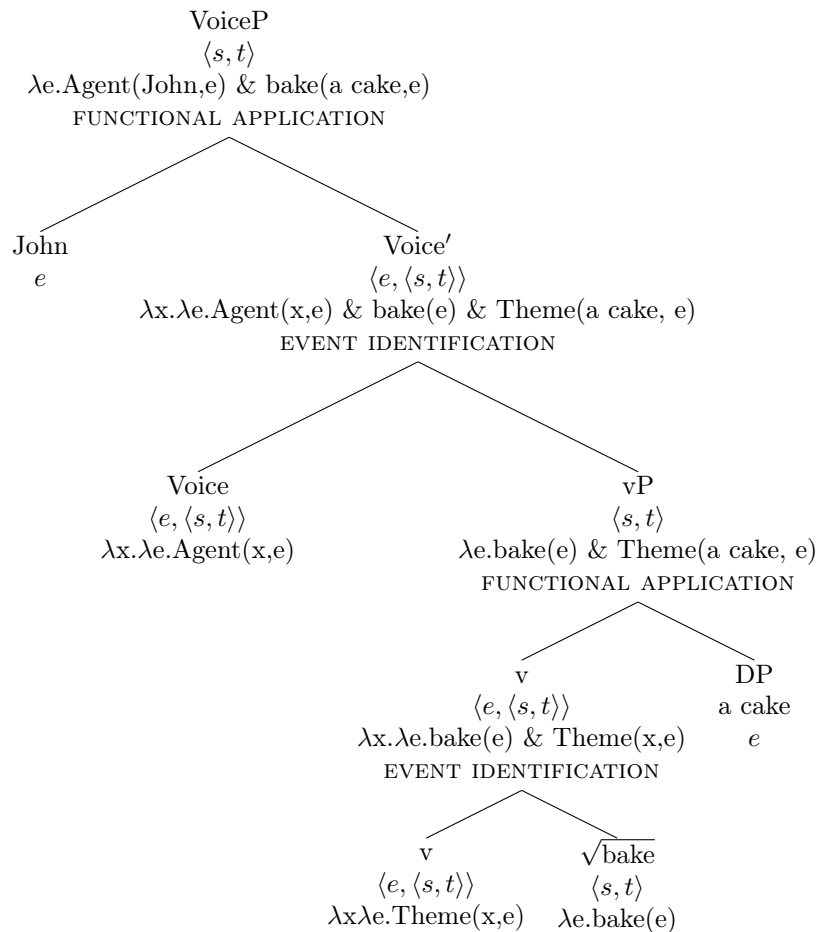
As noted in the introduction, even basic derivations like these are often not made explicit in the argument structure literature. Since the focus of different authors is either on the syntax more broadly or or the (lexical) semantics, one of the two is usually discussed at the expense of the other. This means that if we wish to compare the derivations above to existing work, there are few contenders where explicit proposals can be found. We compare the system as a whole to other approaches in Section 7.

3.2 Change of State vPs

We turn now to Change of State (COS) verbs such as *open, break*, and *clear*, which denote a change of state for their obligatory internal argument:

(14)   a.   John opened the door
          b.   The door opened.
          c.   *John was opening (all day).   *(agentive reading)*

This property of COS verbs is encoded as part of the root; COS roots include a THEME predicate (type $\langle e, \langle s,t \rangle \rangle$), as shown in the example denotation in (15).

(15) $[\![$open$]\!]$ = λx.λe.open(e) & Theme(x,e)

The tree in (16) illustrates the composition in a simple transitive COS sentence up through the introduction of the external argument, assuming the denotation of *open* in (15). We assume for simplicity that $\sqrt{\text{open}}$ combines with $v_{\langle s,t \rangle}$, the intransitive variant of the verbalizer.

(16)   John opened the door.

VoiceP
$\langle s,t \rangle$
λe.Agent(John,e) & open(e) & Theme(the door, e)
FUNCTIONAL APPLICATION

John
e

Voice′
$\langle e, \langle s,t \rangle \rangle$
λx λe.Agent(x,e) & open(e) & Theme(the door, e)
EVENT IDENTIFICATION

Voice
$\langle e, \langle s,t \rangle \rangle$
λx λe.Agent(x,e)

vP
$\langle s,t \rangle$
λe.open(e) & Theme(the door, e)

v
$\langle e, \langle s,t \rangle \rangle$
λx.λe.open(e) & Theme(x,e)
EVENT IDENTIFICATION

DP
the door
e

v
$\langle s,t \rangle$

$\sqrt{\text{open}}$
$\langle e, \langle s,t \rangle \rangle$
λx.λe.open(e) & Theme(x,e)
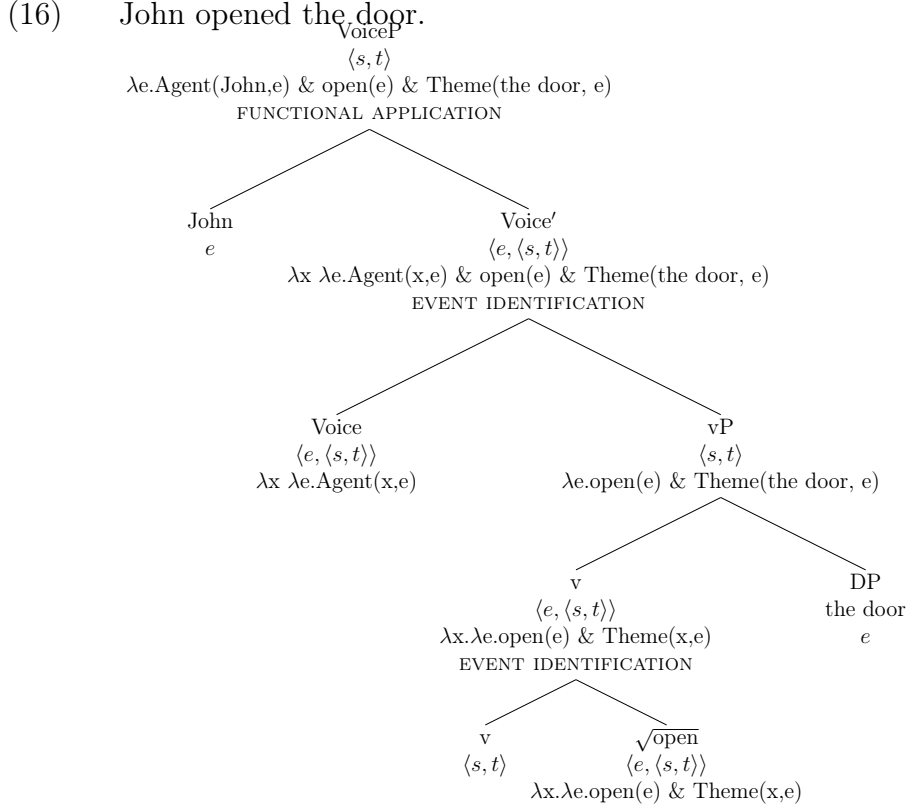
The tree in (16) is very similar to the tree for transitive *bake* in (13). Both vPs are transitive, but for *bake*, the transitivity comes from v; for *open*, transitivity comes from the root (cf. the RESULT entailment of Beavers and Koontz-Garboden 2020). And while we assumed that intransitive v combines with the root in (13), the same outcome would result if it is transitive v that the root modifies (since the Theme role is introduced by the root either way).

While many COS verbs also famously allow for anticausative variants (Haspelmath 1993, Levin and Rappaport Hovav 1995, a.m.o), we set these derivations aside for reasons of space, as we have done with the Explicit Creation Verbs.

3.3   Root Creation vPs

Before showing the derivation of vPs with Root Creation verbs (e.g. *pile, stack, braid*), we must first provide some additional background. Unlike well-established verb classes such as Manner and Result, Root Creation verbs (Levinson, 2010,

2014) and the related "implicit creation verbs" (Geuder, 2000; Osswald, 2005; Levinson, 2007) have only been discussed sporadically in the literature. In English, these verbs are typically denominal (Clark and Clark, 1979).[4] We provide a brief overview of what makes their lexical semantics special and how we encode this in our current approach.

3.3.1 The logic of Root Creation vPs

Like Change of State verbs, Root Creation verbs can form only transitive vPs (17):

(17) a. The kids piled the cushions.
      b. *The kids piled.   (*agentive reading*)

The intuition about Root Creation verbs is twofold. First, these verbs always have an internal argument, a direct object—e.g., *the cushions* in (17a). Second, this direct object names the material out of which a thing indicated by the root is formed. For example, when a person piles some cushions, a pile (made of cushions) is formed; if they stack some books, a stack (made of books) is created; when we braid someone's hair, a braid (of hair) is formed, and so on.

As Levinson (2010) shows, the entailments for Root Creation verbs differ from those of, for instance, Explicit Creation verbs. The latter entail the Explicit Creation of the direct object (18). But Root Creation verbs entail the creation of what is named by the root (19). This property of Root Creation verbs can be diagnosed using a special kind of resultative reading, as we will see in Section 5.

(18) John cooked a **dish**.	(19) Mary **braided** her hair.
a. $\not\Rightarrow$A cook was created.	a. $\Rightarrow$A **braid** was created.
b. $\overset{?}{\Rightarrow}$A cooked thing was created.	b. $\overset{?}{\Rightarrow}$A braided thing was created.
c. $\Rightarrow$A **dish** was created.	c. $\not\Rightarrow$Hair was created.

We analyze the formal type of Root Creation verbs as $\langle e, \langle s, t \rangle \rangle$, the same type as COS verbs. As can be seen from (17), Root Creation verbs take a direct object, just as COS verbs do. The difference between COS and Root Creation verbs is found in the lexical semantics of Root Creation verbs: they not only differ conceptually but also in their denotation. This part of our analysis will be important in the discussion of pseudo-resultative modification (Section 5) and double object constructions (Section 6).

Informally, our analysis of Root Creation verbs is as follows, using *pile* as an example: the verb *pile* is a function that takes an individual (the direct object) and an event and stipulates that there exists a mass or sum that is created from the direct object. Our term for the created thing is LUMP. The direct object that *pile* requires is not the theme of the piling event; it is the material out of which the LUMP is made. The LUMP—which is part of the denotation of Root

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[4]As Levinson discusses, *braid* exhibits polysemy since it has Explicit Creation uses too. For this reason, we use *pile* in most of our examples here.

Creation verbs like *pile*—is the theme of a piling event. The direct object is what the LUMP is made out of. Root Creation verbs thus have the interesting property of a syntax-semantics mismatch: the (syntactic) direct object of *pile* in (17) is *the cushions*, but the (semantic) theme of *pile* is the LUMP whose existence is asserted as part of the denotation of *pile*, and which is created out of the material of the semantic direct object.

The denotation of *pile* is given in (20). Note two important ingredients in the lexical semantics of Root Creation verbs: the predicate LUMP and the predicate MADE-OF. The denotation encodes the distinction between the theme of the verb (the LUMP) and the required argument (the direct object). This splitting of the theme and the direct object is a crucial part of the denotation of *pile*-type verbs. The theme is introduced and closed off as part of the denotation of *pile*; it is a LUMP created out of the material denoted by the direct object DP.

(20) $[\![pile]\!] = \lambda x.\lambda e.\exists y.\text{LUMP}(y)$ & pile(e) & Theme(y,e) & MADE-OF(y, x)

This proposal entails that the predicates LUMP and *made-of* are grammatically-privileged, in the sense of Levin (2017); Rappaport Hovav (2017). The remainder of the paper builds up to the implementation in (20), whereby we show that it correctly predicts the unique behavior of verbs in this class.

3.3.2   Root Creation vPs

Returning to full vPs, we can now derive the simple transitive sentence in (21). The direct object *the cushions* saturates the first argument of *pile*—but here the first argument is not interpreted as a theme but as an argument to the predicate MADE-OF; the direct object is thus interpreted as the material out of which something is created. In terms of type composition, the derivational steps in (21) are the same as they were for a transitive sentence with a Change of State verb like *open*, since both verb types are $\langle e, \langle s, t \rangle \rangle$.

(21)   The kids piled the cushions.

