MEANING AND VALENCY

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Abstract

We draw together ideas from a number of certain recent proposals in the LFG literature for the encoding of lexical information and the sharing of this information across valencies in a generalized fashion. This forms the beginnings of a theory of the representation and specification of information that sits at the lexicon–syntax–semantics interface. Our formal ingredients are: 1. Templates; 2. Aspects of the regular language of f-descriptions, particularly optionality; 3. Resource-sensitive semantic composition, as captured by Glue Semantics. We provide analyses of passives, cognate objects and benefactives, and demonstrate that the analyses of these phenomena interact properly. We derive a system in which composition is flexible and meaning emerges from the properly constrained interaction of a variety of contributors.

1 Introduction

There have been certain recent proposals in the LFG literature (Dalrymple et al. 2004, Asudeh et al. 2008, 2013, Asudeh and Giorgolo 2012) for the encoding of lexical information and the sharing of this information across valencies in a generalized fashion — including, in some cases, 'constructions'.[1] The first main aim of this paper is to make an initial attempt at drawing these proposals together in a consistent way. The second main aim is programmatic: we put this approach forward as the beginning of a theory of the representation and specification of information that sits at the lexicon–syntax–semantics interface. The main intuition behind our approach is similar to the intuition that the lexicon is a "web of meaning", which is in the spirit of some independent proposals (Asher 2011). More particularly, we take a perspective that meaning *emerges* from the interaction of lexically and configurationally triggered components: all and only the possible meanings are selected, depending on the grammatical context.

We focus particularly on the following issues:[2]

1. **The representation of core semantic information, such that the same lexical entry can be involved in a number of valency realizations:** For example, the verb *eat* can be used transitively, intransitively and in the "*way*-construction", but it has a stable meaning across these uses.

   (1) The hamster ate a sheet of newspaper this morning.

   (2) The hamster ate this morning.

   (3) The hamster ate its way through a sheet of newspaper this morning.

   These examples involve different surface realizations and have distinct overall interpretations, but they all involve an eating event, with the hamster as the agent/eater.

2. **The representation of missing/understood arguments:** For example, the patient of intransitive *eat* in (2) is unrealized, but still understood: The hamster ate *something* this morning. Moreover, there are implicit limits on *what* the hamster is understood to have eaten (hamster food, not newspapers). Another example of this is the understood argument in a short passive.

3. **The representation of additional/derived arguments:** For example, the verb *laugh* does not normally take an object, but it can take a *cognate object*:

   (4) *The performer laughed the children.

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[1]We intend this term only pretheoretically and do not commit to Construction Grammar.

[2]The editors point out that some of these ideas are similar in spirit to Rappaport Hovav and Levin's (1998) notion of *Template Augmentation*. We have not had the opportunity to explore this connection carefully.

(5) The performer laughed a funny laugh.

4. **The possibility of associating meanings with syntactic configurations:** For example, certain verbs that do not inherently have a benefactive reading can receive one if they occur in a double object structure:

   (6) The performer sang the children a song.

   Similarly, Asudeh et al. (2013) argue that the Swedish "Directed Motion Construction" (Toivonen 2002) involves association of a meaning similar to that of the English *way*-construction with a specific phrase structure configuration.

5. **Templates as generalizations over lexically encoded meaning:** Commonalities across lexical entries can be factored out and stated once only. For example, *eat* and *kick* are both AGENT-PATIENT verbs, but differ in other aspects of their semantics; this is reflected by some shared template calls and some distinct calls. The same technique can capture similarities between verb types like *eat* and *devour* that share core meaning but display distinct valency options.

6. **Templates as the locus of specification of meanings which can be associated with lexical entries or c-structure rules:** A single abstract meaning can be stated for, e.g. *benefactive*, which could be associated with a lexical entry, e.g. *give*, or with a syntactic configuration, such as the double object structure. It then becomes an empirical question which approach gives the more parsimonious description or explanation, but it is not necessary to dispense with the distinction between lexicon and syntax.[3]

Our formal ingredients are the following:

1. Templates (Dalrymple et al. 2004, Asudeh et al. 2008, 2013, Asudeh and Toivonen 2014)
2. Aspects of the regular language of f-descriptions, particularly optionality (Kaplan and Bresnan 1982, Kaplan 1989)
3. Resource-sensitive semantic composition, as captured by Glue Semantics (Dalrymple 1999, 2001, Asudeh 2012)

The following schematic lexical entry for *ate* illustrates the above:

(7) *ate* V ($\uparrow$ PRED) = 'eat'
(@AGENT-PATIENT)
(@UNDERSTOODOBJECT)
$\lambda e.eat(e) : (\uparrow_\sigma \text{ EVENT}) \multimap \uparrow_\sigma$

The only obligatory meaning constructor is the constructor that specifies the core meaning. The meaning templates AGENT-PATIENT and UNDERSTOODOBJECT, which contribute further meaning constructors, are optional. Our use of optional semantic resources is different from an approach that simply lists alternative lexical entries for each use of the verb. The resource sensitivity of Glue Semantics provides further constraints on well-formedness and ensures that the options are selected appropriately (Asudeh and Giorgolo 2012). Resource sensitivity ensures that: 1. neither optional meaning template can be selected for a *way*-construction example like (3); 2. only the AGENT-PATIENT template is additionally possible for a transitive example like (1); 3. both optional templates are required for a syntactically intransitive example like (2).

In general, templates for optional semantic resources will be functions that work on the core semantic resource by adding to its valency appropriately. For example, fundamental valency templates such as

[3] We envisage that this would vitiate the need for lexical rules as an added mechanism, but we have not explored this systematically. Some relevant discussion can be found in Asudeh and Toivonen (2014).

AGENT-PATIENT add the basic argument structure. In the case of missing arguments, the template will modify the basic argument structure from a binary relation to a unary predicate, existentially binding the object argument. In contrast, in a case like (5), the optional resource specified for *laughed* should change the type of the core semantic resource by adding an argument, possibly a dummy one, but also checking for specific semantic properties of the cognate object (e.g. the added argument must be something that is a kind of laugh).

Our main proposals/claims are as follows:

1. Lexical entries for predicates generally contain no specific information except:
   (a) A stripped down PRED value, which now serves only as a label and ensures f-structural uniqueness (Dalrymple 2001, Asudeh 2012).[4]
   (b) A predicate over events that provides the fundamental meaning, which is optionally augmented by a-structure templates, and possibly other optional templates, and which interacts with templates triggered by c-structure configurations ('constructions').
   (c) At least in some cases, information about selectional restrictions.
2. Composition is *flexible*: the relation between syntax and semantics is not total and one-to-one, but rather partial and one-to-many. A single terminal node (i.e., lexical entry) can contribute multiple meaning constructors or possibly none (e.g., expletives).
3. Meaning is *emergent*: the possible interpretations for an expression are fully determined by the information in the terminal nodes and the syntactic structure, thus maintaining compositionality and ensuring that all syntactic structures produced by the grammar are interpreted, but the meanings arise from an interaction of a set of meaning constructors whose cardinality is possibly larger than that of the set of terminal nodes.

The overall system brings a constraint-based ethos to semantic composition and the lexicon–syntax–semantics interface, as in Minimal Recursion Semantics (Copestake et al. 2005) and certain other approaches, but without giving up the type-logical approach to composition as founded on functional application.

