DE GRUYTER MOUTON DRAFT GCLA 2017; 5: 177–194

Jens Fleischhauer, Thomas Gamerschlag and Wiebke Petersen

A frame-analysis of the interplay of grammar and cognition in emission verbs

https://doi.org/10.1515/gcla-2017-0012

Abstract: Most decompositional approaches are confined to representing event structural properties whereas the idiosyncratic lexical content is often reduced to an unanalyzed atomic root. While approaches of this type are successfully applied to argument linking and some additional grammatical phenomena, we argue that other grammatically relevant aspects of verb behavior cannot be accounted for in this way. In order to illustrate the limits of 'traditional' decompositional accounts, we focus on the class of verbs of emission. Verbs of this class exhibit some grammatical asymmetries whose analysis requires lexical decomposition beyond traditional event structure templates. We argue that frames are a suitable format for extending event structure templates and provide an analysis of the phenomena at issue.

Keywords: emission verbs, verb gradation, directed motion use, frame analysis

1 Lexical decomposition and its limits

It is a common view within semantics that lexical items are built up from smaller and more basic meaning components. Approaches describing how lexical meaning can be decomposed are often labeled 'lexical decompositional approaches'. Dowty (1979) has formulated a particularly prominent decompositional approach to verb meaning which forms the basis for many follow-up accounts applied in the investigation of the syntax-semantics interface. The basic idea of such decompositional approaches is that verb meaning can be broken down into a small set of event predicates and a set of unanalyzed idiosyncratic

Jens Fleischhauer: Heinrich Heine University Düsseldorf.
E-mail: fleischhauer@phil.uni-duesseldorf.de
Thomas Gamerschlag: Heinrich Heine University Düsseldorf.
E-mail: gamer@phil.uni-duesseldorf.de
Wiebke Petersen: Heinrich Heine University Düsseldorf.
E-mail: petersen@phil.uni-duesseldorf.de

meaning components, so-called 'roots'. Decompositional approaches differ with respect to the set of event predicates they assume; the criticism formulated in this paper applies to all of these accounts. We use the approach of Rappaport Hovav & Levin (1998) for illustration.

The aim of decompositional approaches to verb meaning is to represent "components of meaning that recur across significant sets of verbs" (Levin & Rappaport Hovav 2005:69). A common starting point is Vendler's (1957) aktionsart classification (but see Croft 1991 for an approach based on causal chains). Levin & Rappaport Hovav apply the event predicates ACT, BECOME and CAUSE for building different aktionsart classes. As shown in (1), state predicates only consist of a state root, whereas all other aktionsart classes combine an event predicate with a root.

(1) (a) State predicate [x ⟨State⟩]
(b) Activity predicate [x $\text{ACT}_{\langle\text{Manner}\rangle}$]
(c) Achievement predicate [BECOME [x ⟨RESULT⟩]]
(d) Accomplishment predicate [x CAUSE [BECOME [y ⟨RESULT⟩]]]

Verbs belonging to the same aktionsart class differ only with respect to the root. This is shown for the two activity predicates *drone* and *bleed* in (2). Lexical representations like the one in (2) only capture meaning components which are grammatically relevant for classes of verbs. The root, on the other hand, "is [...] opaque to grammar" (Rappaport Hovav & Levin 1998:254).

(2) a. [x $\text{ACT}_{\langle\text{drone}\rangle}$]
b. [x $\text{ACT}_{\langle\text{bleed}\rangle}$]

However, there are grammatical phenomena which demonstrate that the root cannot be opaque to the grammar, but rather that the acceptability and interpretation of the constructions under discussion depend on the root elements. In the paper, we will illustrate two such grammatical constructions: first verbal degree gradation of emission verbs and later – in more detail – extended uses of emission verbs as verbs of directed motion. What the two particular constructions have in common is that their analysis requires a deeper lexical decomposition that goes beyond the root template.

2 Grading verbs of emission

In this paper, we take verbs of emission as a case study. Verbs of emission are basically intransitive predicates which denote the emission of a stimulus. Levin (1993:233ff.) distinguishes four classes of emission verbs: verbs of smell emission

(*smell, stink*), verbs of light emission (*shine, glitter, sparkle*), verbs of sound emission (*drone, bark, howl*) and verbs of substance emission (*bleed, fester*). The first two classes consist of stative predicates, whereas the other two classes are activity predicates according to Rappaport Hovav & Levin (2000).