VoiceP
$\langle s,t \rangle$
λe.∃y.Agent(the kids,e) & LUMP(y) & pile(e)
& Theme(y,e) & MADE-OF(y,cushions)
FUNCTIONAL APPLICATION

The kids
e

Voice′
$\langle e, \langle s,t \rangle \rangle$
λx.λe.Agent(x,e) & ∃y.LUMP(y) & pile(e)
& Theme(y,e) & MADE-OF(y,cushions)
EVENT IDENTIFICATION

Voice
$\langle e, \langle s,t \rangle \rangle$
λx.λe.Agent(x,e)

vP
$\langle s,t \rangle$
λe.∃y.LUMP(y) & pile(e)
& Theme(y,e) & MADE-OF(y,cushions)
FUNCTIONAL APPLICATION

v
$\langle e, \langle s,t \rangle \rangle$
λx.λe.∃y.LUMP(y) & pile(e)
& Theme(y,e) & MADE-OF(y,x)

DP
the cushions
e

v
$\langle s,t \rangle$

√pile
$\langle e, \langle s,t \rangle \rangle$
λx.λe.∃y.LUMP(y) & pile(e)
& Theme(y,e) & MADE-OF(y,x)

The VoiceP in (21) denotes a function from eventualities to truth values: the kids are the agents of a piling event such that there exists a thing (LUMP) y which is the theme of a piling event, and the LUMP y is made out of the cushions. This formula shows the syntax-semantic mismatch which makes Root Creation verbs so interesting: the direct object is the DP *the cushions*, but this DP is not interpreted as a theme. Instead, *the cushions* is interpreted as an argument to a predicate MADE-OF. This predicate is part of the denotation of Root Creation verbs. The entity that receives the theme interpretation–the LUMP—is one that is asserted to exist as part of the lexical semantics of all Root Creation verbs.

3.4   Summary

This section has shown the basic derivations for unmarked transitive and intransitive uses of verbs in the three classes under discussion. Already these patterns serve to motivate the view under which roots have semantic types: Explicit Creation

verbs are $\langle s, t \rangle$ since they can form both transitive and unergative vPs, whereas COS verbs and Root Creation verbs are $\langle e, \langle s, t \rangle \rangle$ since they require an internal argument. We have also set the stage for a distinction between these last two classes in terms of the internal argument: whereas for COS verbs the direct object is a theme, for Root Creation verbs the direct object is what the theme is made of. With the basic machinery in place, we turn to the three diagnostics proposed by Levinson (2014) and show how our analysis accounts for the data.

4 Diagnostic #1: Obligatory object

The first diagnostic tests whether the direct object is necessary. Based on the system set up already, we expect Explicit Creation verbs to be acceptable in unergative vPs but the other two verb classes not to be, since they always require a syntactic object to satisfy a semantic argument. We proceed, again, by verb class.

4.1 Explicit Creation vPs: Object is not obligatory

The exposition of intransitive (unergative) verbs in Section 3.1 showed that a direct object in not required in vPs with Explicit Creation verbs. Since Explicit Creation roots are of type $\langle s, t \rangle$, they can combine with the intransitive verbalizer (v) and derive an unergative verb phrase. In this sense, no object is necessary and the derivation converges. The derivation for (22) was given in (12).

(22)   John baked (all day yesterday).

The question of whether the reading is purely an activity one or whether there is some unspecified, generic, or existentially closed-over theme is one that has been approached in different ways. A range of works argues for a null object in unergatives, from Hale and Keyser (1993) to Pérez-Leroux et al. (2017). We assume with recent work that there is no theme when there is no object (Mittwoch, 2005; Alexiadou and Schäfer, 2014). This can be seen in our data as well since there is nothing for a resultative to modify (23). Nevertheless, our analyses can be modified to accommodate these kinds of theories as well, for example by adding a stipulation regarding the content of the theme.

(23)   *John baked e_i (all day) {to a crisp / burnt / bitter}$_i$
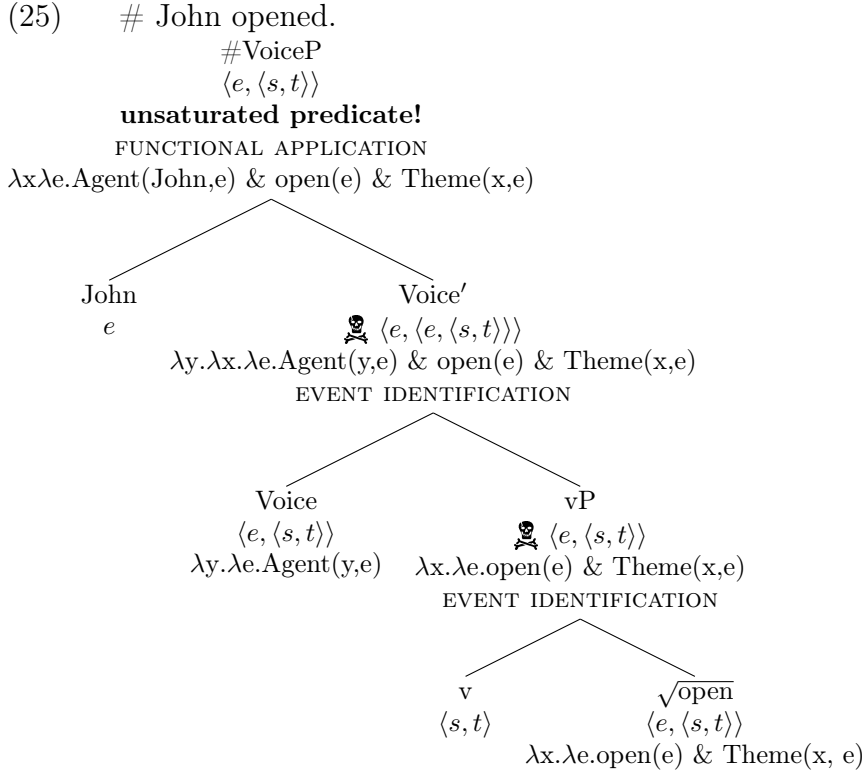
4.2 Change of State vPs: Object is obligatory

In sentences with COS verbs the object is obligatory (24):

(24)   #John was opening all day.   *(agentive reading)*

COS verbs require a theme: the thing that was opened, cleared or cooled. On our analysis, this requirement is a property of the root. The failure to saturate

the internal argument required by the root thus leads to unacceptability, but this unacceptability is semantic in nature. As we will see now, syntactic composition can proceed normally when a direct object is missing; the unacceptability is caused by an unsaturated predicate—a semantic problem. The tree in (25) shows the derivation. Formally, the root/verb *open* is $\langle e, \langle s, t \rangle \rangle$; it requires an argument of type e. Up until the Voice level, syntactic and semantic composition proceeds normally; the fact that the vP has an unsaturated argument is notated with ☠ in (25), so the reader can see where trouble starts.

(25) # John opened.

#VoiceP
$\langle e, \langle s, t \rangle \rangle$
unsaturated predicate!
FUNCTIONAL APPLICATION
$\lambda x \lambda e.\text{Agent(John,e) \& open(e) \& Theme(x,e)}$

John
e

Voice$'$
☠ $\langle e, \langle e, \langle s, t \rangle \rangle \rangle$
$\lambda y.\lambda x.\lambda e.\text{Agent(y,e) \& open(e) \& Theme(x,e)}$
EVENT IDENTIFICATION

Voice
$\langle e, \langle s, t \rangle \rangle$
$\lambda y.\lambda e.\text{Agent(y,e)}$

vP
☠ $\langle e, \langle s, t \rangle \rangle$
$\lambda x.\lambda e.\text{open(e) \& Theme(x,e)}$
EVENT IDENTIFICATION

v
$\langle s, t \rangle$

$\sqrt{\text{open}}$
$\langle e, \langle s, t \rangle \rangle$
$\lambda x.\lambda e.\text{open(e) \& Theme(x, e)}$

The vP-internal derivation proceeds as follows: since v is $\langle s, t \rangle$, $\sqrt{\text{open}}_{\langle e, \langle s, t \rangle \rangle}$ and v combine through event identification. The verb is therefore of type $\langle e, \langle s, t \rangle \rangle$. Voice and an external argument are merged with no problem. But a problem arises at this point in the derivation, since there is still an unsaturated predicate at the VoiceP level, namely the Theme "x". The derivation does not converge *at LF*.[5]

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[5]This view of semantic composition might be at odds with the mechanism of "delayed saturation", however construed (Higginbotham, 1985; Schäfer, 2012; Wood, 2014; Wood and Marantz, 2017; Myler, 2017; Kastner, 2020; Tyler, to appear), since the Agent in Spec,VoiceP (*John*) would not be able to also saturate the open Theme role. But the conflict is less problematic if we take it to indicate that object licensing and subject licensing proceed differently, as is already commonly assumed; this much is clear given that *John kicked* cannot mean 'John$_i$ kicked John$_i$'.

4.3   Root Creation vPs: Object is obligatory

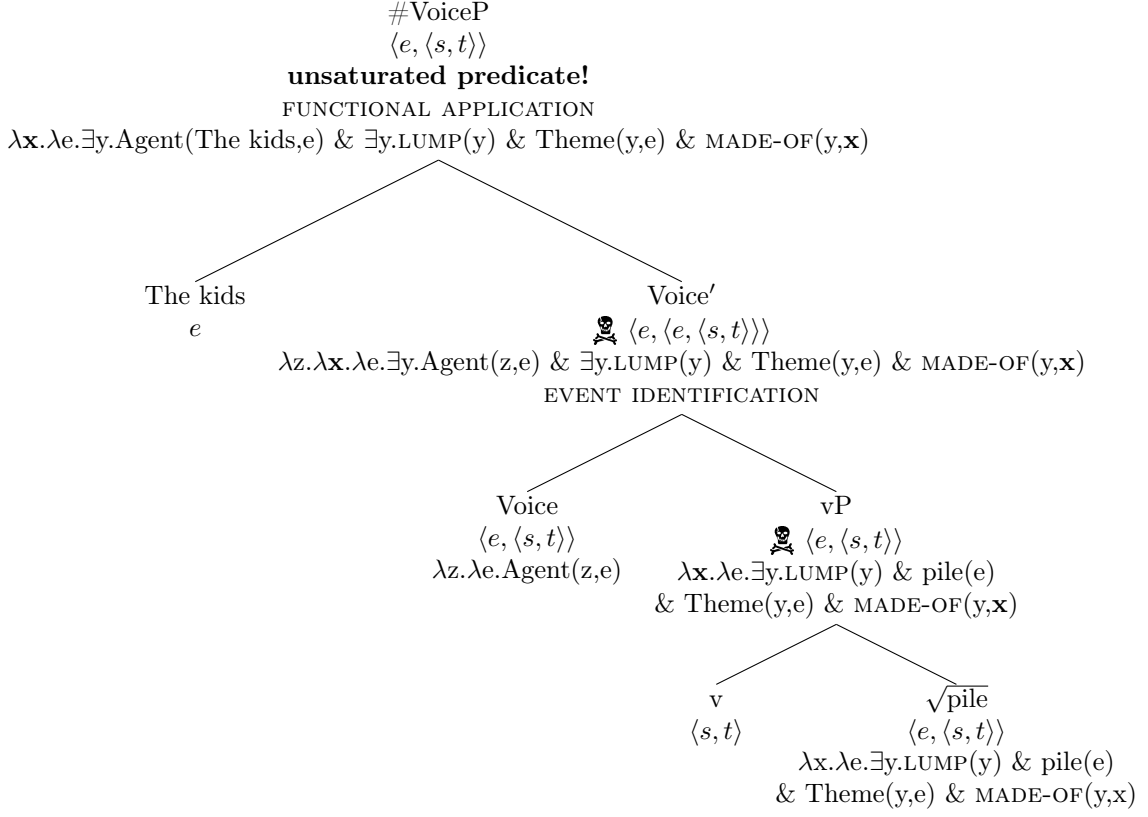Like Change of State verbs, Root Creation verbs require a syntactic object and cannot be used to form an unergative vP (26):

(26)   #The kids piled (all day).   *(agentive reading)*

On our analysis of Root Creation verbs, the semantic theme argument is already closed off as part of the denotation of the root. What is really obligatory—and what is the problem in (26)—is the direct object, which has the MADE-OF relation to the LUMP (the theme). Informally put, the syntax needs to provide a DP that will be interpreted as material so that the verb can say what the (implicit) theme is made out of. The problem with (26) is that the predicate MADE-OF has an unsaturated argument: we simply do not know what the pile was created out of.