2 Data/Phenomena

We restrict ourselves to three empirical phenomena and their interactions, all exemplified by data from English:

1. Passives
   (a) Short passive
      (8) Kim was crushed last night.
   (b) Passive with *by*-phrase
      (9) Kim was crushed by Godzilla last night.
2. Cognate objects
   (10) Kim laughed a crazy laugh.
3. Benefactives
   (a) Double object benefactive

[4]Even the latter function would seem to be covered by resource sensitivity in Glue Semantics, but we will not comment further here, as the nature of PRED values is not our primary focus. See Asudeh (2012) for some initial discussion.

(11) Kim drew Sandy Godzilla.

(b) *For*-benefactive

(12) Kim drew Godzilla for Sandy.

4. Interactions

(a) Double object benefactive with cognate object

(13) The performer sang the children a song.

(14) *The clown laughed the children a crazy laugh.

(b) Double object benefactive with cognate object and short passive

(15) The children were sung a song.

(16) *The children were laughed a laugh.

The analysis of the passive is essentially that of Asudeh and Giorgolo (2012), but updated in light of the mapping theory of Findlay (2014). The analysis of benefactives is based on Toivonen (2013) and Findlay (2014), which in turn builds on unpublished work by Asudeh (2013).

3 Theoretical and Formal Ingredients

3.1 Derived Arguments

The distinction between arguments and adjuncts is vital in linguistic theory, but sometimes a phrase displays mixed argument/adjunct characteristics, behaving in some ways as an argument and in other ways as an adjunct. Examples from the literature include: the passive *by*-phrase (Cook 2006, Grimshaw 1990), possessive phrases in event nominals (Grimshaw 1990), benefactives (*for*-PPs), displaced themes (*with*-PPs; Lewis 2004), instruments (Donohue and Donohue 2004, Koenig et al. 2003, Van Valin and LaPolla 1997, Schütze 1995), experiencer PPs (Asudeh and Toivonen 2007, 2012, Bosse et al. 2012), directionals (Needham and Toivonen 2011, van Luven 2014), result XPs (Christie 2013). Needham and Toivonen (2011) treat such 'in-between cases' as *derived* arguments; that is, arguments added to the basic argument frame of a verb. We will find it useful to appeal to the notion of derived arguments below.

3.2 Templates

A template in LFG is just a named lexical description: templates contain all and only the sort of information that is encoded in LFG f-descriptions. Templates were introduced as part of the XLE (Crouch et al. 2011) for implementation of LFG grammars, but have since made their way into the theoretical LFG literature (Dalrymple et al. 2004, Asudeh et al. 2008, 2013, Asudeh 2012, Asudeh and Toivonen 2014). The rest of this section introduces templates, following the exposition of Asudeh and Toivonen (2014).

The following is an agreement template for third singular subject agreement, 3SG:

(17) 3SG =
(↑ SUBJ NUM) = 3
(↑ SUBJ PERS) = SG

The template 3SG is simply equal to the f-description on the right side of the equality in (17). The semantics of template invocation (written @TEMPLATE) is thus just substitution. It follows, then, templates do not increase the expressive power of LFG grammars. However, they do allow certain generalizations about common uses of linguistic information to be captured in ways that the extensionally equivalent non-templatic grammar would not.

The use of the agreement template 3SG is illustrated in the following partial lexical entries for the intransitive verbs *laughs* and *laugh*:

(18) a. *laughs* V ($\uparrow$ PRED) = 'laugh⟨SUBJ⟩'
($\uparrow$ TENSE) = PRESENT
@3SG

b. *laugh* V ($\uparrow$ PRED) = 'laugh⟨SUBJ⟩'
{ ($\uparrow$ TENSE) = PRESENT
¬@3SG |
¬($\uparrow$ TENSE) }

The disjunction in the lexical entry for *laugh* states that it is either a present tense verb, but not in the third person singular, or else not a tensed verb (as in, e.g., *It is fun to laugh.*)

It is possible to further generalize these lexical entries, using more templates. The following lexical entries have abstracted all non-idiosyncratic information away into templates:[5]

(19) a. *laughs* V @INTRANSITIVE(laugh)
@TENSE(PRESENT)
@3SG

b. *laugh* V @INTRANSITIVE(laugh)
@BAREV

The templates INTRANSITIVE and BAREV can be defined as follows:

(20) INTRANSITIVE(X) =
($\uparrow$ PRED) = 'X⟨SUBJ⟩'

(21) BAREV =
{ @TENSE(PRESENT)
¬@3SG |
¬($\uparrow$ TENSE) }

The INTRANSITIVE template illustrates that templates can take arguments. In this case, it is the PRED function that is the argument of the template, e.g. laugh in (19). These templates — TENSE, INTRANSITIVE, BAREV, 3SG — thus capture cross-cutting generalizations about *laugh*, *laughs*, and other elements of the lexicon, as follows (Asudeh and Toivonen 2014):

1. The argument to the template TENSE, which is also invoked by BAREV, captures that *laughs* is necessarily present tense and that *laugh* can be present tense (unless it is a bare verb).

2. The argument to INTRANSITIVE captures the fact that *laugh* and *laughs* are instances of the same lemma, while the template itself relates these verbs to other intransitive verbs, which would also invoke this template.

3. Similarly, the template BAREV captures the relationship between *laugh* and other uninflected regular verbs. Lastly, the negated invocation of 3SG within BAREV captures the fact that no uninflected regular verbs in English are third person singular.

Asudeh et al. (2008, 2013) discuss how templates can generalize not just across lexical items, but also across lexical items and phrase-structural configurations, thus capturing constructional effects, but without admitting into the theory constructions as specific theoretical constructs, in contrast to Construction Grammar (e.g., Goldberg 1995). Asudeh and Toivonen (2014) illustrate the point with English restrictive relatives, which have elsewhere indeed been analyzed as constructions (Sag 1997). Consider the reduced relative (22a) and its counterpart with a relative pronoun (22b).

[5] We have not taken morphology into account here, but we assume that templates for morphologically complex words like *laughs* are in fact contributed appropriately by their parts. This could be formally captured and implemented in a framework like that of Beesley and Karttunen (2003).

(22) a. *the book Kim read*

b. *the book which Kim read*

The relevant point here is that English relative clauses can contain a relative pronoun, but do not necessarily have to.

Asudeh and Toivonen (2014) propose the template REL in (23), building on work by Dalrymple (2001).

(23) REL = $\lambda Q.\lambda P.\lambda x.P(x) \wedge Q(x) : clause \multimap nominal \multimap nominal$

This template expresses the compositional semantics of restrictive relativization, using Glue Semantics. This demonstrates that templates can also capture semantic information, which we will put to use below. The Glue logic term has been abbreviated to $clause \multimap nominal \multimap nominal$, which captures the fact that relativization is a modification of a nominal by an open clause; see Dalrymple (2001: 417) for the full term. In the meaning language side, this is intersective modification of the nominal predicate by the relative clause predicate.

The template REL can be associated with a relative pronoun, as in (24), or with a node in a c-structure rule, as in (25), since c-structure rules in LFG are annotated with the same sorts of descriptions that occur in LFG lexical entries.