Verbs of sound emission and verbs of substance emission admit degree gradation like adjectives but also many other verbs also do (see Bolinger 1972, Löbner 2012, Fleischhauer 2016). Two German examples of verbal degree gradation are shown in (3). The intensifier *sehr* 'very' specifies the loudness of the emitted sound in (3a), whereas in (3b) it refers to the quantity of emitted blood.

(3) a. *Der Motor hat sehr gedröhnt.*
the engine has very droned
'The engine droned a lot.'
b. *Die Wunde hat sehr geblutet.*
the wound has very bled
'The wound bled a lot.'

Verbal degree gradation is not restricted to certain aktionsart classes (see Fleischhauer 2016:101f.), but its interpretation is sensitive to the verbal root. Both *dröhnen* 'drone' and *bluten* 'bleed' are activity predicates and compatible with progressive aspect. The German periphrastic progressive construction (the so-called *am-Progressiv*) is shown in (4) with the two graded verbs *dröhnen* and *bluten*. The interpretation of (4a) is the same as the one of (3a), namely that the engine continuously emitted a loud droning sound. But there is a difference in the interpretation of (4b) compared to (3b). In (3b), it is expressed that the overall quantity of emitted blood was large, whereas in (4b) it is only indicated that the quantity emitted at a certain stage of the event was large.

(4) a. *Der Motor war sehr am Dröhnen, als wir*
the engine was very at.the droning when we
den Berg hochfuhren.
the mountain drove_up
'The engine was droning a lot, when we drove up the mountain.'
b. *Die Wunde war sehr am Bluten.*
the wound was very at.the bleeding
'The wound was bleeding a lot.'

As the examples reveal, grammatical aspect does affect degree gradation of verbs of substance emission since the interpretations of (3b) and (4b) differ depending on aspect. It is, however, irrelevant for the interpretation of a degree construction based on verbs of sound emission. The quantity of an

emitted substance increases as the event unfolds. Loudness, on the other hand, does not (necessarily) increase while the event progresses. Accounting for this difference requires a deeper lexical decomposition since both types of graded verbs denote different types of emission processes which are relevant for determining the grammatical behavior of the two classes of verbs. In the next section, we turn to the extended use of sound emission verbs as verbs of directed motion.

3 Verbs of sound emission: extended use as verbs of directed motion

Even within the same subclass, verbs of emission exhibit grammatical asymmetries that are not predicted by the template representations in (1). This is shown by the extended use of verbs of sound emission as verbs of directed motion; a phenomenon which is well attested for English and German. In this use, verbs originally referring to sound emission are applied as verbs of directed motion. As illustrated by the German example in (5), the sound emission verb *jaulen* 'howl, yowl' can be utilized to refer to motion along a path. Characteristically, in this use, the verb can combine with directional PPs which specify properties of the path of motion.

(5) *Das Motorrad jaulte über die Kreuzung.*
the motorbike howled over the crossing
'The motorbike howled over the crossing.' (Kaufmann 1995a:91, slightly adapted)

This extended use is productive in German and English. However, as already observed by Kaufmann (1995a, b) and Levin & Rappaport Hovav (1991, 1995) among others, the motion verb use of sound emission verbs is accessible only if the specific sound can be interpreted as a by-product of motion as in (5). By contrast, this use is not licensed if such a relation does not hold as in (6a), which is marked as semantically awkward by the symbol '§' since the motion of the subject referent 'puppy' does not characteristically produce a howling sound. (Note that (6a) cannot be ruled out due to a violation of the sortal restrictions of the verb since *jaulen* allows for the combination with *Welpe* 'puppy' in the non-extended use in (6b).)

(6) a. §*Der Welpe jaulte unter das Bett.*
the puppy howled under the bed
lit.: 'The puppy howled under (dir) the bed.'

b. *Der Welpe jaulte.*
the puppy howled
'The puppy howled.' (Kaufmann 1995a:91, slightly adapted)

In order to account for the motion use in (5), Kaufmann (1995a, b) proposes a lexical decompositional analysis based on the Semantic Form template in (7) in which a core predicate contributed by the meaning of a base verb is extended by a MOVE-predicate allowing for the addition of further spatial information. By applying this template to the representation of the sound emission verb *jaulen* in (8a), one arrives at the Semantic Form of the directional use in (8b). (8c) finally shows the result of replacing the predicate variable in the last conjunct with the information contributed by the directional PP in example (5). (cf. Kaufmann 1995a, b for details of the underlying framework).