The tree in (27) shows the derivation of (26) up to VoiceP. The trouble starts when the vP still has an unsaturated argument, the boldfaced "x" argument of the MADE-OF predicate. Starting in the vP of (27), note that the first argument to *pile* is the DP that is interpreted as the material in the MADE-OF predicate. As we know for Root Creation verbs, the theme y is accounted for—this is the LUMP. But the vP has an unsaturated predicate: this is the x argument of MADE-OF. As before, syntactic and semantic composition can occur, but at the VoiceP level, there is still an unsaturated predicate: we do not know what the LUMP was made out of. The resulting sentence would be as if we could say (27) to mean 'the kids piled (something)'. In languages with object drop, this might be possible. But it is not possible in sentences with English Root Creation verbs.

(27)   # The kids piled

#VoiceP
$\langle e, \langle s, t \rangle \rangle$
unsaturated predicate!
FUNCTIONAL APPLICATION
$\lambda\mathbf{x}.\lambda e.\exists y.\text{Agent}(\text{The kids},e) \ \& \ \exists y.\text{LUMP}(y) \ \& \ \text{Theme}(y,e) \ \& \ \text{MADE-OF}(y,\mathbf{x})$

The kids $\qquad\qquad$ Voice$'$
$e \qquad\qquad$ ☠ $\langle e, \langle e, \langle s, t \rangle \rangle \rangle$
$\lambda z.\lambda\mathbf{x}.\lambda e.\exists y.\text{Agent}(z,e) \ \& \ \exists y.\text{LUMP}(y) \ \& \ \text{Theme}(y,e) \ \& \ \text{MADE-OF}(y,\mathbf{x})$
EVENT IDENTIFICATION

Voice $\qquad\qquad$ vP
$\langle e, \langle s, t \rangle \rangle \qquad\qquad$ ☠ $\langle e, \langle s, t \rangle \rangle$
$\lambda z.\lambda e.\text{Agent}(z,e) \qquad \lambda\mathbf{x}.\lambda e.\exists y.\text{LUMP}(y) \ \& \ \text{pile}(e)$
$\& \ \text{Theme}(y,e) \ \& \ \text{MADE-OF}(y,\mathbf{x})$

v $\qquad\qquad$ $\sqrt{\text{pile}}$
$\langle s, t \rangle \qquad\qquad \langle e, \langle s, t \rangle \rangle$
$\lambda x.\lambda e.\exists y.\text{LUMP}(y) \ \& \ \text{pile}(e)$
$\& \ \text{Theme}(y,e) \ \& \ \text{MADE-OF}(y,x)$

4.4 Summary

We have so far presented the first set of derivations for a formal system integrating syntax and lexical semantics. The first part of our analysis of the three verb classes is now complete, summarized in the first column of Table 3: Explicit Creation verbs are acceptable with No object; Change of State and Root Creation verbs are not acceptable without an object.

Verb (from root)	No object	Pseudo-resultative	Double object
Explicit Creation	✓	✗	✓
Change of State	✗	✗	✓
Root Creation	✗	✓	✗

Table 3: Verb class patterns

At this point we have little evidence for the role of lexical semantics—that will soon change. In this theory, the syntax is free to generate syntactically licit structures, which are then sent to LF, where the semantic composition may or may not converge. It is at this interface that we expect certain kinds of crosslinguistic variation and even differential sensitivity to conceptual components within a given language. The latter point is just what we will see at play in the next two sections, as we discuss the Pseudo-resultative and Double-object diagnostics.

5 Diagnostic #2: Pseudo-resultative modification

This section focuses on the pseudo-resultative diagnostic. Section 5.1 explains the difference between the pseudo-resultative and what we call the "standard" resultative interpretation. The subsections that follow (5.2–5.4) show how Explicit Creation and COS verbs do not allow pseudo-resultative modification and explain why Root Creation verbs do. First, though, we will need a basic syntax and semantics for resultative modifiers, distilled from a substantial literature.

The main proposals we draw on are those of Embick (2004) and Levinson (2010) for the syntax, and those of Rothstein (2004) and Williams (2012, 2015) for the semantics; see also Dowty (1979), Simpson (1983), Hovav and Levin (2001), Mateu (2005) and Beavers (2012). Various factors constrain the combination of resultative, argument and predicate, beyond just verb class. Taking this variation as a given, we concentrate on the readings that do arise for those modifiers which are licit. The simplified syntactic structure we assume is given in (28): the resultative is merged "low" in the vP, combining syntactically with the verb, before the direct object is merged. Some might prefer to add a Result head which licenses the resultative reading of the modifier; for our purposes this makes little difference.

(28) $[_{vP} [_v [_v \text{ pound}] [_{aP} \text{ flat }]] [_{DP} \text{ the cutlet}]]$

Regarding the semantics, one aspect of resultatives which has been repeatedly subject to scrutiny is the "Direct Object Restriction" (DOR), a constraint according to which resultative XPs modify only the direct object of a verb (Simpson, 1983; Hovav and Levin, 2001; Mateu, 2005). Translating this into formal semantic requirements, we stipulate a requirement on Themes: the modifier comes pre-specified to modify the Theme of the verb it attaches to, (29). We leave out mention of degrees and other aspects of the semantics of adjectives for simplicity.

(29) $\llbracket \text{flat} \rrbracket = \lambda P(x,e).P(x,e) \ \& \ (\text{Theme}(x,e) \rightarrow \text{flat}(x))$

Another option is to let the resultative modify the first element it combines with, which is always the lowest one in the structure, hence the Theme. For concreteness we assume the first option, (29).

More articulated implementations in the semantics literature either have the modifier combine semantically with the event and its "argument" (Rothstein, 2004), or stipulate that the modifier and the verb share an argument; see Williams (2015) for in-depth discussion, as well as a proposal along these lines. Again, while these authors have good reasons for proposing their specific implementations, they all end up stipulating in one way or another what Williams (2015) calls "object sharing" between verb and modifier. Our goal here is not to suggest novel accounts for resultatives—or any other contested constructions for that matter—but to find out what has to be said in order to have the syntax, semantics and lexical semantics play nice with each other. The pared down analysis of (28)–(29) is enough to capture the facts with minimal machinery. Its reliance on the DOR

and the Theme role will now serve as the basis for our analysis.

5.1   Resultatives and pseudo-resultatives

One of Levinson's (2010) most important empirical contributions was to clarify the properties of what she called pseudo-resultative modification. This construction is a particular reading of a resultative, one in which the direct object is interpreted as the material out of which a created thing is formed, and the created thing is modified by a resultative predicate. Such a reading contrasts with standard resultatives, in which the modifier indicates the resultant state of the direct object. Crucially, only Root Creation verbs are compatible with this diagnostic.

Clauses with standard resultative modification—keeping in mind that the term *resultative* is used for what is likely a heterogeneous group of vPs—have the reading in which the direct object is in the state named by the resultative modifier (30); cf. the "object sharing" analysis of resultatives (Williams, 2015).

(30)   "Standard" resultatives
    a.   Mary hammered the metal$_i$ flat$_i$.
        $\Rightarrow$ The metal became flat ('Mary hammered some metal, and the metal became flat as a result').
    b.   Mary cooked the meat$_i$ black$_i$.
        $\Rightarrow$ The meat became black ('Mary cooked the meat, and the meat became black as a result').
    c.   The kids lifted the pillow$_i$ high$_i$.
        $\Rightarrow$ The pillow became high ('The kids lifted a pillow, and the pillow is high as a result').

As Levinson (2010) shows, the reading of pseudo-resultatives is different. The constructions in (31) are not standard resultatives: the cushions are not high as the result of a piling event, and Lisa's hair is not tight as the result of a braiding event. Instead, the created element named by the verb is modified. The generalization is that only Root Creation verbs are compatible with pseudo-resultative modification: *braid, pile* and *grind* are all Root Creation verbs. *Hammer, cook* and *lift* are not.

(31)   Pseudo-resultative modification
    a.   Lisa braided$_i$ her hair$_k$ tight$_i$.
        $\nRightarrow$ The hair became tight.
        $\Rightarrow$ 'Lisa formed a tight braid out of her hair'.
    b.   The kids piled$_i$ the cushionsr$_k$ high$_i$.
        $\nRightarrow$ The cushions became high.
        $\Rightarrow$ 'The kids formed a high pile out of the pillows.'
    c.   Mary ground$_i$ the coffee beansr$_k$ fine$_i$.
        $\nRightarrow$ The coffee beans became fine.

⇒ 'Mary formed a fine grind out of the coffee beans.'

A particularly telling minimal pair is given in (32) with the verb *slice*. Levinson (2010:138) notes that this verb is ambiguous between an Explicit Creation and Root Creation reading, making it compatible with both kinds of readings for different resultatives. In (32a), the loaf of bread becomes thin, but there are no implications for how thick the slices are; this is the standard resultative interpretation. By contrast, the most salient reading of (32b) is one in which the slices themselves are thin: this is the pseudo-resultative reading. In this paper we avoid examples with verbs like *slice* and *braid* to focus on verbs like *pile*, which unambiguously fit in only one of the three verb classes.

(32)   a.   She sliced the loaf of bread thin.   (resultative)
       b.   She sliced the bread thin.   (pseudo-resultative)

In the following subsections, we explore which readings are available for each verb class, confirming Levinson's generalization and providing our own analysis which follows from the system we have set up here. This analysis relies crucially on the lexical semantic primitives in the denotation of Root Creation verbs.

5.2   Explicit Creation: Pseudo-resultatives are not possible
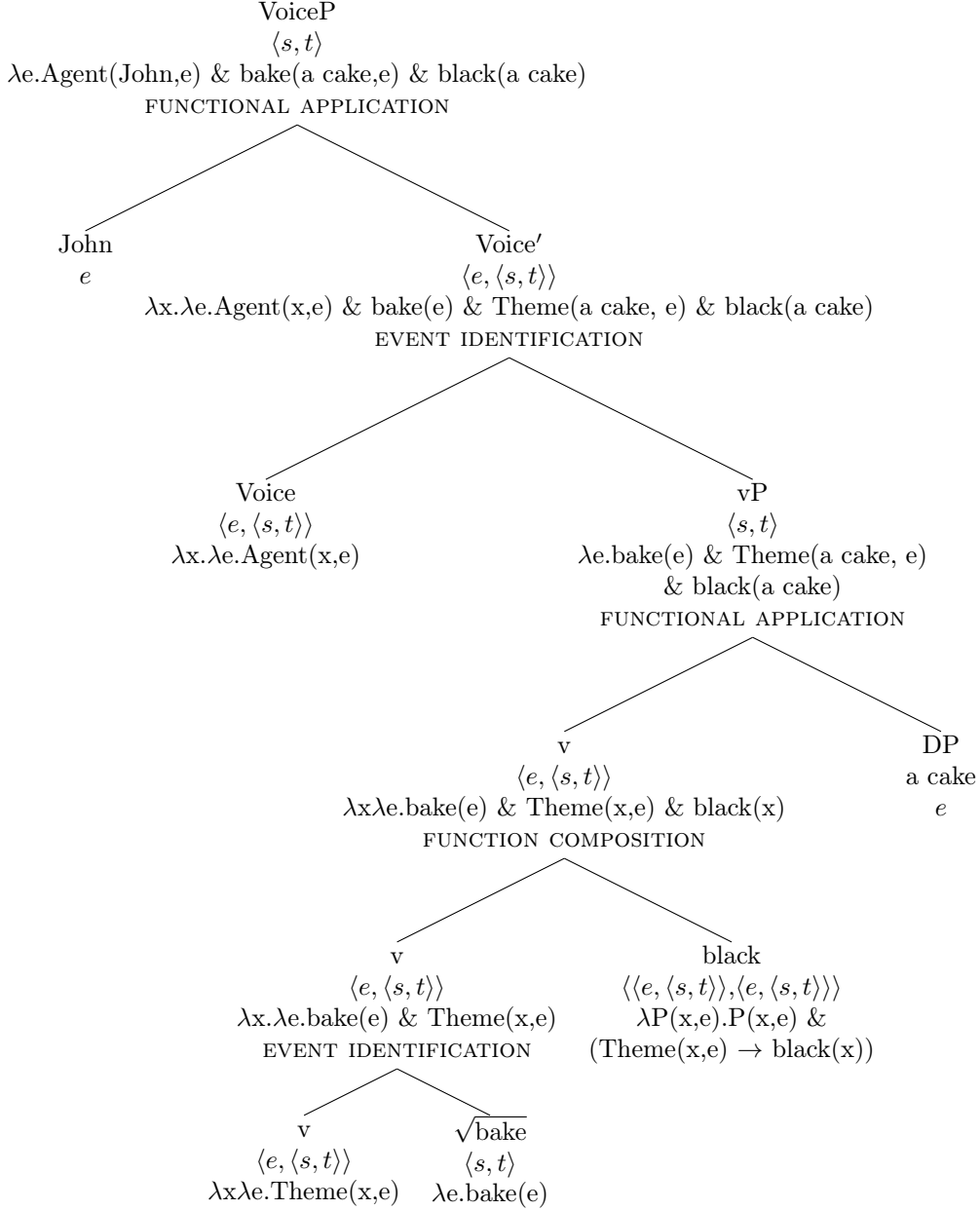
Explicit Creation vPs typically allow only the standard resultative modification (33); they do not allow pseudo-resultative readings (34):

(33)   True resultatives

       a.   John baked the cake$_i$ crispy$_i$.
       b.   John baked the cake$_i$ black$_i$.

