Regular Meaning Shifts in German Particle Verbs: A Case Study

Sylvia Springorum, Jason Utt and Sabine Schulte im Walde
Institut für Maschinelle Sprachverarbeitung
Universität Stuttgart
{riestesa|uttjn|schulte}@ims.uni-stuttgart.de

Abstract

This paper provides a corpus-based study on German particle verbs. We hypothesize that there are regular mechanisms in meaning shifts of a base verb in combination with a particle that do not only apply to the individual verb, but across a semantically coherent set of verbs. For example, the syntactically similar base verbs *brummen* 'hum' and *donnern* 'rumble' both describe an irritating, displeasing loud sound. Combined with the particle *auf*, they result in near-synonyms roughly meaning 'forcefully assigning a task' (in one of their senses). Covering 6 base verb groups and 3 particles with 4 particle meanings, we demonstrate that corpus-based information on the verbs' subcategorization frames plus conceptual properties of the nominal complements is a sufficient basis for defining such meaning shifts. While the paper is considerably more extensive than earlier related work, we view it as a case study toward a more automatic approach to identify and formalize meaning shifts in German particle verbs.

1 Introduction

Our focus of interest is on German particle verbs. We hypothesize that there are regular mechanisms that trigger a meaning shift of a base verb (such as *brummen* 'hum') in combination with a particle (such as *auf*, in this case referring to a contact relation) that do not only apply to the individual verb, but across a semantically coherent set of verbs. For example, *donnern* 'rumble' agrees with *brummen* in properties at the syntax-semantic interface in that both verbs are intransitive, and both describe an irritating, displeasing loud sound that the typically non-agentive, non-living subject produces. In addition, the resulting particle verbs *aufbrummen* and *aufdonnern* are near-synonyms, roughly meaning 'forcefully assigning a task' (in one of their senses). Furthermore, they agree in properties at the syntax-semantic interface in that both verbs (again, in one of their senses) are ditransitive, with an agentive subject imposing something on another person.

The example demonstrates that a coherent set of base verbs in combination with a particle meaning[1] may result in a coherent set of particle verbs. Equation (1) illustrates this pattern: a base verb **BV** with properties pBV_i in combination with a particle with meaning **PM** results in a particle verb **PV** with properties pPV_j.

(1) $\quad \mathbf{BV}\ \{pBV_1,\ pBV_2,\ \ldots,\ pBV_n\}\ \mathbf{+}\ \mathbf{PM} \rightarrow \mathbf{PV}\ \{pPV_1,\ pPV_2,\ \ldots,\ pPV_m\}$

The goal of this paper is to demonstrate that we can find such regular meaning shifts across semantically coherent verb groups and across particle meanings by using a property selection process. Our work is corpus-based, i.e., we identify coherent verb groups and particle meanings on the basis of large-scale corpus data. The empirical data is used to describe the base verbs as well as the particle verbs with regard to common properties at the syntax-semantic interface. Covering 6 base verb groups with 3 particles and 4 particle meanings, we consider this paper as considerably more extensive than earlier related work, but at the same time we view it as a case study toward an even more extensive, and also more automatically driven identification of meaning shifts in particle verbs. We therefore combine the corpus-based analyses with advice on future elaborations, mainly with regard to applying approaches of regular polysemy.

[1] Note that particles in German particle verbs are in general highly ambiguous.

The paper is organized as follows. Section 2 presents related work. Section 3 represents the core of the paper: We describe our corpus-based acquisition method, the empirical behavior for each of our BV–PV groups, and regularities in the meaning shift. In Section 4, we generalize over the concrete patterns in meaning shift, discuss elaborations of the existing method, and hypothesize about a more automatic approach to identifying and formalizing meaning shifts in German particle verbs.

2 Related Work

Previous work on meaning shifts of semantically coherent groups of verbs has shown that there are regularities at the syntax-semantic interface with regard to the literal vs. transferred meanings of the verbs. For example, Morgan (1997) uses schematic diagrams to illustrate the meaning shifts of particle verb constructions with English *out*. She claims that the source domain in a shift is systematically determined by the base verb, and the particle meanings are instantiated by cognitive image schemas. Ibarretxe-Antuñano (1999) describes systematic non-prototypical meanings of perception verbs cross-linguistically for English, Spanish, and Basque. She investigates the meaning shifts on the basis of corpus examples and introspection.