(7) Template for motion extension (Kaufmann 1995b:206)
CORE_PREDICATE(x) & MOVE(x) & P(x)

(8) Representation of the use of *jaulen* 'howl' as a verb of directed motion
a. *jaulen* 'howl' (basic use): HOWL(x)
b. *jaulen* 'howl' (directional use): HOWL(x) & MOVE(x) & P(x)
c. *über die Kreuzung jaulen* 'howl over the crossing':
HOWL(x) & MOVE(x) & INTERSECT(PATH(x), UPPER_REGION(crossing))

The template in (7) is not arbitrarily evoked to deal with the extended use but rather is licensed by a more general constraint on Semantic Form given in (9).

(9) General constraint on Semantic Form:
"In a decomposed structure, the predicates that are embedded higher in Semantic Form activate the properties of their arguments. Any more deeply embedded predicate must specify these properties." (Kaufmann 1995b:93)

According to this constraint the predicate MOVE(x) can only be added as a further specification ("embedded deeper") if the base predicate activates some meaning component related to movement in the concept of the argument. This is the case in (5) since the particular sound expressed by the verb activates information related to movement in the concept 'motorbike'. By contrast, the motion extension template is not available for the subject-verb combination in (6a). Here, there is no link between sound emission and motion in the 'puppy'-concept which allows for a motion extension of the base verb meaning. By consequence, (5) is well-formed whereas (6a) is rendered awkward.

In spite of the valuable insights of Kaufmann's approach, the (non)availability of the extended use is not captured by the template representations as such, but rather needs to be constrained further by the restriction in (9) which makes extra-representational reference to properties of the argument instead of

addressing them within the same representational format. In the next section, we will show how this approach can be reformulated within a frame model by referring to the necessary semantic properties of the verb and the argument in a unitary representational format.

Due to space limitations, we cannot compare Kaufmann's approach to alternative accounts. For instance, Goldberg & Jackendoff (2004) have proposed a Construction Grammar analysis of the extended use which treats it as a subtype of resultative called "Sound-emission path resultative." For this subtype the authors assume a constructional scheme in which the major meaning of the construction is directional motion with the emission of a sound as a resulting subevent which is encoded by the verb. This account clearly goes in the same direction as the one proposed by Kaufmann as it derives the meaning of the extended use from some abstract scheme not encoded by the base verb. However, it does not become clear how this particular construction type derives from a general principle in spite of being a particular subconstruction of the resultative construction. In addition, the approach remains inexplicit in regard to the sortal properties of the subject referent.

4 Towards a frame analysis of verbs of emission

The data in the preceding sections show that traditional analyses of verbs of emission do not capture the finer semantic contrasts between different kinds of emission. The major reason is that the modeling assumptions lead to representations that are too weak to express these contrasts. As the examples show, one needs to enrich the representations of objects and events with additional structure. Therefore, our approach is based on frames that offer the flexibility to specify lexical restrictions, constraints inferred from world knowledge and temporal and structural properties of events and objects in one uniform format. Our notion of frames is based on Barsalou's claim that frames provide the fundamental representation of knowledge in human cognition (Barsalou 1992). Frames are cognitively motivated and universal in the sense that they represent all kinds of knowledge: "Frame semantics [...] differs importantly from formal semantics in emphasizing the continuities, rather than the discontinuities, between language and experience" (Fillmore 1982). In recent years, new efforts have been taken towards a formalization of frame theory that, on the one hand, is cognitively adequate and goes along with recent neurocognitive results on human language processing (cf. Naumann & Petersen 2017) and that, on the other hand, allows

for the formulation of a rigid theory of compositional semantics (cf. Petersen 2015, Löbner 2017, Kallmeyer & Osswald 2013).

Frames are defined as recursive attribute-value structures with types and functional attributes. Figure 1 shows a frame graph of the object concept 'red motorbike with 100 hp motor'.

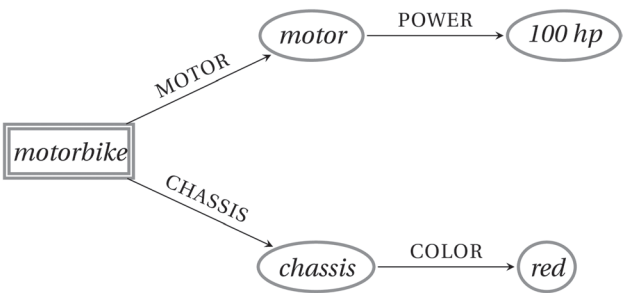

Figure 1: Frame representation of the object concept 'red motorbike with 100 hp motor'.