(34)   Pseudo-resultatives

       a. #John baked$_i$ the cake tasty$_i$.
       b. #John baked$_i$ the ingredients tasty$_i$.

Sentence (34a) does not have the interpretation that a cake was the material out of which a (tasty) baking was formed; (34b) attempts to give the pseudo-resultative a better chance of succeeding by having the direct object be a type of "material" used in a baking event. Still, the sentence is degraded.

   Since the direct object in (33) and (34a)—or more accurately, the theme—is *cake*, this is the only thing that can be modified by the resultative adjective. Since there is no way for this modifier to directly access any other entity related to the event, the derivation in (35) yields only the standard resultative reading. In (35), the resultative constituent combines through FUNCTION COMPOSITION (Kobele, 2010; Wood, 2015) or RESTRICT (Chung and Ladusaw, 2004).

(35)   # John baked the cake black.   (unavailable pseudo-res reading)

VoiceP
$\langle s,t \rangle$
λe.Agent(John,e) & bake(a cake,e) & black(a cake)
FUNCTIONAL APPLICATION

John
e

Voice′
$\langle e, \langle s,t \rangle \rangle$
λx.λe.Agent(x,e) & bake(e) & Theme(a cake, e) & black(a cake)
EVENT IDENTIFICATION

Voice
$\langle e, \langle s,t \rangle \rangle$
λx.λe.Agent(x,e)

vP
$\langle s,t \rangle$
λe.bake(e) & Theme(a cake, e)
& black(a cake)
FUNCTIONAL APPLICATION

v
$\langle e, \langle s,t \rangle \rangle$
λxλe.bake(e) & Theme(x,e) & black(x)
FUNCTION COMPOSITION

DP
a cake
e

v
$\langle e, \langle s,t \rangle \rangle$
λx.λe.bake(e) & Theme(x,e)
EVENT IDENTIFICATION

black
$\langle \langle e, \langle s,t \rangle \rangle, \langle e, \langle s,t \rangle \rangle \rangle$
λP(x,e).P(x,e) &
(Theme(x,e) → black(x))

v
$\langle e, \langle s,t \rangle \rangle$
λxλe.Theme(x,e)

√bake
$\langle s,t \rangle$
λe.bake(e)

On our analysis, sentences like (34) not unacceptable; they are simply degraded because only the standard resultative interpretation is available. The lexical semantics of vPs with verbs like *bake* is incompatible with what pseudo-resultatives mean. This view is contrasted with the analysis of Levinson (2010) in Section 7.

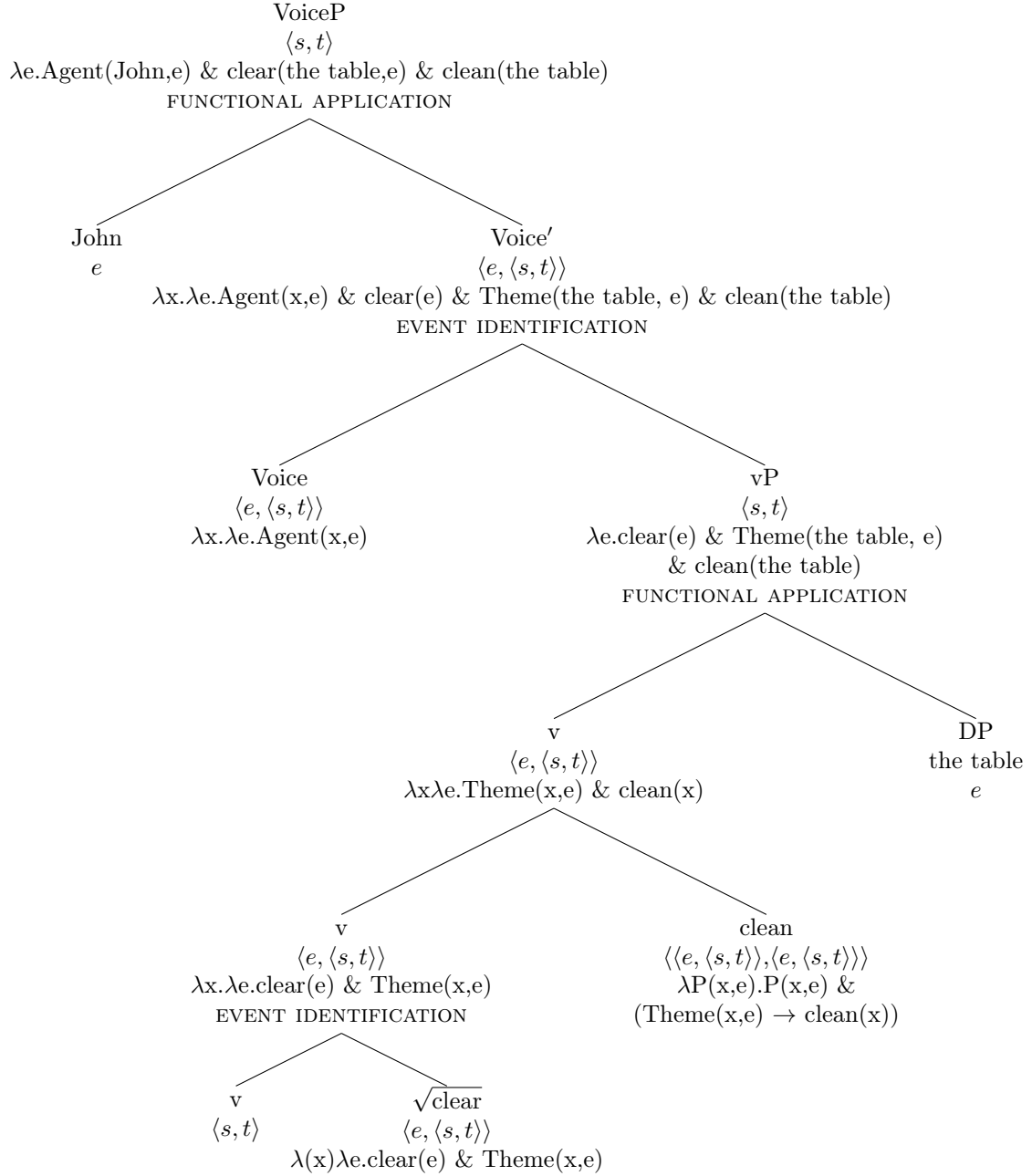## 5.3   COS: Pseudo-resultatives are not possible

COS verbs like *break* and *open* pattern with Explicit Creation verbs for pseudo-resultative modification. Neither pass this diagnostic (37) because only a standard resultative interpretation is available (36).

(36)   Standard resultatives
     a.   John cleared the table$_i$ clean$_i$.
     b.   John broke the door$_i$ to pieces$_i$.

(37)   Pseudo-resultatives
     a. #John opened$_i$ the door tiny$_i$.
     b. #John broke$_i$ the mirror jagged$_i$.

Observe that (37a) cannot mean that John used the door to form an opening that was tiny; (37b) cannot mean that John used the mirror to fashion a "break" that was jagged.

The same explanation for the unavailability of pseudo-resultative modification with COS verbs is the same as it is for Explicit Creation verbs: the direct object the only thing that can be modified by the resultative, and the only available reading is a standard resultative interpretation. The tree in (38) shows the derivation.

(38)   #John cleared the table clean.   (unavailable pseudo-res reading)

VoiceP
$\langle s, t \rangle$
λe.Agent(John,e) & clear(the table,e) & clean(the table)
FUNCTIONAL APPLICATION

- John
  e

- Voice′
  $\langle e, \langle s, t \rangle \rangle$
  λx.λe.Agent(x,e) & clear(e) & Theme(the table, e) & clean(the table)
  EVENT IDENTIFICATION

  - Voice
    $\langle e, \langle s, t \rangle \rangle$
    λx.λe.Agent(x,e)

  - vP
    $\langle s, t \rangle$
    λe.clear(e) & Theme(the table, e)
    & clean(the table)
    FUNCTIONAL APPLICATION

    - v
      $\langle e, \langle s, t \rangle \rangle$
      λxλe.Theme(x,e) & clean(x)

      - v
        $\langle e, \langle s, t \rangle \rangle$
        λx.λe.clear(e) & Theme(x,e)
        EVENT IDENTIFICATION

        - v
          $\langle s, t \rangle$

        - √clear
          $\langle e, \langle s, t \rangle \rangle$
          λ(x)λe.clear(e) & Theme(x,e)

      - clean
        $\langle \langle e, \langle s, t \rangle \rangle, \langle e, \langle s, t \rangle \rangle \rangle$
        λP(x,e).P(x,e) &
        (Theme(x,e) → clean(x))

    - DP
      the table
      e

As with pseudo-resultatives and Explicit Creation vPs, the issue here is not with syntactic composition or formal semantic composition: sentences like (37a)–(37b) are degraded because the vPs built on COS verbs do not have the right lexical semantic meaning to make sense with pseudo-resultative modification.

Before proceeding to Root Creation verbs, it is worth noting that COS verbs provide an interesting twist. Examples like (39) are possible with a certain class of size or volume modifiers, which do seem to have a pseudo-resultative interpretation:

(39)   a.   John closed$_i$ the door **partway**$_i$.
       b.   Roger **half** filled$_i$ the glass$_i$.

Levinson (2010) acknowledges these datapoints and argues that a modifier such as *partway* modifies the closed *state* embedded in the event, not the closed *entity*. This is to be contrasted with how *tight* modifies the causative braided *entity* in the Root Creation root $\sqrt{\text{braid}}$. In other words, the verbal root here "denotes a predicate of stative eventualities" (Levinson, 2010:179). We believe this point can be made even more strongly, although we will not argue for it explicitly without additional empirical investigation. The idea as we see it is that roots like $\sqrt{\text{open}}$ and $\sqrt{\text{fill}}$ have a scale built into their denotation (or perhaps their encyclopedic meaning), which functions similarly to the Root Creation LUMP. That is to say, the verbalized root first makes available some state or scale as an internal argument, which the (pseudo-)resultative then modifies (cf. again Beavers and Koontz-Garboden 2020). To the extent that this idea has merit, it fits in with the overall picture of the grammar we have been painting.

5.4   Root Creation: Pseudo-resultatives are possible

In contrast to Explicit Creation verbs and COS verbs, Root Creation verbs do allow the pseudo-resultative reading:

(40)   Standard resultatives

   a. #The kids piled the cushions$_i$ small$_i$/squished$_i$.
   b. #Lisa braided her hair$_i$ clean$_i$.