(24) *which* D @REL

(25) $\text{CP} \rightarrow \begin{pmatrix} \text{RelP} \\ \ldots \end{pmatrix} \quad \begin{matrix} \text{C}' \\ (\ @\text{REL}\ ) \end{matrix}$

In the c-structure rule above, RelP is the relative pronoun (or, more accurately, the phrase containing the relative pronoun, to allow for pied-piping), which is optional, as exemplified in (22a) above. If the RelP is present, it contributes the @REL meaning constructor. Otherwise, the very same information is directly contributed by the C′ node in the c-structure rule. The @REL template thus generalizes the same information across relative pronouns and bare relatives.

3.3 Flexible Composition

Asudeh and Giorgolo (2012) assume a version of LFG's Correspondence Architecture (Kaplan 1987, 1989) in which argument structure (a-structure) is captured in a new connected level of semantic structure (s-structure). Some of the benefits of this approach are as follows:

1. A simplified architecture is achieved, which eliminates a separate a-structure projection, without losing information
2. Linking relations can be preserved and they are still post-constituent structure, as required for empirical reasons (Butt 1995, Butt et al. 1997).
3. Many of the meaning constructors for semantic composition are more elegant and simplified.
4. The simple, traditional ϕ mapping from c-structure to f-structure is regained.
5. Semantic structure is a true, connected structure, in contrast to the unconnected s-structures which serve only to enable proofs in Glue Semantics (Dalrymple 1999, 2001, Asudeh 2012, among others).

Figure 1 shows relevant structures and correspondences from Asudeh and Giorgolo (2012). They assume an event semantics for the meaning language, such that thematic roles are functions from events to individuals (Parsons 1990), so avoid redundancy in the argument structure by using attributes like ARG_1 instead of AGENT, etc.

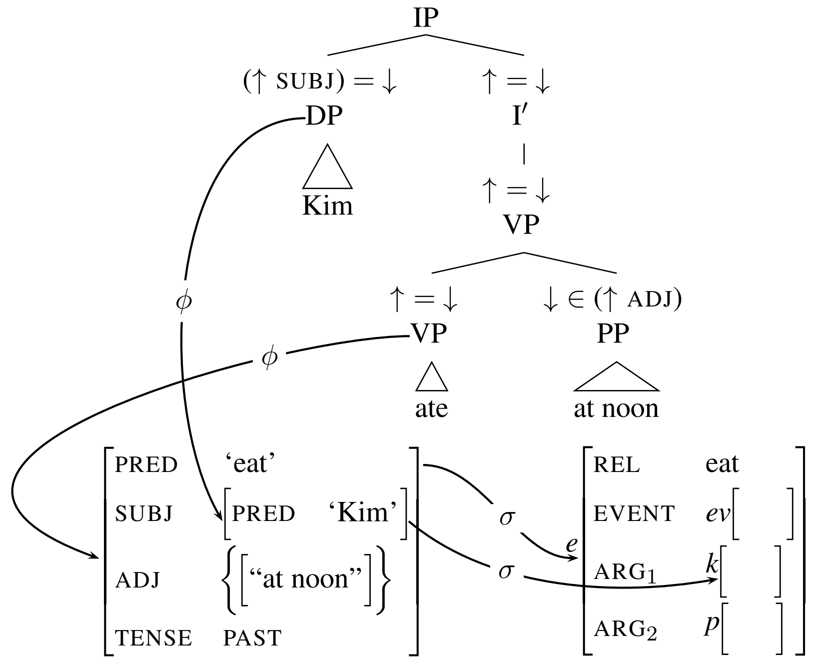

Figure 1: *Kim ate at noon.*

3.4 Kibort-Findlay Lexical Mapping Theory

The lexical entries and templates in Asudeh and Giorgolo (2012) stipulated equations for *argument realization* (Levin and Rappaport-Hovav 2005), also known as *linking* or *mapping*. For example, the last line in the following lexical entry specifies that $(\uparrow \textsc{obj})_\sigma = (\uparrow_\sigma \textsc{arg}_2)$, i.e. the object maps to $\textsc{arg}_2$ at semantic structure.

(26) *devoured* V $(\uparrow \textsc{pred}) = $ ‘devour’
$(\uparrow \textsc{tense}) = \textsc{past}$
$\vdots$ $(\uparrow \textsc{obj})_\sigma = (\uparrow_\sigma \textsc{arg}_2)$

Ideally, we would like such equations to be derived from some version of Lexical Mapping Theory (Bresnan and Kanerva 1989, Alsina 1996, among others).

This has been addressed in recent unpublished work by Jamie Findlay (Findlay 2014), which presents a formalization of Anna Kibort's version of LMT (Kibort 2001, 2007, 2008, 2013a,b) in the context of the formalization of argument structure in Asudeh and Giorgolo. In Kibort's mapping theory (LMT_K), the grammatical function hierarchy in (27) is assumed to map to argument position in the universally available subcategorization frame in (28) (Kibort 2001, 2007, 2008).

(27) $\textsc{subj} > \textsc{obj}, \textsc{obl}_\theta > \textsc{obj}_\theta$

(28) $\langle\ \underset{[-o]}{\text{arg}_1}\quad \underset{[-r]}{\text{arg}_2}\quad \underset{[+o]}{\text{arg}_3}\quad \underset{[-o]}{\text{arg}_4}\quad \ldots\quad \underset{[-o]}{\text{arg}_n}\ \rangle$

The positions in the universal phrase are intrinsically associated with LMT feature specifications, where we have the standard LMT features r for *restrictive* and o for *objective*.

Predicates do not have to select a contiguous series of arguments (Kibort 2001, 2007, 2008), as exemplified by the following frame for *put*:

(29) *put* $\langle\ \underset{[-o]}{\text{arg}_1}\quad \underset{[-r]}{\text{arg}_2}\quad \underset{[-o]}{\text{arg}_4}\ \rangle$

It should thus be stressed that Kibort uses these underspecified argument labels in a different way than Asudeh and Giorgolo: for Kibort, the argument labels correspond to underspecified LMT features, r and o.

In Findlay's version of LMT, which builds on Kibort's theory and which we'll designate as LMT_{KF}, the [±r] and [±o] feature specifications are defined as features (Findlay 2014):

(30) $\text{MINUSR} \equiv \{\text{SUBJ}|\text{OBJ}\}$ $[-r]$

(31) $\text{MINUSO} \equiv \{\text{SUBJ}|\text{OBL}_\theta\}$ $[-o]$

(32) $\text{PLUSR} \equiv \{\text{OBL}_\theta|\text{OBJ}_\theta\}$ $[+r]$

(33) $\text{PLUSO} \equiv \{\text{OBJ}|\text{OBJ}_\theta\}$ $[+o]$

The universally available subcategorization frame is accordingly revised as follows (Findlay 2014):

(34) $\left\langle \begin{matrix} \text{ARG}_1 & \text{ARG}_2 & \text{ARG}_3 & \text{ARG}_4 \\ \text{MINUSO} & \text{MINUSR} & \text{PLUSO} & \text{MINUSO} \end{matrix} \right\rangle$

Findlay (2014: 25) assumes that only $\text{ARG}_{1...4}$ are core arguments and that all other arguments are *derived arguments* (Needham and Toivonen 2011), in the sense sketched in section 3.1.