The central node, marked by a double border, specifies what the frame is about (indicated by the type 'motorbike'). Thus only objects categorized as motorbikes can instantiate the represented concept. The attributes CHASSIS and MOTOR are functional mappings from motorbike instances to instances of their subparts. Due to recursiveness, frames allow for zooming into attribute values and describing them by further attribute-value pairs. In Figure 1, the motorbike concept is restricted by specifying that the value of the COLOR of the CHASSIS is of type 'red' and that the value of the POWER of the MOTOR is '100 hp'.

Formally, frames are constrained by a type signature that provides the types and attributes and specifies admissible attributes and what type of values they can take (for details see Petersen 2015). Type signatures model the conceptual knowledge of language users which is grounded in linguistic and non-linguistic experience. They express all kinds of learned constraints such as hierarchical relations (e.g., a motorbikes is a vehicle), value restrictions (e.g., the power of the motor of a motorbike falls into a specific range and differs from the power of the motor of an airplane), value dependencies (e.g., if a motor is operating it emits a sound) and others.

As events may change the values within object frames, static frames are not sufficient to capture the full picture of an event. Therefore, we separate the static event frame level that expresses the relations of the objects involved in an event from the dynamic situation frame level that models the changes of the objects in the temporal evolution of the event. Figure 2a illustrates this idea for the event 'a motorbike drives

around the corner' (The formal details of dynamic frames are given in Naumann 2013 and elaborated on and exemplified in Gamerschlag et. al. 2014).

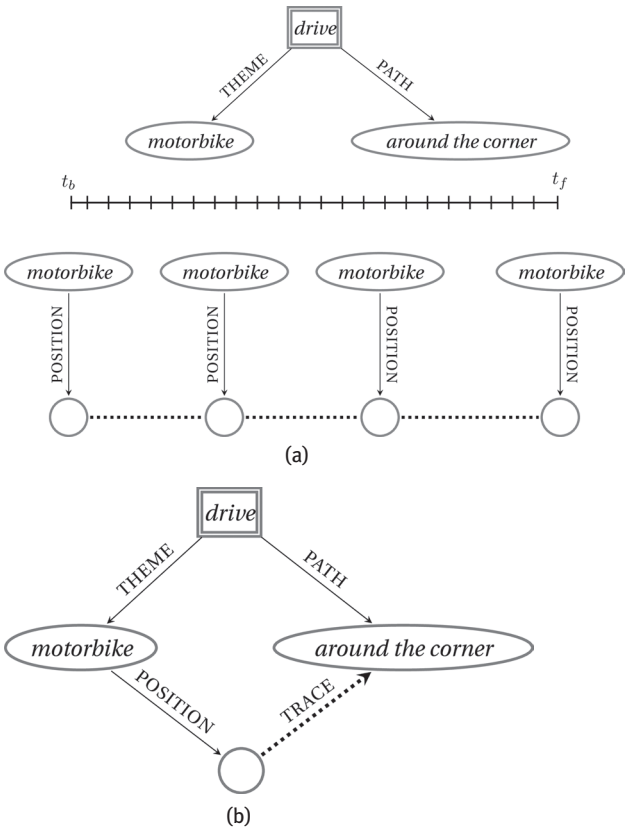

Figure 2: Frame representation of the event 'a motorbike drives around the corner'.

On the top level of Figure 2a, the static event frame specifies that a driving event involves a theme and a path. The movement of the motorbike is modeled at the bottom level that allows for zooming into the situation at any time point. The driving event involves a change of the position of the motorbike. The connection between the driven path restricted by 'around the corner' and the POSITION changes of the motorbike is made explicit in the condensed frame in Figure 2b: The actor has a POSITION whose values are changing constantly during the event. The changing POSITION is linked to the static PATH value of the event via the dynamic attribute TRACE that maps the temporal position change to the static spatial path object (we follow here the lines of path semantics specified in Zwarts 2005).

As will be shown in 4.1. and 4.2, event frames are capable of modeling the asymmetries found with sound and substance emission verbs introduced above.

4.1 Gradation of verbs of substance emission

Static event frames of emission verbs specify an emitter and an emittee. While the latter is incorporated in the verb, the former must be specified in the context. Thus, frames of emission verbs have one open argument slot as depicted by the rectangular node expressing the value of the EMITTER of the sound emission verb *dröhnen* 'drone' in Figure 3a.