(41)   Pseudo-resultatives

   a.   The kids piled$_i$ the cushions high$_i$.
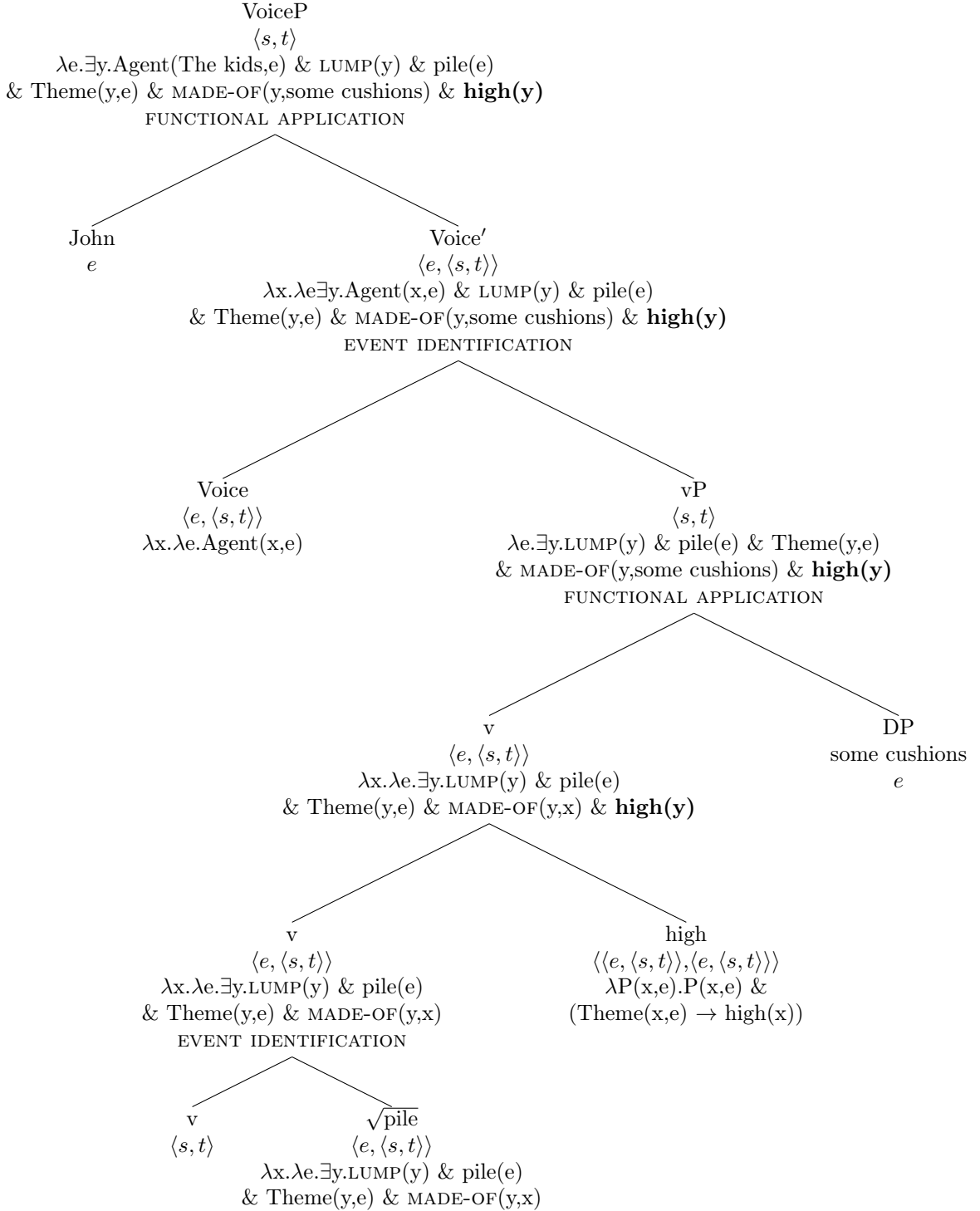   b.   Lisa braided$_i$ her hair tight$_i$.

The observation about pseudo-resultative modification is that the modifiers *high* and *tight* in (41) are not standard resultatives in the sense that the cushions themselves might be high as the result of a piling event. The cushions may be described as *high*, of course, but the meaning of a sentence like (41a) is that the *pile of cushions* is high as a (result of a piling event).

   The judgments for this verb class are the reverse of the other classes, which suggests that one difference drives the difference for both readings. Accordingly, on our analysis, the syntactic derivation for standard and pseudo-resultatives is identical; what makes pseudo-resultatives possible with Root Creation verbs is the lexical semantic denotation of this class of verbs. The denotation of *pile* is as in (20), repeated below as (42):

(42)   ⟦pile⟧ = λx.λe.$\exists$y.LUMP(y) & pile(e) & Theme(y,e) & MADE-OF(y, x)

The derivation in (43) shows how the theme LUMP is what is modified.

(43)   The kids piled the cushions high.

VoiceP
$\langle s,t\rangle$
λe.∃y.Agent(The kids,e) & LUMP(y) & pile(e)
& Theme(y,e) & MADE-OF(y,some cushions) & **high(y)**
FUNCTIONAL APPLICATION

John
e

Voice′
$\langle e,\langle s,t\rangle\rangle$
λx.λe∃y.Agent(x,e) & LUMP(y) & pile(e)
& Theme(y,e) & MADE-OF(y,some cushions) & **high(y)**
EVENT IDENTIFICATION

Voice
$\langle e,\langle s,t\rangle\rangle$
λx.λe.Agent(x,e)

vP
$\langle s,t\rangle$
λe.∃y.LUMP(y) & pile(e) & Theme(y,e)
& MADE-OF(y,some cushions) & **high(y)**
FUNCTIONAL APPLICATION

v
$\langle e,\langle s,t\rangle\rangle$
λx.λe.∃y.LUMP(y) & pile(e)
& Theme(y,e) & MADE-OF(y,x) & **high(y)**

DP
some cushions
e

v
$\langle e,\langle s,t\rangle\rangle$
λx.λe.∃y.LUMP(y) & pile(e)
& Theme(y,e) & MADE-OF(y,x)
EVENT IDENTIFICATION

high
$\langle\langle e,\langle s,t\rangle\rangle,\langle e,\langle s,t\rangle\rangle\rangle$
λP(x,e).P(x,e) &
(Theme(x,e) → high(x))

v
$\langle s,t\rangle$

√pile
$\langle e,\langle s,t\rangle\rangle$
λx.λe.∃y.LUMP(y) & pile(e)
& Theme(y,e) & MADE-OF(y,x)

We are aware of only one other account which has been proposed for this phenomenon, that of Levinson (2010). The intuition there is similar in that the

pseudo-resultative modifies a very low element, there the root itself (as a *pile*).

5.5 Summary

In terms of our exploration of how the verb classes pattern with respect to the three syntactic diagnostics, we have now covered two out of the three verb class diagnostics (Table 4).

Verb (from root)	No object	Pseudo-resultative	Double object
Explicit Creation	✓	✗	✓
Change of State	✗	✗	✓
Root Creation	✗	✓	✗

Table 4: Verb class patterns

In Section 2.1 we proposed that the role of lexical semantics in the syntax can be viewed in terms of three competing approaches. In an Exo-skeletal approach, there is no way for lexical semantics to play a role in the syntax. Contrasts such as the one just discussed would be seen as epiphenomenal and must be treated outside of the grammar proper. . Our own account instantiates a different kind of theory, one where some lexical semantic content is encoded in the denotation of roots. This view contrasts with another alternative, the type-driven hybrid view. On that approach, roots have highly articulated formal semantic types, such that verbs in each root class can only fit into very specific syntactic structures; this analysis decomposes verbs like *pile* into a root $\sqrt{\text{pile}}$ and the functional heads $v_{reconfigure}$, TO and IN. We argue against this account in Section 7.

6 Diagnostic #3: Double object constructions

The final diagnostic to be considered in depth is the double object construction, which makes a different kind of cut between the three classes than either of the previous two diagnostics: Explicit Creation and COS verbs pattern allowing the double object construction, and Root Creation verbs do not.

The first thing to note about double objects in English is that their distribution is restricted regardless of verb class. As a rule, double objects are acceptable only with an interpretation that involves a transfer of possession from the theme to the recipient; a general "benefactive" reading familiar from other languages is not possible. Pylkkänen (2008) and Levinson (2010, 2014:226) discuss this fact about English, which (44) exemplifies using a COS verb. Example (44a) easily accepts a transfer of possession interpretation in which John opens a beer and gives it (or intends to give it) to his mother. Example (44b) is unacceptable because it is hard to conceive of the door undergoing a transfer of possession from John to his mother; (44c) sounds degraded, but it improves in a context in which John's

brother is building a little structure out of sticks, and John is helping by breaking sticks and giving them to him. Why this might be the case falls beyond the scope of the current article, although it is very much part of the same enterprise.

(44) COS verbs in double object vPs
  a. John opened his mom a beer. ⇒*change of possession*
  b. *John opened his mom the door.
  c. ?John broke his brother a stick.

Putting this constraint aside, we assume next that examples such as (44a) are derived using the applicative head Appl.

6.1 Explicit Creation: Double objects are allowed

Explicit Creation verbs generally allow double object constructions. The meaning of (45) is one of transfer of possession: John created a cake by act of baking, and this cake went or will go from being possessed by him to being possessed by his mother.
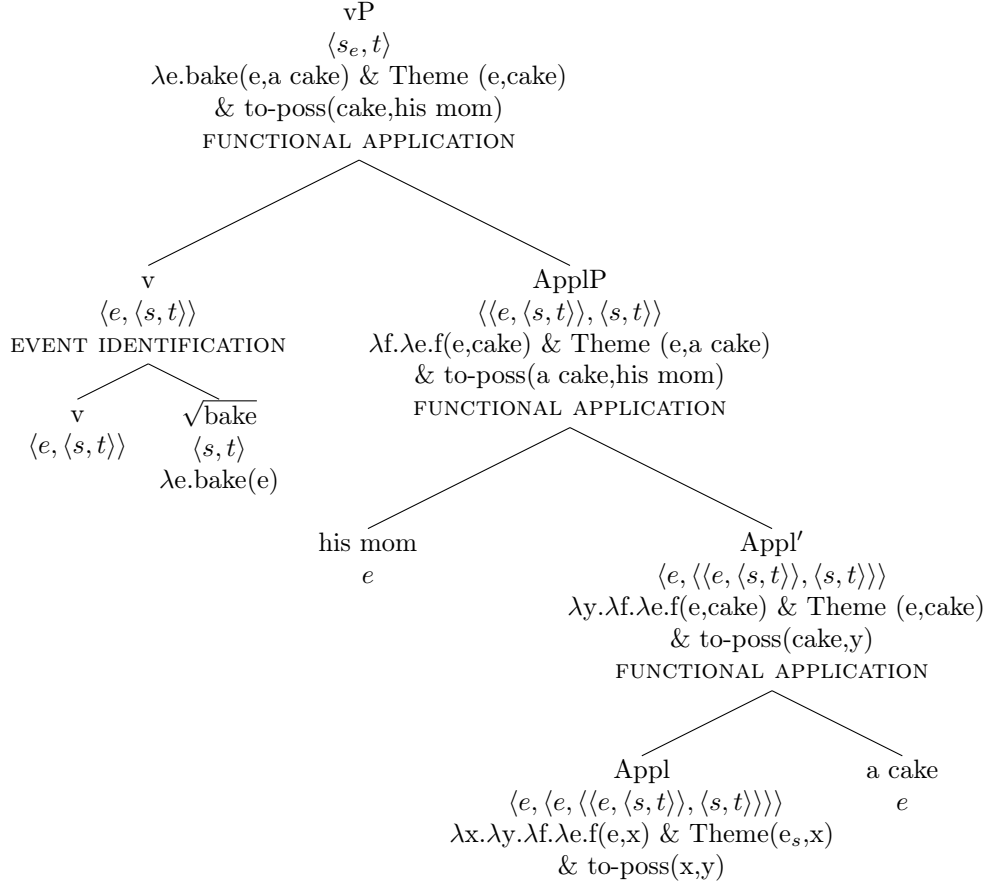
(45) John baked his mom a cake.