Findlay (2014) recasts (34) in terms of the approach to a-structure of Asudeh and Giorgolo (2012):

(35) $(\uparrow \text{MINUSO})_\sigma = (\uparrow_\sigma \text{ARG}_1)$

(36) $(\uparrow \text{MINUSR})_\sigma = (\uparrow_\sigma \text{ARG}_2)$

(37) $(\uparrow \text{PLUSO})_\sigma = (\uparrow_\sigma \text{ARG}_3)$

(38) $(\uparrow \text{MINUSO})_\sigma = (\uparrow_\sigma \text{ARG}_4)$

These mapping equations need to be optional, in order to capture the fact that certain arguments may actually be unrealized; for example, optional objects of verbs like *eat* or the logical subject in short passives.

However, pure optionality is insufficient, as we need the relevant argument to map appropriately if it actually is realized. We therefore need disjunctions that state that an argument is mapped appropriately *unless* it is unrealized, e.g.:[6]

(39) $\{\ (\uparrow \text{MINUSO})_\sigma = (\uparrow_\sigma \text{ARG}_1)\ |\ (\uparrow_\sigma \text{ARG}_1)_{\sigma^{-1}} = \varnothing\ \}$

We can define templates to capture the disjuncts in (39) (Findlay 2014).

(40) MAP(F,A) =
$(\uparrow \text{F})_\sigma = (\uparrow_\sigma \text{A})$

(41) NOMAP(A) =
$(\uparrow_\sigma \text{A})_{\sigma^{-1}} = \varnothing$

The template MAP maps a grammatical function to a-structure, as in the left disjunct of (39). The template NOMAP states that a given argument in argument structure is not mapped from anything in f-structure, as in the right disjunct of (39).

The LMT_{KF} templates for universal mapping principles are then as follows (Findlay 2014):

(42) ARG1 =
$\{\ \text{@MAP}(\text{MINUSO},\text{ARG}_1)\ |\ \text{@NOMAP}(\text{ARG}_1)\ \}$

[6]Our presentation of some details at this point diverges a little from the presentation in Findlay (2014), but essentially only notationally — the ideas are Findlay's.

(43) ARG2 =
{ @MAP(MINUSR,ARG$_2$) | @NOMAP(ARG$_2$) }

(44) ARG3 =
{ @MAP(PLUSO,ARG$_3$) | @NOMAP(ARG$_3$) }

(45) ARG4 =
{ @MAP(MINUSO,ARG$_4$) | @NOMAP(ARG$_4$) }

The lexical entry for *devour* can now be rewritten in terms of LMT$_{KF}$ as follows:

(46) *devoured* V ($\uparrow$ PRED) = DEVOUR
@PAST
@ARG1
@ARG2
⋮

Lastly, we add a template ADDMAP for monotonic addition of further mapping constraints, e.g. in passive.

(47) ADDMAP(F,A) =
{ @MAP(F,A) | @NOMAP(A) }

This template simply calls the MAP and NOMAP templates to add another mapping constraint.

4 Analysis

We now demonstrate how the theory works by providing analyses for the phenomena in section 2. We first specify the templates, which constitute the heart of the flexible composition approach (section 4.1). We then use these templates along with lexical and c-structure specifications to analyses passives (section 4.2), cognate objects (section 4.3), benefactives (section 4.4) and some interactions of these phenomena (section 4.5).

4.1 Templates

We first define templates for agent arguments and patient arguments:

(48) AGENT =
@ARG1
$\lambda P \lambda x \lambda e.P(e) \wedge agent(e) = x$:
$[(\uparrow_\sigma \text{EVENT}) \multimap \uparrow_\sigma] \multimap (\uparrow_\sigma \text{ARG}_1) \multimap (\uparrow_\sigma \text{EVENT}) \multimap \uparrow_\sigma$

(49) PATIENT =
@ARG2
$\lambda P \lambda x \lambda e.P(e) \wedge patient(e) = x$:
$[(\uparrow_\sigma \text{EVENT}) \multimap \uparrow_\sigma] \multimap (\uparrow_\sigma \text{ARG}_2) \multimap (\uparrow_\sigma \text{EVENT}) \multimap \uparrow_\sigma$

Each of these templates has two parts. The first part is a call to the appropriate LMT$_{KF}$ mapping template. These ensure the correct correspondence between grammatical functions and arguments, as discussed in section 3.4. The second part of each template is a meaning constructor that modifies an event, adding an $agent$ or $patient$ argument.

The following template is defined in terms of these templates:

(50) AGENT-PATIENT =
@AGENT
@PATIENT

This template thus provides both the appropriate linking and interpretation for agent-patient verbs.

The template for passives is as follows:[7]

(51) PASSIVE =
$(\uparrow \text{VOICE}) = \text{PASSIVE}$
@ADDMAP(PLUSR,ARG$_1$)
$(\ \lambda P \exists x.[P(x)] : [(\uparrow_\sigma \text{ARG}_1) \multimap \uparrow_\sigma] \multimap \uparrow_\sigma\ )$

This template does two things. First, it uses the ADDMAP template from section 3.4 to add a further linking constraint, such that ARG$_1$ is either a restricted grammatical function or else absent. The linking theory will ensure that if it is present it corresponds to the restricted function OBL. Second, the template provides an optional meaning constructor that must be selected for the short passive but cannot be selected if there is a *by*-phrase, due to the resource sensitivity of the Glue logic, as discussed by Asudeh and Giorgolo (2012).

The following template is used in cognate object cases:

(52) COGNATEOBJECT
$\lambda x \lambda P \lambda e.P(e)\ \wedge\ x = \varepsilon(e) :$
$(\uparrow \text{OBJ})_\sigma \multimap [(\uparrow_\sigma \text{EVENT}) \multimap \uparrow_\sigma] \multimap (\uparrow_\sigma \text{EVENT}) \multimap \uparrow_\sigma$

The template provides the capacity to deal with an OBJ in the verb's f-structure, even if it would not normally be licensed by the verb. The fact that it must be a *cognate* object is captured by the meaning term. The function ε embeds the type of events into the types of individuals, i.e. it maps each event to an individual that represents that event. Being an embedding, it is injective and can be made surjective (and therefore a bijection) by restricting its codomain to the image of the set of events under ε. Since ε is a bijection, it means we also have an inverse mapping ε^{-1} from individuals to events.

The following template handles double-object benefactives:[8]

(53) BENEFACTIVE =
@ARG3
$\lambda x \lambda y \lambda P \lambda e.P(y)(e)\ \wedge\ \mathit{beneficiary}(e) = x :$
$(\uparrow_\sigma \text{ARG}_2) \multimap (\uparrow_\sigma \text{ARG}_3) \multimap [(\uparrow_\sigma \text{ARG}_2) \multimap (\uparrow_\sigma \text{EVENT}) \multimap \uparrow_\sigma] \multimap (\uparrow_\sigma \text{EVENT}) \multimap \uparrow_\sigma$

Independent linking constraints will ensure that there is a correspondence between the OBJ of the verb and its ARG$_2$. The template also encodes a kind of formal trick: the dependency that the verb would have otherwise discharged in terms of ARG$_2$ is now discharged instead in terms of the OBJ$_\theta$, which corresponds to ARG$_3$

Lastly, the following template is used to provide tense and to existentially close the event variable:

(54) PAST =
$(\uparrow \text{TENSE}) = \text{PAST}$
$\lambda P \exists e.[P(e)\ \wedge\ \mathit{past}(e)] :$
$[(\uparrow_\sigma \text{EVENT}) \multimap \uparrow_\sigma] \multimap \uparrow_\sigma$

4.2 Passives

Let us consider the following two examples, respectively a short-passive and a *by*-passive:

(55) Kim was crushed last night.