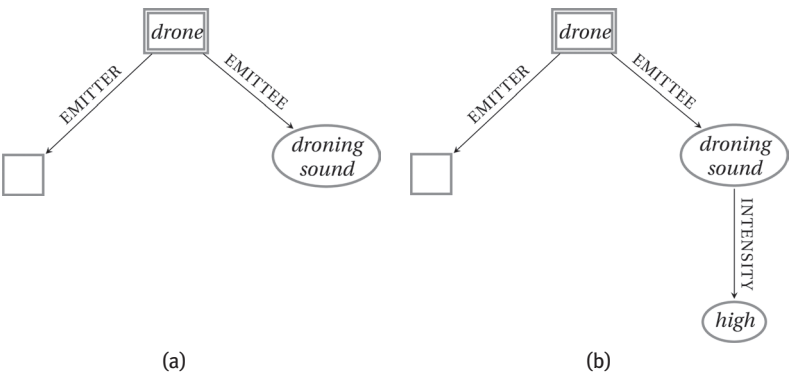

Figure 3: Frame representations of 'dröhnen/drone' (a) and 'laut dröhnen/drone a lot' (b).

Sound emission verbs do not imply a change at the level of the emitter or the emittee, hence it is not necessary to zoom into the temporal level in order to specify their meaning. However, zooming into the temporal structure is always possible and can be coerced by the context, for example to adequately express something like *immer lauter dröhnen* 'to drone louder and louder'. Figure 3b shows the result of verb gradation applied to *dröhnen* 'drone', which is an instance of event-independent degree gradation since *dröhnen* is a verb of sound emission. The frame graph captures this by isolating the INTENSITY attribute and stating its value as high.

Though substance emission verbs such as *bluten* 'bleed' share the same static event frame with verbs of sound emission, they differ when it comes to degree gradation which targets QUANTITY as the relevant attribute of the emittee. As described in Section 2 there is a subtle but important difference between the reading of *sehr bluten* 'bleed a lot' in the perfective aspect and the progressive that cannot be captured on the level of the static event frame.

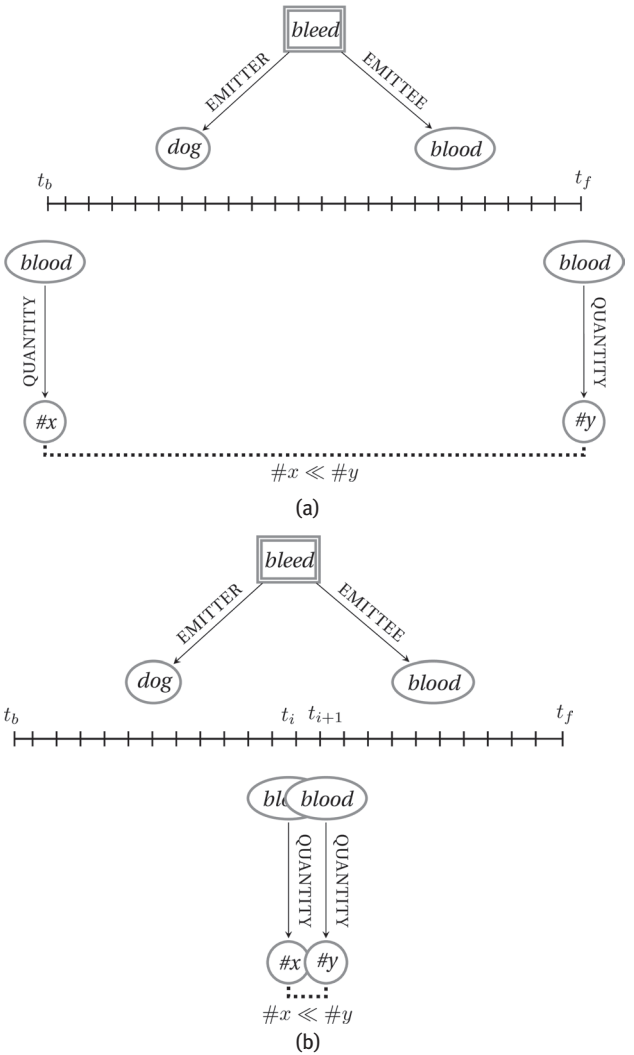

Figure 4: Frame representations of 'bluten/bleed' in perfective (a) and progressive reading (b).

Figure 4a shows the frame structure of the event-dependent degree gradation *der Hund hat sehr geblutet* 'the dog has bled a lot' in perfective reading. Note that, although two objects are involved in the event, namely the dog and the emitted blood, only the blood is referred to in the situation frames here, because the intensifier is not specifying the intensity of the injury suffered by the dog but only the amount of emitted blood. This amount must be high as indicated by the constraint between the values of QUANTITY at the beginning and end of the event.