Our account of applicative constructions in English is borrowed in its entirety from standard analyses, leaving any differences between verb classes to the lexical semantics of the root. Double object constructions such as (45) are modeled as (low) applicatives, based on Pylkkänen (2008). Pylkkänen's denotation of the Appl head is given in (46). This function relates two individuals—a theme (e.g., *a cake*) and a recipient or goal (e.g., *his mom*)—to a function, and returns a function. This function is essentially the verb (e.g., *bake*), which denotes a set of baking events (type $\langle s,t \rangle$).

(46) Appl head (from Pylkkänen 2008)
    $[\![\text{APPL}_{TO}]\!] = \lambda x \lambda y \lambda f_{\langle e,\langle s,t \rangle \rangle} \lambda e.f(e,x) \ \& \ \text{Theme }(e,x) \ \& \ \text{to-the-possession}(x,y)$
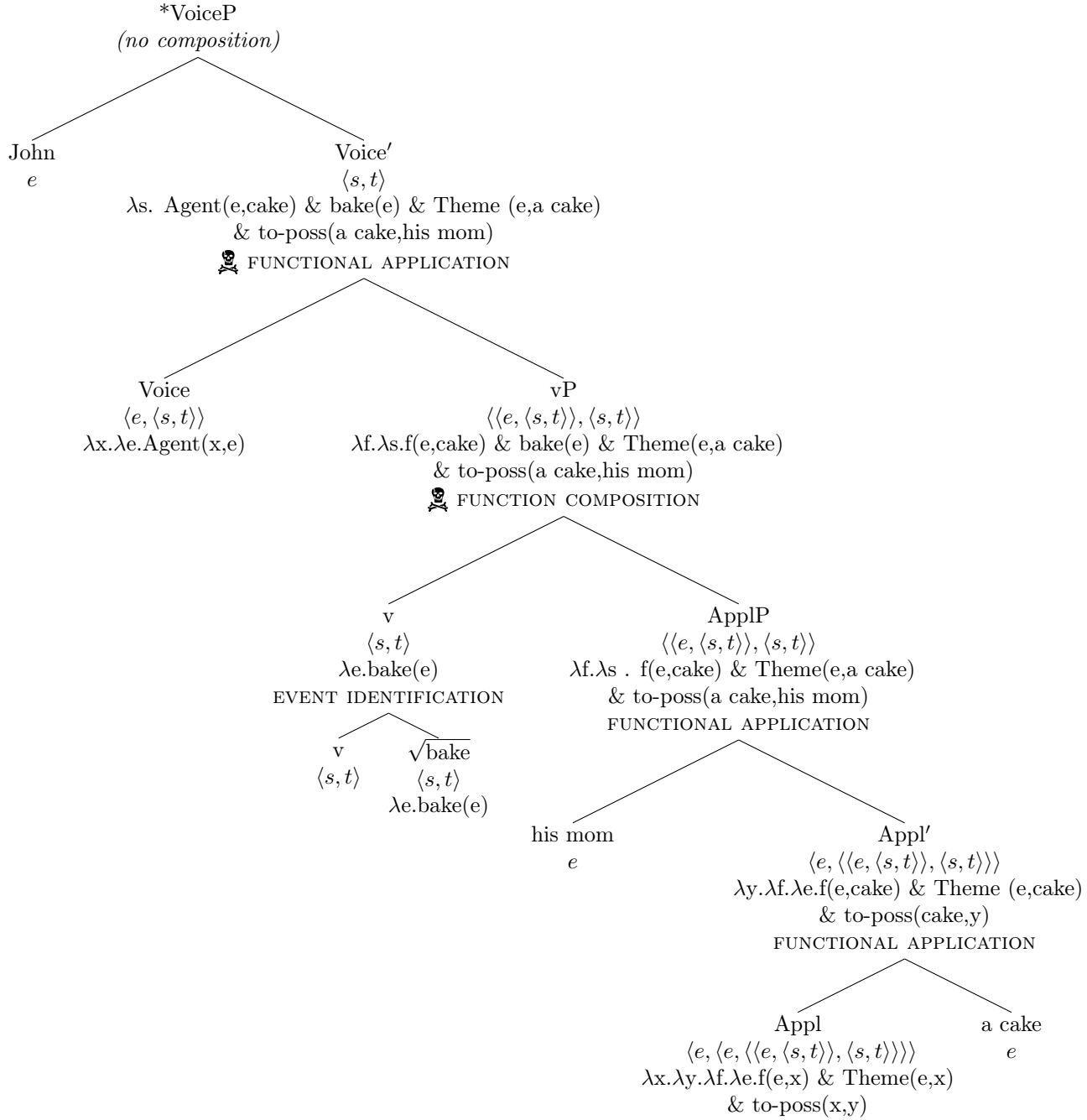
The derivation proceeds as follows: the Appl head first combines with the theme argument—*a cake* in (47)—through functional application. The recipient is then added, in Spec,ApplP, again through functional application. The verb then serves as the (semantic) argument to the ApplP (Pylkkänen, 2002:22). The verb *bake* is of type $\langle e, \langle s,t \rangle \rangle$, and this is the type that ApplP is looking for. In double object sentences like (47), the [v+root] unit is transitive, type $\langle e, \langle s,t \rangle \rangle$.

(47) vP for *John baked his mom a cake.*

vP
$\langle s_e, t \rangle$
λe.bake(e,a cake) & Theme (e,cake)
& to-poss(cake,his mom)
FUNCTIONAL APPLICATION

v
$\langle e, \langle s, t \rangle \rangle$
EVENT IDENTIFICATION

ApplP
$\langle \langle e, \langle s, t \rangle \rangle, \langle s, t \rangle \rangle$
λf.λe.f(e,cake) & Theme (e,a cake)
& to-poss(a cake,his mom)
FUNCTIONAL APPLICATION

v
$\langle e, \langle s, t \rangle \rangle$

√bake
$\langle s, t \rangle$
λe.bake(e)

his mom
e

Appl′
$\langle e, \langle \langle e, \langle s, t \rangle \rangle, \langle s, t \rangle \rangle \rangle$
λy.λf.λe.f(e,cake) & Theme (e,cake)
& to-poss(cake,y)
FUNCTIONAL APPLICATION

Appl
$\langle e, \langle e, \langle \langle e, \langle s, t \rangle \rangle, \langle s, t \rangle \rangle \rangle \rangle$
λx.λy.λf.λe.f(e,x) & Theme(e_s,x)
& to-poss(x,y)

a cake
e

Recall our assumption that the syntax generates structures which are then interpreted by the interfaces. For our combinatorics, this leaves open the case in which the intransitive variant of v combines with √bake. In this case, the resulting verb would be of type $\langle s, t \rangle$, as shown in (48). This type cannot serve as an argument to ApplP, since ApplP requires its argument to be type $\langle e, \langle s, t \rangle \rangle$. They could combine, however, through Function Composition. In this case, though, the result would be a vP that is the same formal type as ApplP: $\langle \langle e, \langle s, t \rangle \rangle, \langle s, t \rangle \rangle$. Even at this point, semantic composition can proceed and Voice can combine with the vP, albeit through a very non-standard mode of composition for Voice. Typically, Voice combines with a vP through event identification. In this case, though, Voice is the type of the first argument of the vP, so they would have to combine through functional application. This derivation is not impossible but not necessary either.

(48)

*VoiceP
(no composition)

John
e

Voice′
$\langle s,t \rangle$
λs. Agent(e,cake) & bake(e) & Theme (e,a cake)
& to-poss(a cake,his mom)
☠ FUNCTIONAL APPLICATION

Voice
$\langle e, \langle s,t \rangle \rangle$
λx.λe.Agent(x,e)

vP
$\langle \langle e, \langle s,t \rangle \rangle, \langle s,t \rangle \rangle$
λf.λs.f(e,cake) & bake(e) & Theme(e,a cake)
& to-poss(a cake,his mom)
☠ FUNCTION COMPOSITION

v
$\langle s,t \rangle$
λe.bake(e)
EVENT IDENTIFICATION

v
$\langle s,t \rangle$

√bake
$\langle s,t \rangle$
λe.bake(e)

ApplP
$\langle \langle e, \langle s,t \rangle \rangle, \langle s,t \rangle \rangle$
λf.λs . f(e,cake) & Theme(e,a cake)
& to-poss(a cake,his mom)
FUNCTIONAL APPLICATION

his mom
e

Appl′
$\langle e, \langle \langle e, \langle s,t \rangle \rangle, \langle s,t \rangle \rangle \rangle$
λy.λf.λe.f(e,cake) & Theme (e,cake)
& to-poss(cake,y)
FUNCTIONAL APPLICATION

Appl
$\langle e, \langle e, \langle \langle e, \langle s,t \rangle \rangle, \langle s,t \rangle \rangle \rangle \rangle$
λx.λy.λf.λe.f(e,x) & Theme(e,x)
& to-poss(x,y)

a cake
e

6.2   Change of State vPs: Double objects are allowed

As seen in (49), repeated from (44a), double objects with COS verbs are acceptable
as long as a transfer-of-possession interpretation is available:

(49)   John opened his mom a beer.

The composition of double object sentences with COS verbs is just like that of

double objects with Explicit Creation verbs. Like in (47), Appl relates a recipient (e.g., *his mom*) a theme (e.g., *a beer*) and a function (e.g., opening). The semantic type of COS roots, $\langle e, \langle s, t \rangle \rangle$, is just the type that ApplP needs, and so ApplP takes the verb as its argument, just as Appl typically does (50):

(50)   John opened his mom a beer.

vP
$\langle s_e, t \rangle$
λe.open(e,beer)
& Theme (e,beer) & to-poss(beer,his mom)
FUNCTIONAL APPLICATION

- v
  $\langle e, \langle s, t \rangle \rangle$
  λx.λe.OPEN(e) & Theme(x, e)
  EVENT IDENTIFICATION

  - v
    $\langle s, t \rangle$
  - √open   λx.λe.OPEN(e) & Theme(x, e)
    $\langle e, \langle s, t \rangle \rangle$

- ApplP
  $\langle \langle e, \langle s, t \rangle \rangle, \langle s, t \rangle \rangle$
  λf.λe.f(e,beer) & Theme (e,beer)
  & to-poss(beer,his mom)
  FUNCTIONAL APPLICATION

  - his mom
    e

  - Appl′
    $\langle e, \langle \langle e, \langle s, t \rangle \rangle, \langle s, t \rangle \rangle \rangle$
    λy.λf.λe.f(e,beer)
    & Theme (e,beer) & to-poss(beer,y)
    FUNCTIONAL APPLICATION

    - Appl
      $\langle e, \langle e, \langle \langle e, \langle s, t \rangle \rangle, \langle s, t \rangle \rangle \rangle \rangle$
      λx.λy.λf.λe_s.f(e_s,x) & Theme (e_s,x)
      & to-poss(x,y)

    - a beer
      e

6.3   Root Creation: Double objects are disallowed

Root Creation verbs are not acceptable in the double object construction, regardless of whether transfer of possession is available (51).

(51)   *Mary braided Lisa her hair.

The degraded quality of (51) holds whether *her* refers to Mary or to Lisa. The examples in (52) are taken directly from our experimental results, with a rough translation from mean raw ratings (on the right) to ordinal judgment diacritics. For comparison's sake, the Explicit Creation items had mean ratings in the range

[6.31, 6.79].[6]

(52) Double-object vPs with Root Creation verbs
    a. *John piled his mom some cushions.   (3.86 ± 1.70)
    b. *?John stacked his uncle some wood.   (4.79 ± 1.65)
    c. ??John braided his captain some rope.   (5.29 ± 1.69)

The intuition behind what goes wrong is as follows: the applicative construction already contains a specification of the theme of the event, but a Root Creation verb specifies its own theme—the LUMP—which is existentially closed over.