(56) Kim was crushed by Godzilla last night.

The following lexical entry for *crushed* suffices for both examples:

[7]This template is adapted from Findlay (2014: 33).
[8]This template is from Findlay (2014: 37).

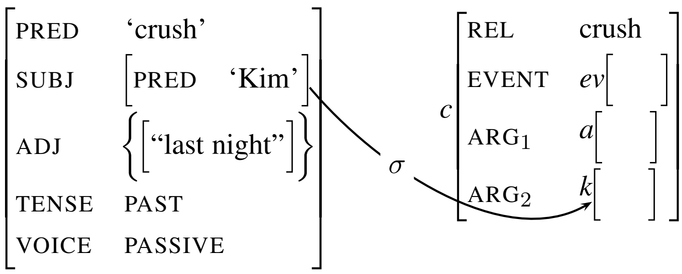

Figure 2: Relevant structures and correspondences for *Kim was eaten last night.*

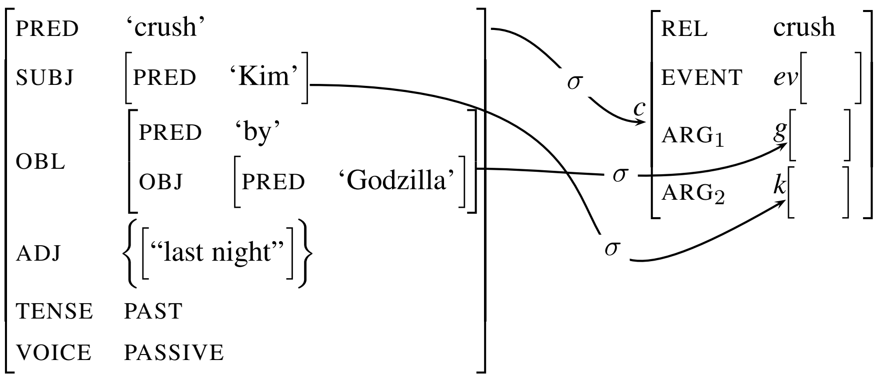

Figure 3: Relevant structures and correspondences for *Kim was crushed by Godzilla last night.*

(57) *crushed* V (↑ PRED) = 'crush'
@AGENT-PATIENT
{ @PAST | @PASSIVE }
$\lambda e.crush(e) : (\uparrow_\sigma \text{ EVENT}) \multimap \uparrow_\sigma$

The verb calls the AGENT-PATIENT which provides its function-argument linking. The lexical entry also states that this morphological form of the verb is either a past tense verb or a passive participle, hence the disjunction on calls to the @PAST template and the PASSIVE template; it is the latter that is relevant here. Lastly, the verb provides its root meaning, a predicate on events. The relevant structures for this example are in Figure 2 and the Glue proof is in Figure 7 in the appendix.

The following lexical entry for *by* covers its use in the passive:

(58) *by* P (↑ PRED) = 'by'
((OBL ↑) VOICE) $=_c$ PASSIVE
$(\uparrow \text{ OBJ})_\sigma = ((\text{OBL} \uparrow)_\sigma \text{ ARG}_1)$
$\lambda x \lambda P.[P(x)] : (\uparrow_\sigma \text{ ARG}_1) \multimap [\uparrow_\sigma \multimap (\text{OBL} \uparrow)_\sigma] \multimap (\text{OBL} \uparrow)_\sigma$

The constraining equation for VOICE ensures that this *by* must occur with a passive participle. The third line maps the object of *by* to be the ARG_1 of the passive predicate. Lastly, the meaning constructor feeds the ARG_1 to the passive predicate as an argument. The relevant structures for this example are in Figure 3 and the Glue proof is in Figure 8 in the appendix.

4.3 Cognate Objects

We now turn to a cognate object example:

(59) Kim laughed a crazy laugh.

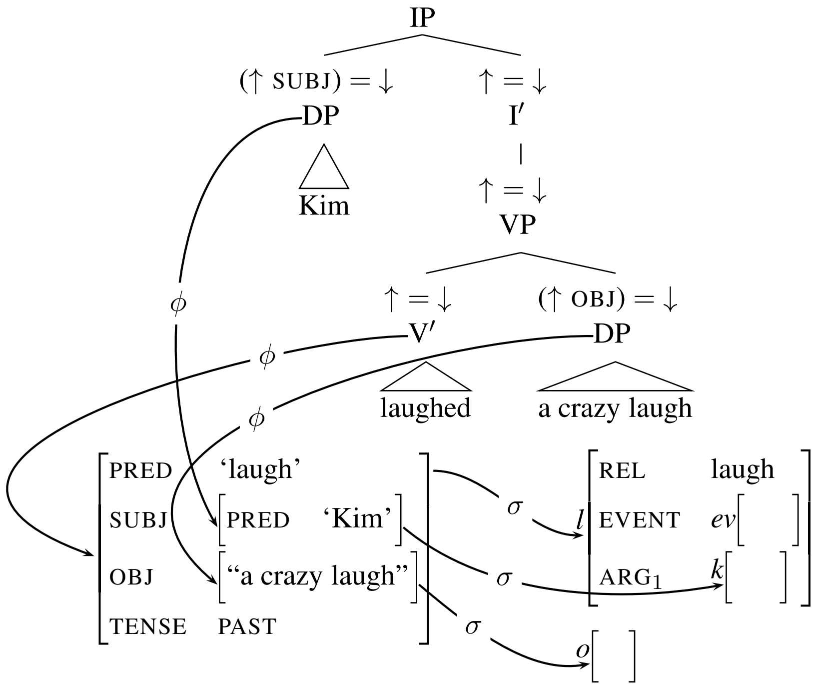

Figure 4: C-structure, f-structure, and semantic structure for *Kim laughed a crazy laugh*

The lexical entry for *laughed* is shown in (60).[9]

(60) *laughed* V
$(\uparrow \text{PRED}) = \text{`laugh'}$
@PAST
@AGENT
(@COGNATEOBJECT)
$\lambda e.laugh(e) : (\uparrow_\sigma \text{EVENT}) \multimap \uparrow_\sigma$

The cognate object is not obligatory, so the call to the COGNATEOBJECT template is optional. This lexical entry is thus general and covers both intransitive and cognate object uses of *laughed*.

The structures for example (59) are in Figure 4. The cognate object is treated compositionally like an adjunct (Sailer 2010), since it does not map to an argument in semantic structure and composes as a modifier, but note that it is in fact an OBJ in f-structure. This accounts for the object-like syntactic behaviour of the cognate object (Jones 1988), without forcing us to treat it as an underlying argument or postulating a transitive version of *laugh*. The Glue proof for example (59) is shown in Figure 9 in the appendix, assuming other standard premises as appropriate and with premises instantiated as per Figure 4.

4.4 Benefactives

Next we consider the following two benefactive examples:

(61) Kim drew Godzilla for Sandy.