By contrast, in the progressive we make reference to a specific stage and state that for this stage the amount of emitted blood is high. Again, this can be captured by a high increase of the value of the QUANTITY attribute at the boundaries of that particular stage (see Figure 4b).

Due to restrictions of space we have only provided a sketch of our analysis of degree gradation in frames. Our main point here is that descriptions on the level of static event frames are too weak to adequately capture the meaning shifts in different aspectual contexts. In the next section, we are going to discuss the phenomenon of applying sound emission verbs as verbs of directed motion in more detail.

4.2 Directed motion use of verbs of sound emission

For a frame analysis of the extended use in (5), we start with the two frames in Figure 5 which represent the major meaning components of this use: emission of a howling sound and directed motion.

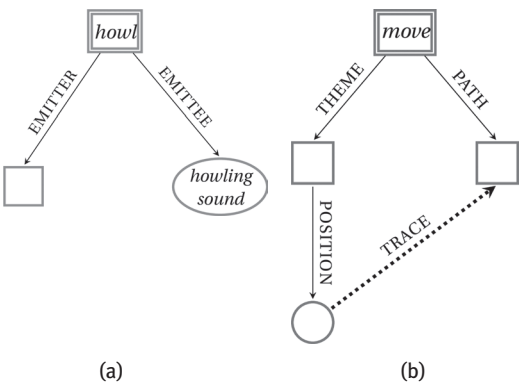

Figure 5: Frame representations of *jaulen* 'howl' (a) and directional motion (b).

According to the frame in Figure 5a, a howling event involves an EMITTER, which is introduced by the sole argument of the verb, and an EMITTEE, i.e. the howling sound which is emitted. The frame in Figure 5b states that a verb expressing directional movement, such as English *move*, has a THEME and a PATH argument. The THEME argument changes its spatial position in the course of the motion event. As in the frame of 'drive' in Figure 2b, this is captured by the attribute POSITION whose value is not constant but changes in dependence of the theme's movement. All the different values of the POSITION attribute are collected by the dynamic attribute TRACE which builds up the PATH as a sequence of spatial

positions (see Gamerschlag et al. 2014 for details of the frame representation of directed motion and the use of dynamic attributes).

Now, one could simply stipulate that these two frames are somehow fused to yield the complex frame for the extended motion use of *jaulen*. However, in the following we will show how Kaufmann's constraint in (9) can be transparently adopted in the composition of the complex frame of the extended use. This is illustrated in Figure 6 for the well-formed example given in (5) above.

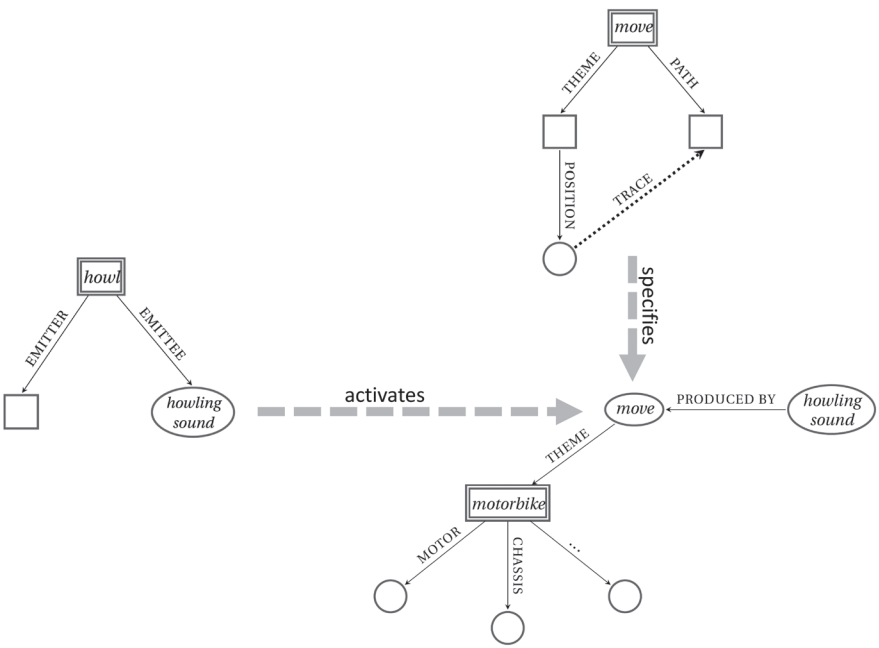

Figure 6: Attribute activation in argument frame and frame extension.