Given that there is substantial theoretical evidence for regular patterns in verb meaning shifts, it is surprising that—to our knowledge—no empirical, corpus-based work so far has applied approaches of regular polysemy to a large, coherent group of verbs. On the one hand, there has been an impressive increase in empirical work on modeling meaning shifts in recent years (mostly with regard to metonymy and metaphor). For example, Stefanowitsch and Gries (2006) edited a volume on corpus-based approaches and Markert and Nissim (2007) provided a shared task for metonymy resolution at SemEval 2007. On the other hand, the research has, in general, been restricted to small groups of target items. For example, the shared task by Markert and Nissim (2007) comprised only locations and organizations; Lönneker-Rodman (2008) describes the working environment and result of developing the *Hamburg Metaphor Database*, comprising a respectable framework that, up to now, covers few targets and less than 2,000 annotated sentences. Work by Birke (2005) provided an extensive automatic detection of non-literal use of English verbs in context, but did not specifically look at regular shifts in meanings across multiple verbs.

3 Corpus-based Acquisition of Base and Particle Verb Groups with a Meaning Shift

Our strategy to identify meaning shifts in BV–PV transfer is as follows. We searched our corpus for examples of base verbs and particle verbs, concentrating on one specific particle at a time. As corpus data, we rely on the SDEWAC corpus (Faaß et al., 2010), a cleaned version of the German web corpus DEWAC created by the WACKY group (Baroni et al., 2009). The SDEWAC contains approximately 880 million tokens and has been parsed by Bohnet's MATE dependency parser (Bohnet, 2010). The information we used for our search was effectively verb subcategorization information that had been extracted and quantified automatically from the corpus parses. That is, for each verb (including BVs as well as PVs), we have quantitative information about how often the verb appeared with a specific subcategorization frame, and how often and which nominal complements appeared within the frames.

In a first step, we searched the subcategorization database for all occurrences of particle verbs with a specific particle (such as *auf*), the particle verbs' subcategorization frames, and the nominal fillers of the various verb complements in the frames. In parallel, we searched for the same information with regard to all base verbs that combine with that particle. We focused on the empirically strongest subcategorization frames, and on the most dominant nominal complements, where empirical strength was determined by *Local Mutual Information (LMI)*, cf. Evert (2005).

On the basis of the parallel data on subcategorization frames and nominal complements for base verbs and for particle verbs, we then manually identified semantically coherent groups of base verbs and the respective particle verbs which showed regularities with regard to a meaning shift. For each of the regular meaning shifts that we identified, the following subsections present the corpus data on the base verbs and the particle verbs, and a description of the meaning shift. The corpus data is provided in tables capturing the following information:

- the base/particle verbs in the respective verb group, identified via a particular particle meaning;
- the predominant subcategorization frame that is relevant for the meaning shift;
- one illustrative example complement per literal and shifted sense, within a relevant slot for the meaning shift;
- the strongest connotations, and
- the concepts that play a role in the meaning shift.

Concerning base verb and particle verb senses, note that many of the verbs are ambiguous. Our analyses focus on those senses that are relevant for the meaning shift, i.e., we only refer to the subcategorization and conceptual information with regard to (a) the base verb sense that undergoes the meaning shift, (b) the literal meaning of the particle verb in relation to the base verb, if there is any, and (c) the particle verb sense that represents the respective meaning shift. For example, we find (a) *Die Sonne strahlt* 'The sun is shining' as a base verb example, with (b) a literal particle verb extension *Die Sonne strahlt das Gebirge an* 'The sun shines on the mountains' and with (c) a meaning shift in *Die Frau strahlt den Mann an* 'The woman smiles at the man'.

3.1 *an*: Emotional Communication

The German verb particle *an* has one very prominent meaning (among others), where it ascribes a direction to the verb complement realized as its direct object. All PVs with this meaning of *an* are transitive, and combining this *an* with communication verbs such as *sprechen* 'talk' or *schreiben* 'write' is productive.

However, there are PVs such as *anstrahlen* in Example (3) that can also be characterized as directed communication verbs, but the BVs do not themselves carry a communication meaning, cf. Example (1). The sun (as well as other intransitive subjects of the base verb *strahlen* which occurred in the data) does not communicate through shining. So there must be an additional extended particle reading which includes communication semantics to get a shift from a literal PV meaning, as exemplified in Example (2), which describes a directed shining event of the uplighter toward the ceiling, to a metaphorical PV meaning with a directed communication action between two persons, cf. Example (3). In this example, the girl has an intention to smile in the direction of the grumpy person and therefore she must also expect him to be a potential experiencer. Compare *'He smiled at the chair', which is odd. While there are many other verbs that describe the manner in which an object may shine, it is necessary for the verb to allow for a directed communication reading: One could assume that verbs such as *glitzern* 'glitter' and *glänzen* 'gleam' which are similar to *funkeln* 'twinkle' also allow such a reading, however, these verbs denote the reflection of light instead of emission, i.e. the object itself is the light source. The verb *scheinen* 'shine' is a near-synonym of *strahlen* 'beam'/'shine', while the latter suggests directed communication, the former does not necessarily.