[9]Recall that wee assume that the predicate $laugh$, defined for events, is mirrored by a corresponding $laugh^\varepsilon$ predicate defined for individuals. In general we assume that there are lexical axioms linking intransitive verbs extensions and the extensions of their cognate objects. In the case of $laugh$ we assume the following axiom:

(i) $\forall e.laugh(e) \leftrightarrow laugh^\varepsilon(\varepsilon(e))$

Notice that this accounts for the redundancy of an expression such as *Kim laughed a laugh*, as the cognate object does not add anything to the truth conditions of the sentence.

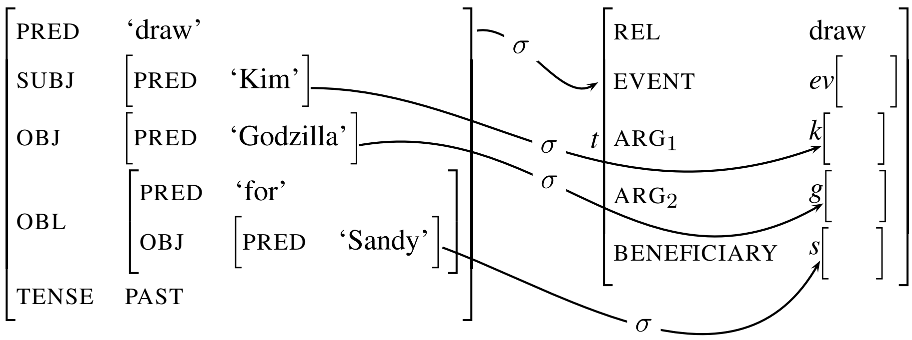

Figure 5: Relevant structures and correspondences for *Kim drew Godzilla for Sandy.*

(62) Kim drew Sandy Godzilla.

We assume the following lexical entry for *drew*:

(63) *drew* V
$(\uparrow \text{PRED}) = \text{`draw'}$
@PAST
@AGENT-PATIENT
$\lambda e.draw(e) : (\uparrow_\sigma \text{EVENT}) \multimap \uparrow_\sigma$

The verb is just treated like a normal transitive and does not encode the benefactive in any way.

In the *for*-benefactive, (61), it is the preposition *for* that adds the benefactive meaning.

(64) *for* P
$(\uparrow \text{PRED}) = \text{`for'}$
$(\uparrow \text{OBJ})_\sigma = ((\text{OBL} \uparrow)_\sigma \text{ BENEFICIARY})$
$\lambda y \lambda P \lambda e.[P(e) \wedge beneficiary(e) = y] :$
$(\uparrow_\sigma \text{BENEFICIARY}) \multimap$
$[((\text{OBL} \uparrow)_\sigma \text{ EVENT}) \multimap (\text{OBL} \uparrow)_\sigma] \multimap$
$((\text{OBL} \uparrow)_\sigma \text{ EVENT}) \multimap (\text{OBL} \uparrow)_\sigma$

The preposition *for*, in this use, maps the OBJ of the predicate it modifies to a designated role BENEFICIARY in semantic structure (see the treatment of instrumental *with*-phrases in Asudeh and Giorgolo 2012). The relevant structures for example (61) are in Figure 5 and the Glue proof is in Figure 10 in the appendix.

For the double-object benefactive, (62), it is the configuration itself that encodes the benefactive meaning, so we associate the c-structure rule for double-objects with the BENEFACTIVE template.

(65) $\text{V}' \rightarrow$ V $\uparrow = \downarrow$ (@BENEFACTIVE) DP $(\uparrow \text{OBJ}) = \downarrow$ DP $(\uparrow \text{OBJ}_\theta) = \downarrow$

The call to BENEFACTIVE is optional, such that the double-object rule is general and can also apply to non-benefactive cases. However, if a non-ditransitive verb occurs in the c-structures described by this rule, BENEFACTIVE must be selected in order for the meanings of both objects to be properly integrated, given the resource sensitivity of the Glue logic. The relevant structures for example (62) are in Figure 6 and the Glue proof is in Figure 11 in the appendix.

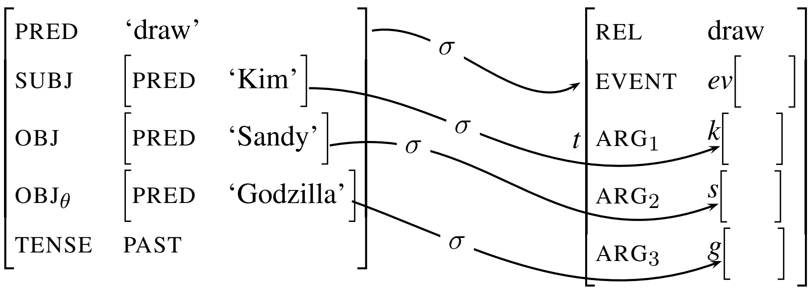

Figure 6: Relevant structures and correspondences for *Kim drew Sandy Godzilla.*

4.5 Interactions

We lastly consider interactions between the passive, cognate objects and the double-object benefactive, as demonstrated by the contrast between the grammatical *sing* examples in (66) and the ungrammatical *laugh* examples in (67):

(66) a. The performer sang the children a song.
  b. The children were sung a song.

(67) a. *The clown laughed the children a laugh.
  b. *The children were laughed a laugh.

These contrasts seem initially surprising, but fall into line if we assume that *laugh* is a true cognate object verb, whereas *sing* is just a transitive verb that allows its object to be dropped, much like *eat* (Asudeh and Giorgolo 2012).

There is independent evidence for this assumption. The verb *sing* allows its object to be an existential quantifier, but the verb *laugh* does not:

(68) Kim sang something.

(69) *Kim laughed something.

The well-formedness of (68) is explained if *sing* is an optional transitive. In that case, (68) in fact conveys exactly the same information as *Kim sang*, since the understood object of an optional transitive is existentially closed (Asudeh and Giorgolo 2012).

Further evidence comes from extraction, which can target the object of *sing* but not that of *laugh*:

(70) What did Kim claim Sandy sang?

(71) *What did Kim claim Sandy laughed?

This is again explained if *sang* is a transitive verb.

The lexical entries for *laughed* and *sang* are contrasted in (72), where the entry for *laughed* is the very same entry in (60) above.

(72)

laughed V
($\uparrow$ PRED) = 'laugh'
@PAST
@AGENT
(@COGNATEOBJECT)
$\lambda e.laugh(e) : (\uparrow_\sigma \text{EVENT}) \multimap \uparrow_\sigma$

sang V
($\uparrow$ PRED) = 'sing'
@PAST
@AGENT
@PATIENT
(@UNDERSTOODOBJECT)
$\lambda e.sing(e) : (\uparrow_\sigma \text{EVENT}) \multimap \uparrow_\sigma$

Since *laugh* is a true cognate object verb, the templates COGNATEOBJECT and BENEFACTIVE both place a requirement on the cognate object, but there is only a single object (*a laugh*), so resource sensitivity blocks the derivation.