The frame on the left represents the base verb meaning as introduced in the preceding figure. On the right, the frame of the argument 'motorbike' is given. It consists of simple attributes such as having a MOTOR and a particular CHASSIS. As a vehicle, it can also be characterized as the THEME of movement. In addition, we can represent our object knowledge that a howling sound is characteristically produced by a motorbike if it moves. As already noted, frame representations are flexible and can vary arbitrarily in regard to complexity. In particular, adding attributes and zooming in and out of attribute nodes yields representations of different degrees of explicitness. For the sake of simplicity, we will keep the frame of 'motorbike' as minimal as in the figure above.

Given the relation between sound emission and motion in the frame of the subject referent, the relevant components of Kaufmann's constraint are directly available in the representation of the base verb and the argument: In the base verb frame, it is information about the emission of a particular sound that is specified for the sole argument. Now, this information about the emission of a howling sound can also be found in the frame of the argument where it is directly linked to movement via the PRODUCED BY attribute, thereby "activating" properties related to motion in the argument frame. Because of this "activational link", movement properties of the argument can be specified further through an extension of the verb meaning by a frame which elaborates on this aspect. This additional movement information is contributed by the frame for directed motion on the upper right.

The resulting complex frame for the directed motion use of *jaulen* is given in Figure 7. Here, both initial frames have been fused in the frame of directional *jaulen* with the EMITTER of *jaulen* and the THEME of move being identified. Again, this is a consequence of the constraint since the newly activated information must be predicated of the sole argument of the base verb.

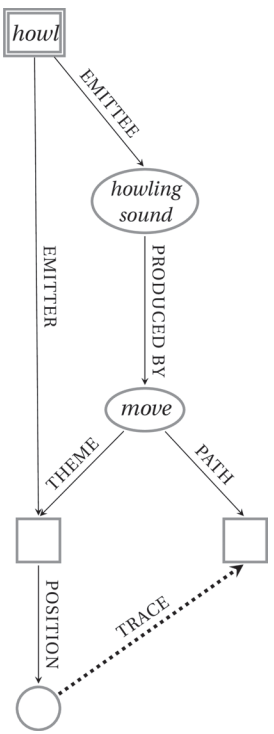

Figure 7: Frame representation of *jaulen* 'howl' in the extended use in (5).

Based on the frame representations, we can also rule out non-admissible combinations as in (6a). As shown in Figure 8, if the argument is *Welpe* 'puppy', there is no link between the emission of the particular sound encoded and movement information in the frame of the subject referent, as informally indicated by striking through the attribute PRODUCED BY. By consequence, there is no movement information in the frame of the subject referent which could be activated by the meaning of the sound emission verb. This, in turn, blocks the extension of the base verb's meaning by further movement information and finally renders the example in (6a) awkward due to a violation of Kaufmann's constraint on the extension of verb meaning.

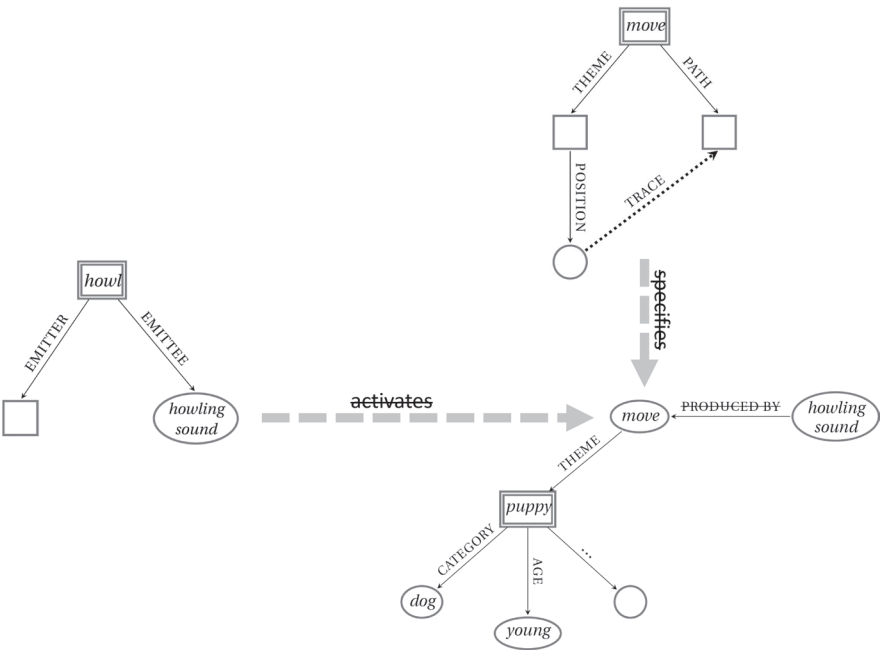

Figure 8: Failed attribute activation in argument frame.