(1) *Die Sonne strahlt.* 'The sun is shining.'

(2) *Der Deckenfluter strahlt den Deckenbereich an.* 'The uplighter shines at the ceiling area.'

(3) *Das Mädchen strahlt den Obermuffel an.* ' The girl smiles at the grumpy person.'

There are four different categories of non-communication BVs with such a shift to communication PVs. They can be sub-divided into two groups, one with a positive connotation as in Tables 1 & 2, and one with a negative connotation as in Tables 3 & 4.

verbs	**frames**	**complements**	**connotations**	**properties**
strahlen 'beam'	intrans	*Sonne* 'sun' / *Auge* 'eye'	bright, warm	light emission
funkeln 'twinkle'	intrans	*Sternlein* 'little star' / *Auge* 'eye'	pleasing, valuable	
lächeln 'smile'	intrans	*Mädchen* 'girl'	happy, friendly	positive emotion
grinsen 'grin'	intrans	*Freund* 'friend'	expression	

Table 1: Base verbs that combine with *an* to mean *positive directed communication*.

It is striking that positively connoted BVs are all perceivable by vision, either because of the brightness ('beam', 'twinkle') or because of a facial expression ('smile', 'grin'), and lead to a positive communication reading in Table 2. The negatively connoted BVs are either sound-related or refer to animal sounds ('bark', 'growl') that are frightening or bear an acoustic intensity, cf. Table 3. In contrast, the PV *anzwitschern*, derived from the rather quiet and non-threatening BV *zwitschern* ('tweet') does not exist in this communication reading, because it is missing the negative connotation.[2] These observations are in line with Ibarretxe-Antuñano (1999), who claims that auditory as well as olfactory perception often comes with a negative connotation, since these senses can be overloaded. This is not the case for the visual sense, which can easily be regulated and effectively 'shut off'.

verbs	**frames**	**complements**	**connotations**	**properties**
anstrahlen 'beam at'	trans	*Deckenbereich* 'ceiling area'		
		Obermuffel 'grumpy person'	pleasing,	pos. directed
anfunkeln 'beam at'	trans	*Großmaul* 'loudmouth'	positive	communication
anlächeln 'smile at'	trans	*Mädchen* 'girl'	communication	
angrinsen 'grin at'	trans	*Mädchen* 'girl'		

Table 2: *Positive directed communication* particle verbs with *an*.

Furthermore, there are negative communication PVs which are not derived by sounds, but by vulgar expressions like 'shit' or 'piss', with an inherent negative polarity, cf. Table 3. Taking the non-vulgar synonym *pinkeln* 'tinkle' for *pissen* results in the odd PV *anpinkeln*, which cannot be readily interpreted except literal. So again, the missing negative connotation excludes the PV from the meaning shift. The BV subjects in the negative cases are mostly animals, whereas the subjects and also the objects in the corresponding PVs are persons (e.g., *Gegner* 'opponent', *Fan* 'fan') if the reading is metaphorical, cf. Table 4. In the literal meaning of, for example, *anbellen* 'bark at', the subject is a dog and we can find also inanimate objects such as *Mond* 'moon' as objects.

verbs	**frames**	**complements**	**connotations**	**properties**
bellen 'bark'	intrans	*Schäferhund* 'German shepherd'	loud sound,	uncivilized
kläffen 'yap'	intrans	*Köter* 'mutt'	displeasing	communication
pissen 'piss'	intrans	*Hund* 'dog'	feces, vulgar,	uncivilized
scheißen 'shit'	intrans	*Taube* 'pigeon'	unpleasant	excretion

Table 3: Base verbs that combine with *an* to mean *negative directed communication*.

verb	**frame**	**complements**	**connotations**	**properties**
anbellen 'bark at'	trans	*Mond* 'moon'	negative,	
		Gutachter 'surveyor'	intense,	neg. directed
ankläffen 'yap at'	trans	*Gegner* 'opponent'	aggressive,	communication
anpissen 'irritate'	trans	*Fan* 'fan'	vulgar	
anscheißen 'pester'	trans	*Bulle* 'cop'		

Table 4: *Negative directed communication* particle verbs with *an*.