In contrast, since *sing* is a transitive verb it does not call the COGNATEOBJECT template and there is no conflict with the BENEFACTIVE template. The optionality of *sing*'s object argument is instead handled by the UNDERSTOODOBJECT template, which is the same template used for, e.g., the intransitive use of *eat* (Asudeh and Giorgolo 2012):

(73) UNDERSTOODOBJECT =
$\lambda P \exists x.[P(x)] : [(\uparrow_\sigma \text{ ARG}_2) \multimap \uparrow_\sigma] \multimap \uparrow_\sigma$

Thus the theory correctly predicts that an optional transitive like *sing* can occur in a double-object benefactive, as in (66a), and in the passivized version of the double-object benefactive, as in (66b), whereas a true cognate object verb like *laugh* cannot occur in either case, as shown in (67a) and (67b).

5 Conclusion

We have drawn together ideas from a number of recent proposals in the LFG literature for the encoding of lexical information and the sharing of this information across valencies in a generalized fashion. This can form the beginning of a theory of the representation and specification of information that sits at the lexicon–syntax–semantics interface. Our formal ingredients were the following: 1. Templates; 2. Aspects of the regular language of f-descriptions, particularly optionality; 3. Resource-sensitive semantic composition, as captured by Glue Semantics. We provided analyses of passives, cognate objects and benefactives, and demonstrated that the analyses of the various phenomena interact properly. We thus derive a system in which composition is flexible and meaning emerges from the properly constrained interaction of a variety of contributors.