As demonstrated above, the constraint proposed by Kaufmann need not be regarded as confined to representations by means of templates, but should rather be considered as a more general constraint on the extension of verb meaning which can easily be applied in a frame approach. In terms of frames, the constraint can be reformulated as in Figure 9.

As shown above, the frame elements relevant for the extended use are confined to local segments of attribute-value pairs. For example, in the derivation of the well-formed extended use in Figure 6 it is the value 'howling sound' of the

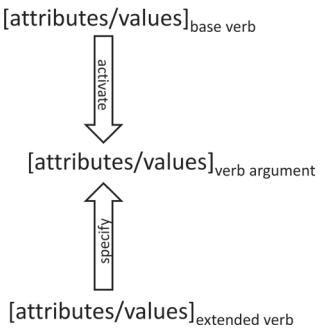

Figure 9: Verb extension licensed by attribute activation in the frame of a base verb argument.

single frame attribute EMITTEE which activates 'move' as a value of the single attribute PRODUCED BY in the frame of the argument. This value 'move' is then specified further by the attributes THEME and PATH in the frame representing directed motion. The structural details of this account need further refinements we cannot elaborate on here. Moreover, note that the sketch in Figure 9 above is only of an informal nature and requires formalization. As shown by Petersen & Gamerschlag (2014) for the inferential use of perception verbs such as German *schmecken* 'taste (of)', extended uses of verbs can be captured by means of type hierarchies. This strategy could as well be adopted for a formalization of the directed motion use of sound emission verbs.

5 Summary and outlook

In this paper, we have shown that two types of asymmetries found with emission verbs are problematic to traditional template representations: (i) The effect of grammatical aspect on the interpretation of degree gradation of verbs of substance emission as opposed to verbs of sound emission and (ii) the impact of argument properties on the availability of the directed motion use of sound emission verbs. We have then presented a first sketch of how some of the shortcomings of traditional template analyses can be overcome in a frame approach. In particular, we have demonstrated how frames give access to the relevant object properties such as the quantity of the emitted substance and the relation between motion and the emission of a particular sound. In addition, we have shown how the insights of Kaufmann's (1995a, b) template analysis of the directed motion use of sound emission verbs can be transferred to a frame approach, with the benefit of being able to address all the relevant semantic components within the same

representation format. We have also argued that Kaufmann's constraint on the extension of verb meaning, which was formulated in terms of Semantic Form, can be regarded as a general constraint on the extended uses of verbs and therefore can be adopted in a frame approach as well.

With respect to the relevant object properties, we would like to point out that the frame approach benefits from the fact that there is no strict demarcation of lexical and encyclopedic knowledge. Rather, both form a continuum that allows for enriching lexical concepts by activating non-lexicalized meaning components which are part of encyclopedic knowledge. Thus, meaning is seen as being dynamic as it is in cognitive semantics (see Hamawand 2016 and references cited therein). Barsalou (1982) also distinguishes between context-independent and context-dependent properties of concepts. Context-independent properties are part of a concept in all its uses, whereas context-dependent properties "are rarely if ever activated by the word for a concept and are only activated by relevant contexts in which the word appears" (Barsalou 1982:82). Context-independent properties represent the lexical meaning of concepts. By contrast, what Barsalou calls 'activation of context-dependent properties' is what we have referred to as 'attribute activation' in accordance with Kaufmann's analysis of the extended use of sound emission verbs.

In future work, we will further develop the approach sketched above in regard to two aspects: (i) formalizing the constraint on the extended use in an adequate way and (ii) applying the resulting framework to other instances of extended uses of verbs such as the resultative construction. This will bring us closer to a general theory of verb extensions which considers verb meaning as well as argument meaning based on an elaborate, uniform representational format giving access to the necessary information.

Acknowledgements: This work was supported by the Collaborative Research Centre (SFB) 991 "The Structure of Representations in Language, Cognition, and Science" (projects A01 and B09) financed by the Deutsche Forschungsgemeinschaft (DFG). In addition, our research was funded by a grant from Heinrich Heine University awarded to Jens Fleischhauer (Strategischer Forschungsfonds, F-2015/946-2). We would like to thank the audience at DGKL 7 and the reviewers for the valuable comments on earlier versions of this article.

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