The ApplP itself is built just as before. The problem arises once the ApplP combines with v: both the ApplP and the root attempt to assign the Theme role. The derivation in (53) shows the consequences of combining v with this ApplP. Theme assignments are shown in boldface; the root assigns Theme to the pile/LUMP (of cushions), and Appl assigns Theme to the cushions. The result is two conflicting themes for the same event.

(53)   * John piled his mom some cushions

vP
$\langle s,t\rangle$
$\lambda e.\exists y.$ LUMP(y) & pile(e) & **Theme(y, e)** & **Theme(e,cushions)**
& MADE-OF(y,cushions) & to-poss(cushions,his mom)
FUNCTIONAL APPLICATION

v
$\langle e,\langle s,t\rangle\rangle$
$\lambda x.\lambda e.\exists y.$LUMP(y) & pile(e)
& **Theme(y, e)** & MADE-OF(y,x)
Event Identification

ApplP
$\langle\langle e,\langle s,t\rangle\rangle,\langle s,t\rangle\rangle$
$\lambda f.\lambda e.f(e,cushions)$ & **Theme(e,cushions)**
& to-poss(cushions,his mom)

v
$\langle s,t\rangle$

$\sqrt{\text{pile}}$
$\langle e,\langle s,t\rangle\rangle$
$\lambda x.\lambda e.\exists y.$LUMP(y) & pile(e)
& **Theme(y,e)** & MADE-OF(y,x)

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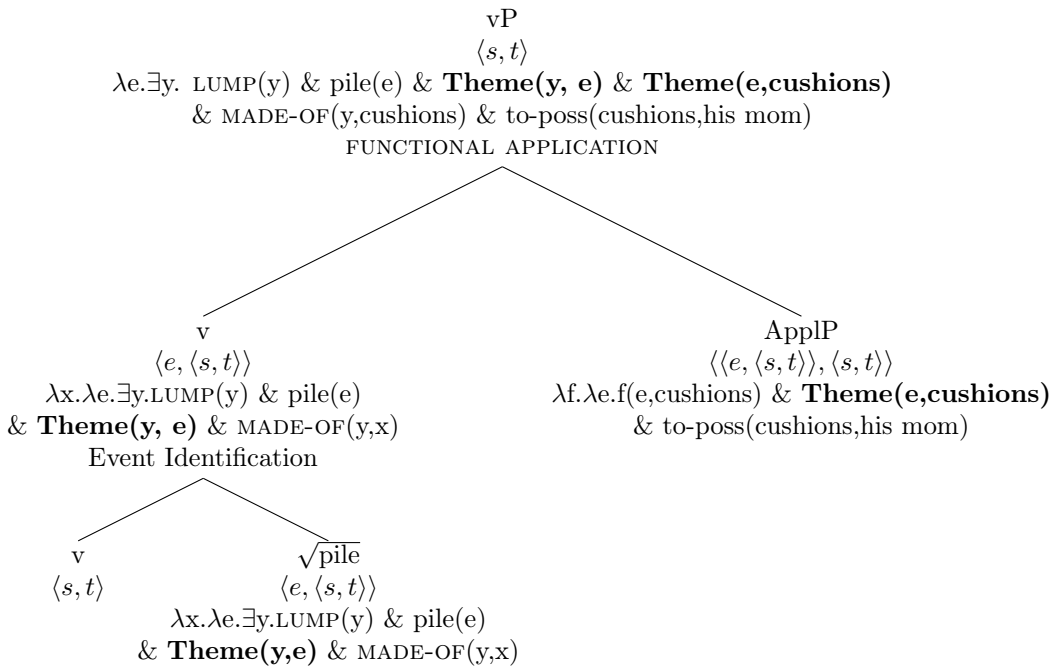
[6]The judgments reported in this paper generalize over different roots within a given class, summarizing diacritics from the ratings given in our acceptability study. Since the variation in this specific condition might be of further theoretical interest, we include it here. See the online repository for full details. Space precludes us from discussing the general influence of context.

6.4 Summary

With this section we have now shown how our system—one in which roots are associated with formal semantic types and contain lexical semantic information—accounts for the behavior of the three verb classes across three different syntactic environments. The diagnostics are summarized in Table 5.

Verb (from root)	No object	Pseudo-resultative	Double object
Explicit Creation	✓	✗	✓
Change of State	✗	✗	✓
Root Creation	✗	✓	✗

Table 5: Verb class patterns, complete

The case of Root Creation verbs has been particularly illustrative, since although Root Creation verbs and COS verbs are of the same formal semantic type, accounting for their similar patterning with respect to the No object diagnostic, the two classes differ in lexical semantic content. These lexical semantic differences lead to differing results for the pseudo-resultative diagnostic and the double-object diagnostic.

We will now compare our account with an alternative view of the syntax-lexical semantics interface, before concluding.

7 Alternative approaches

In Section 2.1 we outlined how different theories of the grammar incorporate lexical semantics. Space considerations prevent us from evaluating Exo-Skeletal approaches, in which lexical semantic content plays no role in the grammar. Below we contrast our approach with the one that our own approach is, in a sense, a descendent of: Levinson's hybrid system, a theory in which roots are constrained by formal semantic type but much lexical semantic meaning is encoded in covert heads.

7.1 A hybrid type-driven system

Levinson (2007) was the first to motivate the three root classes in this paper and to apply the three syntactic tests to them. We first provide an overview of this model and then discuss some empirical issues with it.

While our approach draws heavily on this model, there are a number of substantial differences. The Levinsonian assumption about root distribution is that roots can be merged in one of three different configurations—modifier, argument, or function. But each root class is stipulated to enter the derivation in only one of these configurations, resulting in the sparse matrix in Table 6.

	Explicit Creation $\langle s_e, t\rangle$	Root Creation $\langle e, t\rangle$	Change of State $\langle e, \langle s_s, t\rangle\rangle$
modifier	*build* $\mathrm{root}_{\langle s_e, t\rangle}$ is modifier of v		
argument		*pile* $\mathrm{root}_{\langle e, \langle s, t\rangle\rangle}$ is arg of head IN	
function			*break* $\mathrm{root}_{\langle e, \langle s_s, t\rangle\rangle}$ takes DP arg

Table 6: Root types and distribution in Levinson (2014).

Note that the root types are also different in this theory than in ours; for example, Explicit Creation roots are of type $\langle s_e, t\rangle$. The theory also implements three types of v, one for Root Creation vPs, one for COS vPs, and two for Explicit Creation vPs. This is shown in Table 7 for the four root classes.

Name for v	Semantic type of v	What composes	Mode of composition
$v_{create-trans}$	$\langle e, \langle s_e, t\rangle\rangle$	$v + \mathrm{root}_{\langle s_e, t\rangle}$	Event Identification
$v_{create-intrans}$	$\langle s_e, t\rangle$	$v + \mathrm{root}_{\langle s_e, t\rangle}$	Predicate Modification
$v_{inchoative}$	$\langle\langle s_s, t\rangle, \langle s_e, t\rangle\rangle$	v takes $[\mathrm{root+DP}]_{\langle s_s, t\rangle}$	Functional Application
$v_{reconfigure}$	$\langle\langle s_s, t\rangle, \langle s_e, t\rangle\rangle$	v takes $[\mathrm{IN\text{-}TO\text{-}root\text{-}DP}]_{\langle s_s, t\rangle}$	Functional Application

Table 7: Little-v types, based on Levinson (2014).

Altogether, this matrix yields 3 root types $\times$ 3 positions $\times$ 4 v's = 36 possible combinations. Only four of these combinations are attested. While semantic types are part of the root-centric hypothesis, the different configurations in which these roots can enter the derivation is stipulated.

Compared to the analysis of Explicit Creation and COS verbs, Levinson's (2010) derivation of Root Creation verbs is perhaps the most technically novel account, with immediate application to pseudo-resultatives. On this analysis of pseudo-resultatives, the root is modified directly in the syntax. There are two requirements: the root must be of the right type ($\langle e, t\rangle$), and it must be interpreted as a created individual. The intuition is that (54a) is, underlyingly, essentially (54b):[7]

(54)   a.   She *braided* her hair.
        b.   She *made* her hair *in-to* a braid.

The analysis is shown in (55), with the silent functional heads TO and IN (Levinson, 2010:155). That structure is equated with *make (her hair) into a braid* (56), with *in-to* (Levinson, 2010:164).

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[7]This resembles Exo-Skeletal approaches to similar issues (Acedo-Matellán and Mateu, 2014).

(55) *braid her hair (tight)*

(56) *make her hair into a braid*
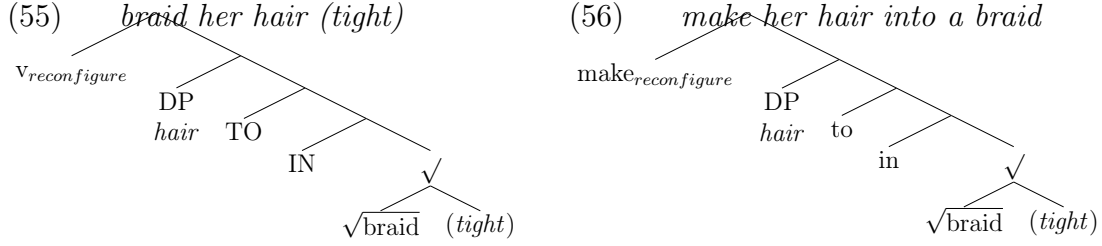
On this analysis, the Theme is *hair*, which constitutes the material for the Goal *braid*. Intuitively, this is because in sentences like (54) the hair comes to be in a braid. This meaning is mediated in the syntax by the silent head IN (which has a slightly different denotation from overt *in*). The denotation of silent IN is reminiscent of our general denotation for Root Creation verbs (57):[8]

(57)　Denotation of silent head IN　　(Levinson 2010:166; Levinson 2014:211)
　　$[\![\text{IN}]\!] = \lambda f_{\langle e,t\rangle}\lambda y_e\lambda s_s \exists x_e.f(x)$ & being-in(s,x) & theme(s,y)

This is a useful point of comparison between the two approaches: components of meaning that in our approach are part of the lexical semantic denotation of Root Creation verbs are, in the Levinsonian approach, decomposed into a particular structure in the syntax—one that appears to occur only with Root Creation verbs.

We now focus on some problems with this analysis, before noting more general cases where this model either over- or undergenerates other readings. The reason for this problem of over- and under-generation, we argue, is the large inventory of elements and combinatorial possibilities that are part of this system.

7.2　Reasons for not deriving *pile* from MAKE INTO *pile*

In this section we briefly provide arguments against an analysis in which the verb *pile* is decomposed into *make into a pile*. In the foregoing approach, a verb like *pile* itself has the same syntactic structure as a "reconfiguration" construction such as *make into a pile*, with (silent) TO and IN nodes. The only difference between the two constructions—between *pile* and *make into a pile*—is whether a light verb v$_{reconfigure}$ or a light verb *make$_{reconfigure}$* is used. These two light verbs apparently differ only in their phonological form. This parallel is one part of the motivation for including TO and IN as nodes in the structure for *pile*. The analysis therefore predicts that the two constructions should be equivalent in meaning. In what follows, we argue that they are not.

In their discussion of Manner/Result complementarity, Beavers and Koontz-Garboden (2012) develop a test of direct causation. The question is whether agency can be ascribed to an animate causer which may or may not be responsible for the consequences of their act. In (58), the causer of the breaking event is not

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[8]Silent TO is "semantically and type-theoretically vacuous" (Levinson, 2014:2012).

an "actor" in the sense that the causer does not engage in any direct movement that breaks the DVD player:

(58)   Kim broke my DVD player, but didn't move a muscle—rather, when I let her borrow it a disc was spinning in it, and she just let it run until the rotor gave out!   (Beavers and Koontz-Garboden, 2012:347)

We can adapt this test to determine whether causer and actor can be distinguished between a sentence with *pile* or *stack* and one with *make into a pile/stack*. Consider the two possible followup sentences to the scenario in the first line of (59): The contrast shows that causer and actor cannot be distinguished with Root Creation verbs (59a), but they can in the "make into" construction (59b).