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A Appendix: Proofs

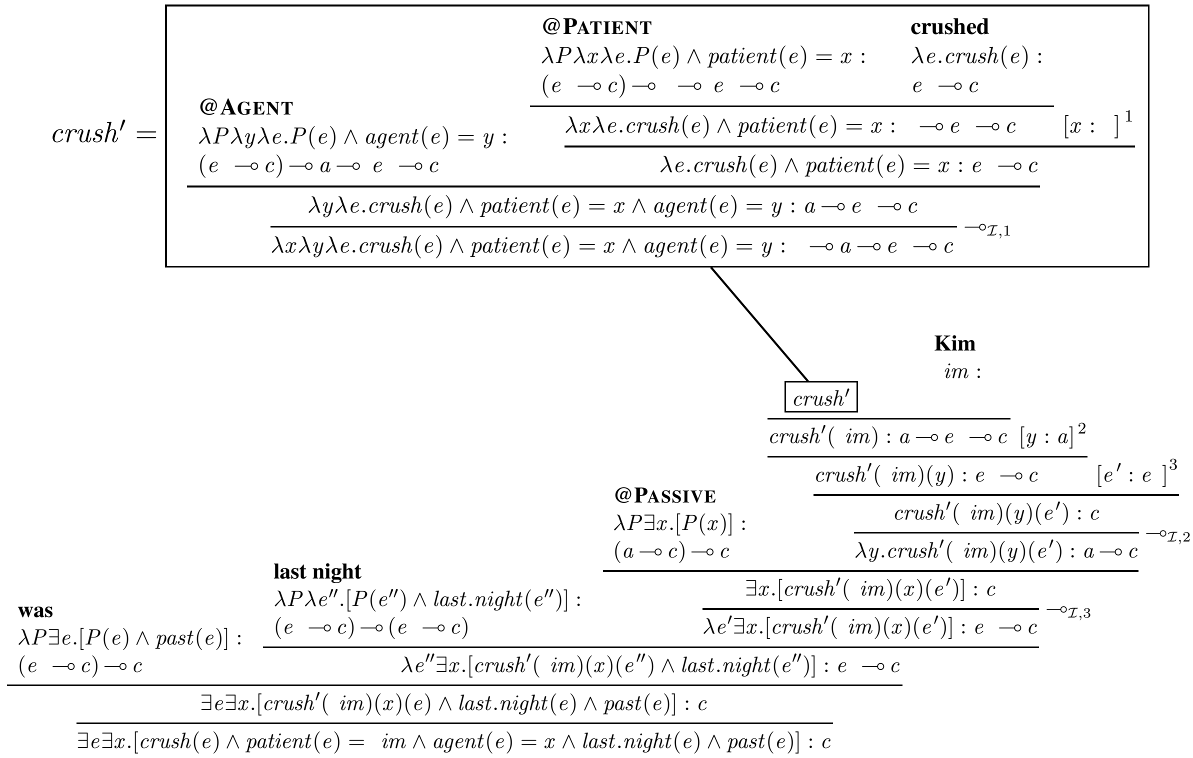

Figure 7: Proof for *Kim was crushed last night.*

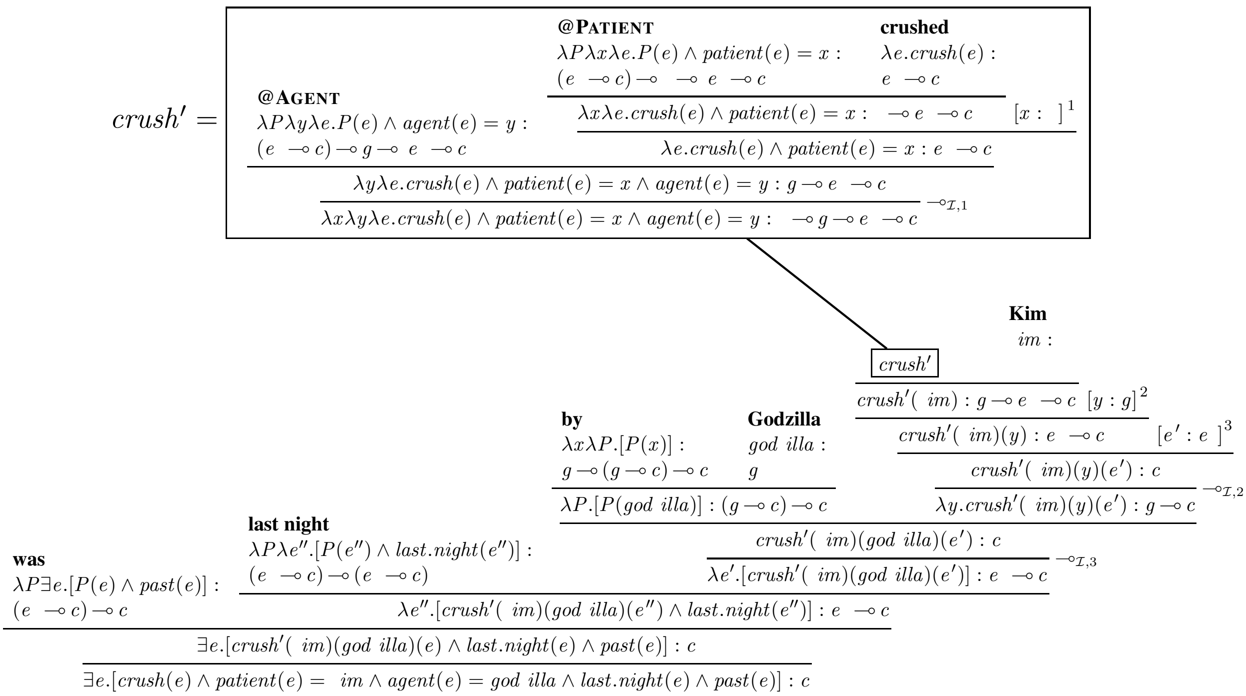

Figure 8: Proof for *Kim was crushed by Godzilla last night.*

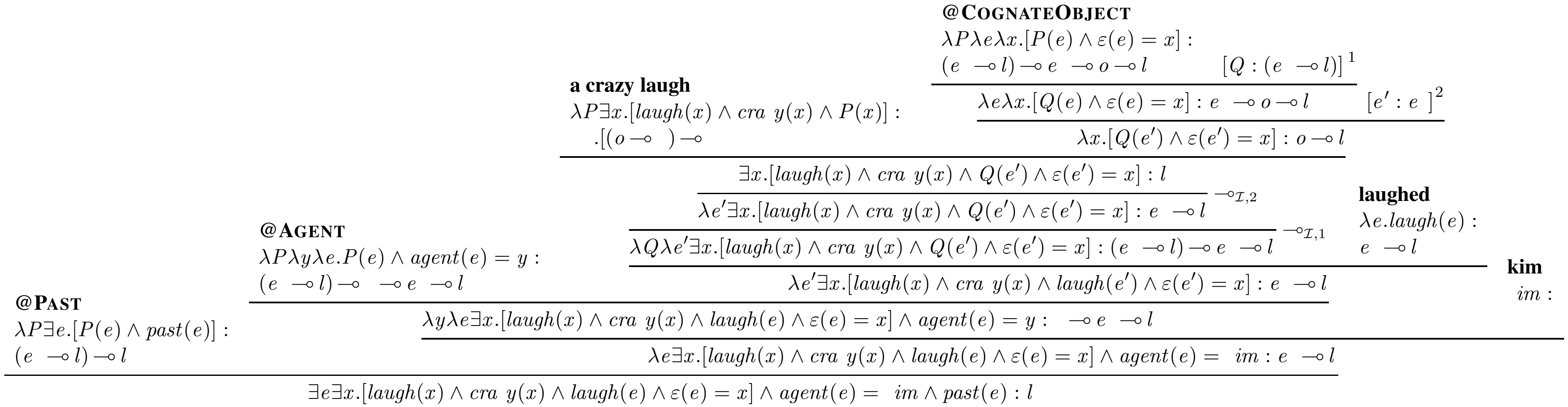

Figure 9: Proof for *Kim laughed a crazy laugh.*

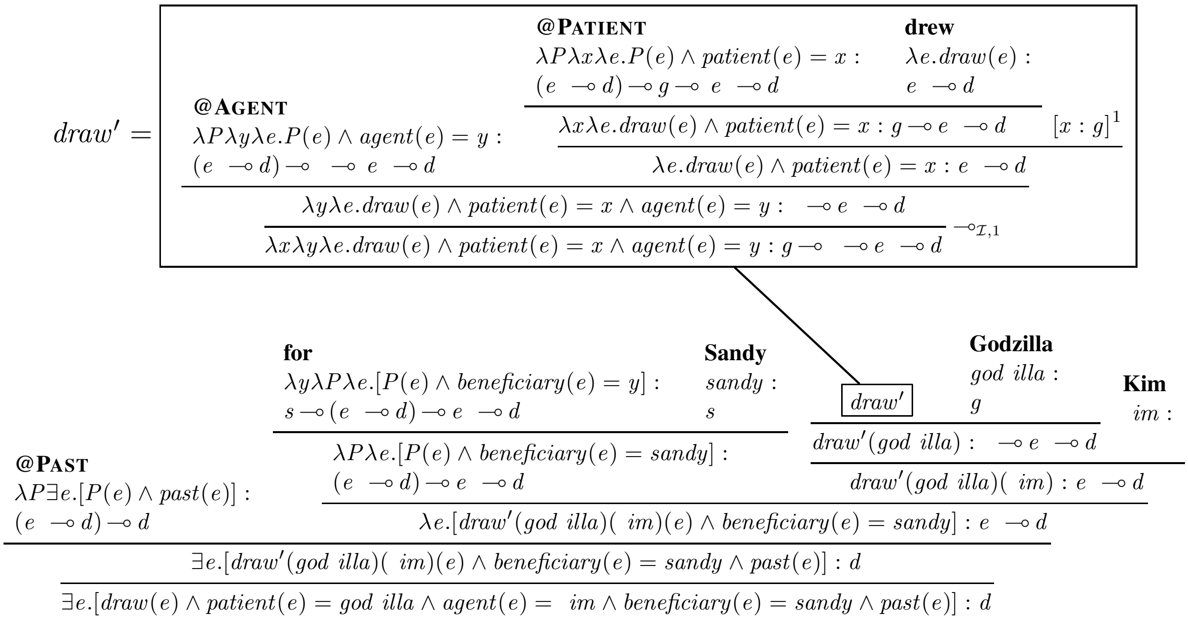

Figure 10: Proof for *Kim drew Godzilla for Sandy.*

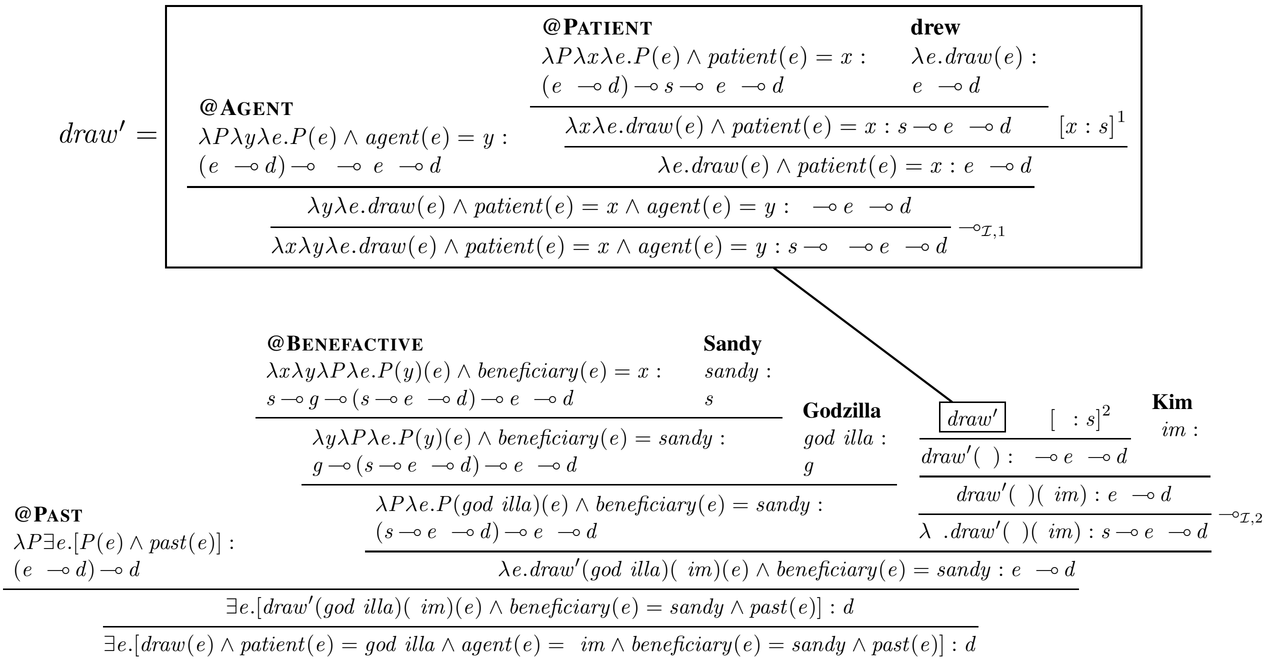

Figure 11: Proof for *Kim drew Sandy Godzilla.*