3.2 *auf*: Social Pressure

We now investigate a meaning shift in PVs with the particle *auf* that have a social pressure reading. The BVs which belong to this group (cf. Table 5) are on the one hand force verbs which bring about a state that would not come about on its own, e.g., *zwängen* 'pressure/wedge' or *lasten* 'charge/weight'. On the other hand, there are the verbs *brummen* 'hum' and *donnern* 'rumble' which describe a heavy

[2]Nowadays, it can have a special communication reading because of the social web service Twitter.

and intense sound. Their complements are affected with a heavy sound in the literal meaning ('skull', 'cannon') and with heavy activity in a metaphorical meaning ('business'). The complements of *zwängen* all indicate a literal meaning (cf. Example 5), whereas *lasten* has direct objects that indicate a literal (*Gewicht* 'weight') and a less literal (*Verantwortung* 'responsibility') meaning.

verbs	**frames**	**complements**	**connotations**	**properties**
zwängen 'pressure/wedge'	trans (in-comp)	*Bus* 'bus'	pressure, negative	
bürden 'burden'	trans (auf-comp)	*Mitschuld* 'complicity'	assignment, strain	pressure, burden
lasten 'charge/weigh'	intrans (auf-comp)	*Gewicht* 'weight'		
		Verantwortung 'responsibility'	pressure, negative	
brummen 'hum'	intrans	*Schädel* 'skull'	loud, heavy activity	
		Geschäft 'business'		sound
donnern 'rumble'	intrans	*Kanone* 'cannon'	loud, menacing force	

Table 5: Base verbs that combine with *auf* to mean *transfer of negative social pressure*.

Combining these verbs with the social pressure triggered by *auf*, we only find abstract objects such as *Risiko* 'risk', *Strafe* 'penalty', etc. (cf. Table 6). Thus we have a meaning shift from an interpretation mostly ascribed to the physical domain to an interpretation within an abstract social domain.

The fact that the verbs **aufquetschen* and *aufschieben* do not have this reading shows that there must be another constraint. In comparison to the previous BVs, *quetschen* 'squeeze' suggests equally opposed forces and *schieben* 'push' one single moving force. The verbs *zwängen, bürden* and *lasten* all imply power inequality with some kind of resistance (e.g. non-compliance if it is a person or inertial/spatial opposition otherwise). In light of this, we can compare the social pressure meaning with the support meaning of *auf*. In both cases we have the concept that something is above something else. In Example (6), with its abstract social pressure reading, Maria bears a more powerful social position and thus is, metaphorically speaking, above her friends. Here, the equivalent of contact is expressed in her friends being the supporter because they have to carry the abstract pressure of the will of somebody else. However, the sound verbs are not restricted to the power inequality constraint; instead, only the semantics of something heavy being involved plays a role. The non-existence of *auf* together with *summen* 'sum', which sounds similar to *brummen* (but with higher sound frequencies and therefore not as heavy) is evidence for this assumption. Similarly, such loud sounds as those denoted by *krachen* ('crash') and *knallen* ('bang') lack a clear presence of a long, low-frequency sound. By contrast, while not present in the standard German dictionary Duden[3], the heavy sound of *dröhnen* ('drone'), gives rise to *aufdröhnen*, which is attested on the web:

(4) *Gehen wir einmal davon aus, Ihnen wird kein Fahrtenbuch aufgedröhnt, um den privaten Nutzungsanteil nachzuweisen.* 'Let's assume you are not forced to keep a driver's logbook in order to account for private use.'

The social pressure meaning as in Example (7) can only come from *auf*. The shift occurs here from being a sound verb to a verb describing somebody exerting negative social force upon somebody else.

(5) *Der Fahrer zwängt den Bus in eine kleine Parklücke.* 'The driver wedges the bus in a small parking space.'

(6) *Maria zwängt ihren Freunden ihren Willen auf.* 'Maria imposes her will on her friends.'

(7) *Der Richter hat dem Einbrecher eine gerechte Strafe aufgebrummt.* 'The judge inflicted a justified punishment on the burglar.'

3.3 *auf*: Initialization/Intensification of Visual Perceivables

The second reading of PVs with *auf* we take into account describes a transient change in which something suddenly appears and usually shortly after disappears. In Example (8), it is Micha's cry which abruptly appears and shortly afterwards becomes silent.