(59)   Mary lost her Tetris game on purpose . . . .
        a.   She made the Tetris pieces into a pile/stack by not pushing the arrow buttons at all.
        b. ??She piled/stacked the Tetris pieces by not pushing the arrow buttons at all.

Next, Fodor (1970) famously presented three arguments against deriving *kill* from *cause to die.* One of Fodor's tests involves adding two time adverbials to try to separate out the causing event from the Change of State event (60):

(60)   a.   Mary caused the glass to melt on Sunday by heating it on Saturday.
        b.   *Mary melted the glass on Sunday by heating it on Saturday.

This test can be applied to Root Creation verbs if some helping context is added, given in the first line of (61). Again, we see from the contrast between (61a) and (61b) that stacking and making into a stack mean different things.

(61)   Mary wanted to see how long a game of Tetris lasts if she doesn't touch any of the keys. She started a new game just before midnight and found out that the game takes about two minutes. . .
        a.   She made the pieces into a pile/stack at 00:01 by launching {them / the game} at 23:59.
        b.   *She piled/stacked the pieces at 00:01 by launching {them / the game} at 23:59.

These diagnostics provide some initial arguments that the two constructions are not the same underlyingly, thus removing an argument for the IN-TO analysis of Root Creation verbs. The next critique is more technical in nature.
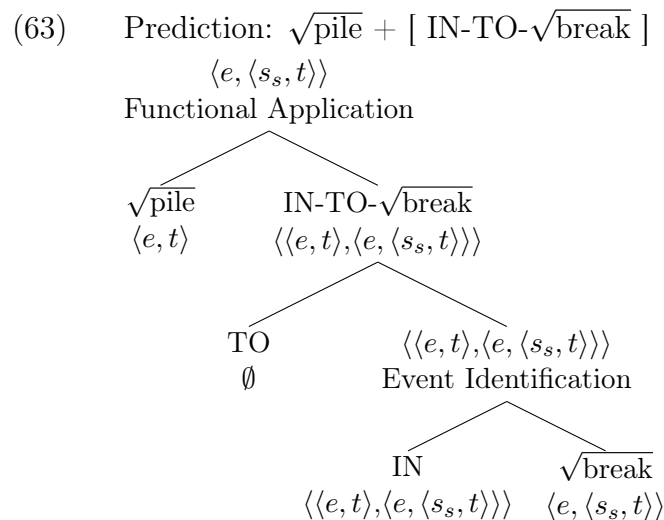
7.3   Empirical issues: transitives

In Levinson (2010), a transitive sentence with a Root Creation verb requires TO and IN. Root Creation roots like $\sqrt{\text{pile}}$ combine with these functional heads to

yield a node of type $\langle e, \langle s_s, t \rangle \rangle$, the same type as Change of State verbs, and a node ready to combine with a direct object like *the cushions*. This is shown in (62) as the node labeled IN-TO-$\sqrt{\text{pile}}$.

(62)   [IN-TO-$\sqrt{\text{pile}}$]   (based on Levinson 2010:167)

$$
\begin{array}{c}
\text{IN-TO-}\sqrt{\text{pile}} \\
\langle e, \langle s_s, t \rangle \rangle
\end{array}
$$

TO
∅

$\langle e, \langle s_s, t \rangle \rangle$
Functional Application

IN
$\langle \langle e, t \rangle, \langle e, \langle s_s, t \rangle \rangle \rangle$

$\sqrt{\text{pile}}$
$\langle e, t \rangle$
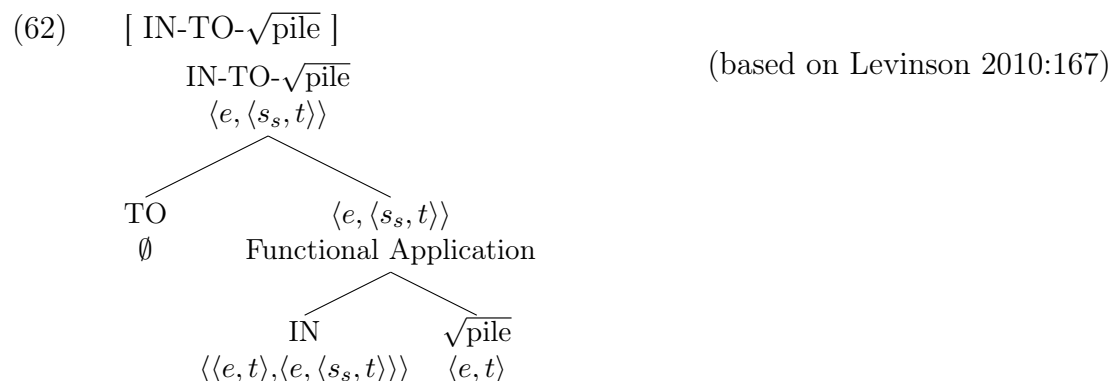
The TO and IN of this analysis essentially convert a Root Creation verb $\langle e, t \rangle$ into a Change of State one $\langle e, \langle s_s, t \rangle \rangle$. So we might ask, instead of feeding IN-TO a thing of type $\langle e, t \rangle$, why not carry out Event Identification between IN-TO and a COS verb, of type $\langle e, \langle s_s, t \rangle \rangle$, as in (63)?

(63)   Prediction: $\sqrt{\text{pile}}$ + [IN-TO-$\sqrt{\text{break}}$]

$\langle e, \langle s_s, t \rangle \rangle$
Functional Application

$\sqrt{\text{pile}}$
$\langle e, t \rangle$

IN-TO-$\sqrt{\text{break}}$
$\langle \langle e, t \rangle, \langle e, \langle s_s, t \rangle \rangle \rangle$

TO
∅

$\langle \langle e, t \rangle, \langle e, \langle s_s, t \rangle \rangle \rangle$
Event Identification

IN
$\langle \langle e, t \rangle, \langle e, \langle s_s, t \rangle \rangle \rangle$

$\sqrt{\text{break}}$
$\langle e, \langle s_s, t \rangle \rangle$

This derivation then requires an element of type $\langle e, t \rangle$ in Spec,IN-TO-$\sqrt{\text{break}}$ to saturate the first argument of [IN-TO-$\sqrt{\text{break}}$]; but one could imagine a scenario in which the argument is in fact another root, one of type $\langle e, t \rangle$ like $\sqrt{\text{pile}}$. In this case, we would need to say that there is some limit on how many roots can fit under one v (not something that follows from the basic assumptions of the hybrid typed system, since roots can be arguments or functions). It could also be in principle another vP or VoiceP—nothing should prevent that, giving us (64), which would mean something like 'John caused the ball's falling to become a broken thing'.

(64)   * John [$_\text{VoiceP}$ the ball fell] break.
        ⇏ 'John caused the ball's falling to become a broken thing'

Nevertheless, the semantic composition works, and the syntactic derivation can also be made to converge, assuming it is possible to have v+Root without finite Tense (which we know is possible in e.g. nominalizations).

The hybrid account could rule out (64) by stipulating that COS roots like $\sqrt{\text{break}}$ are only allowed to be functions, not arguments to a function. Again, it is not clear where and how this kind of constraint would be encoded.

7.4 Summary

We have examined the hybrid type-driven system of Levinson (2007, 2010, 2014) in some depth, precisely because it is the most explicit account we have seen to date of how lexical semantics interacts with the syntax. Weaknesses aside, this work is highly illuminating in that it exposes exactly the sort of questions that a theory must commit to: what is an argument of a root and what is an argument of a functional head? How do root classes differ from one another? What compositional mechanisms do we have in the syntax and the semantics? By now, we hope it is clear how the strengths and weaknesses of this account (as well as those of the Exo-Skeletal model) have informed our own conclusions.

8 Conclusion

To conclude, we have proposed two ways in which meaning components are encoded formally by the grammar. These are (A) syntactically-relevant semantic primitives as part of the denotation of different root classes, and (B) formal semantic types for roots. Surveying a set of syntactic diagnostics across three verb classes in English, we have derived the differences in acceptability from these two components, thereby arguing for their relevance.

While neither conceptual point is novel in and of itself, the explicit implementation is, insofar as it draws attention to different components of root meaning than those discussed so far. The root types here are different from those in previous work on Mayan languages and English—and crucially different from previous work in English on the same phenomena. The denotations of each root class are also of a different kind than in important recent work such as Beavers and Koontz-Garboden (2020).[9]

Three final comments conclude. First, one should ask whether LUMP and MADE-OF can be found elsewhere in the grammar. We think that LUMP carries a similar meaning to the SUM operator "⊕" of Link (1983) and much related work (which we cannot hope to review here). The function MADE-OF might be

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[9]In this work, the primitives are semantically light functions such as cause(), become(), have() and at(). Since the authors explore this inventory in the context of the Bifurcation Thesis for Roots of Embick (2009), they focus on functions that are often associated with functional elements as well (v_{cause}, v_{become}, HAVE, P).

the same as the PART-OF relation of Myler (2016) and related work on alienable and inalienable possession, which may be among the best candidates for a grammatically-privileged concept. Figuring out which predicates might inhabit functional heads and which inhabit roots is an important part of the overall research program, as highlighted in work such as Embick (2009) and Beavers and Koontz-Garboden (2020).

Second, because much of our introduction was framed with reference to Manner/Result Complementarity, we briefly show how our approach can extend to this distinction. A discussion of Manner/Result in terms compatible with our view has recently been given by Beavers and Koontz-Garboden (2012, 2020:Ch. 4), where functions like BECOME() are part of the denotation of some roots. The authors stop short, however, of suggesting an explicit formal distinction, alluding instead to general [±manner] and [±result] features which remain to be explored further. It is tempting to propose that this difference can be captured by making reference to formal semantic types; perhaps manner roots are of type $\langle e, t \rangle$ and result roots are of type $\langle e, \langle s, t \rangle \rangle$ (or whichever formalization accords better with the specific implementation of Beavers and Koontz-Garboden 2020).

Here is why we refrain from making such a claim: Recall that we have confined ourselves to acceptability judgments, trying to employ syntactic diagnostics. The Manner/Result literature has for the most part made use of semantic entailment tests. Space considerations prevent us from discussing these tests here; some of the diagnostics can indeed be explained using our current tools (e.g., restricted resultatives); some are entailment tests and thus unlikely to be captured—highlighting once again the need for both entailment tests and syntactic tests. Other findings from the Manner/Result literature (e.g., complexity of action and selectional restrictions) should be amenable to explanation in future versions of our theory . We have not attempted to evaluate these claims in our current work since they draw on different empirical domains.

With this in mind, a unified theory should ultimately be able to converge on a set of semantic primitives that are available crosslinguistically. In this sense the current work and that of Beavers and Koontz-Garboden (2020) and colleagues are part of the same enterprise, aiming to make precise how lexical semantics translates into semantic primitives which interact with the syntax. It should go without saying that investigating additional root/verb classes, in English as well as other languages, stands to teach us much about these issues.

Third and finally, we have been careful to note that although we frame our approach in terms of uncategorized roots, our empirical domain consists solely of verbs. One important question for this general enterprise concerns the extent to which generalizations can be made across syntactic categories. In some cases this is clearly possible; we refer once again to Beavers and Koontz-Garboden (2020), who suggest that the DP *crack* entails a change of state just like the verb *crack* does. On the other hand, they note that the verb *hand* entails motion and possession whereas the noun *hand* does not (Beavers and Koontz-Garboden, 2020:25fn). This

state of affairs forces them to conclude that the verb and the noun are formed from two separate roots (call them $\sqrt{\text{hand}_1}$ and $\sqrt{\text{hand}_2}$) which are only historically related.

We cannot delve into the literature on root-derived verbs, root-derived nouns, noun-derived verbs and verb-derived nouns here (see Harley and Haugen 2007 and Rimell 2012 for an overview of some issues). Instead, we simply acknowledge at this point that we do not know what generalizations need to be accounted for; a large-scale comparison of roots across categories remains to be carried out.

In sum, our aim here is to contribute to a growing body of work that makes explicit how lexical semantics interacts with the syntax, using contemporary tools and assumptions in order to provide testing ground for different theories of the grammar. We hope the tools we have proposed can clarify the different components of sentence meaning contributed by roots, syntactic structure, and roots interpreted in different syntactic structures.

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