[3] http://www.duden.de

verbs	frames	complements	connotations	properties
aufzwängen 'impose on'	ditrans	*Wille* 'will'	negative	
aufbürden 'impose on'	ditrans	*Schuld* 'blame/debt'	pressure,	negative social pressure
auflasten 'impose on'	ditrans	*Verantwortung* 'responsibility'	burden,	
aufbrummen 'force s.o. to do s.th.'	ditrans	*Strafe* 'penalty'	strenuous	
aufdonnern 'force s.o. to do s.th.'	ditrans	—		

Table 6: *Transfer of negative social pressure* particle verbs with *auf*.

(8) *Als Micha das Buch auf den Fuß fiel, schrie er auf.* 'Micha let out a cry when the book fell on his foot.'

Table 7 groups BVs that are intransitive and visually perceivable.The subjects can thereby be seen as the source of the perceivable impulse, e.g. a lamp or a star. In some cases this visually perceivable source optionally produces heat like in Example (9). Other subjects we found in this context are blaze, spark, flame, light, etc. Such stimuli can grow in intensity very quickly. Therefore we can already find some non-literal usages in the BVs describing an intense emotion like hate, however only with *flammen* and *lodern* (the heat-related verbs).

verbs	frames	complements	connotations	properties
glimmen 'glimmer'	intrans	*Funke* 'spark'	bright, warm,	visual perception
glühen 'glow'	intrans	*Licht* 'light' / *Auge* 'eye'	pleasant	
lodern 'blaze'	intrans	*Flamme* 'flame' / *Hass* 'hate'	hot, (emotionally)	visual, thermal perception
flammen 'flame'	intrans	*Feuer* 'fire'	intense, bright	

Table 7: Base verbs that combine with *auf* to mean *initialization/intensification of visual perceivable*.

Combining these BVs with the particle *auf*, the metaphorical meaning turns out to be prominent. This is consistent with the characteristics of emotions which can appear and disappear very quickly. Comparing something like anger with a heat source is very common and captured in Lakoff et al.'s (2005) INTENSE EMOTIONS ARE HEAT conceptual metaphor. Therefore the parallel usage sharing one PV is not surprising. The only difference between the literal Example (10) and the non-literal Example (11) is that the perceived heat belongs to another domain. Other examples of emotion subjects are *Hoffnungsschimmer*, 'glimpse of hope', *Mitleid* 'pity' and *Debatte* 'debate', which is not an emotion, but in context of the *auf*-verb it refers to an intense discussion which involves emotions.

(9) *Das Feuer flammt.* 'The fire flames.'

(10) *Das Feuer flammt auf.* 'The fire flared up.'

(11) *Die Debatte flammt auf.* 'The debate flared up.'

In summary, we can say that both light and heat in these verbs seems to be central. While there is a wide class of BVs that allow for such a meaning shift (including most verbs applicable to light coming from a fire, e.g., *flackern* 'glint'), we find counterexamples where such an emotional metaphorical meaning is not present: *aufleuchten* 'light up', *aufblinken* 'flash', *auffunkeln* 'twinkle', *aufglitzern* '(suddenly) glitter'—all of which do not necessitate a notion of heat. It seems the 'light' property, as opposed to 'heat', is more involved in the perception and cognition domain (cf. the conceptual metaphors IDEAS ARE LIGHT SOURCES, UNDERSTANDING IS SEEING). The mental enlightenment is more a process than a sudden appearance which explains the incompatibility with this particle meaning.

3.4 *auf*: Intensification/Initialization of Emotion

A completely different class of base verbs leads to the same reading of a quick increase in intensity as the 'flare up' verbs. These are verbs which describe internally caused processes, such as *brausen*

verbs	frames	complements	connotations	properties
aufglimmen 'light up/flicker'	intrans	*Glimmlampe* 'glow lamp'	(more) visible	
		Hoffnungsschimmer 'glimmer of hope'	(and vanish),	initialization
aufglühen 'light up'	intrans	*Rücklichter* 'tail lights' / *Auge* 'eye'	quickly become	(intensification)
auflodern 'become intense'	intrans	*Feuer* 'fire' / *Wut* 'anger'	perceivable	
aufflammen 'flare up'	intrans	*Kampf* 'fight' / *Debate* 'debate'		

Table 8: *Initialization/intensification of perceivable* particle verbs with *auf*.

'roar', *kochen* 'boil' which denote a forceful movement, cf. Examples (12,13). The force involved can be physical (e.g., *schaukeln* 'swing') but can also be conceptualized as emotional, as in the metaphorical meaning in Example (14):

(12) *Der Sturm braust.* 'The storm is roaring.'

(13) *Der Sturm braust auf.* 'The storm is roaring up.'

(14) *Der Jubel braust auf.* 'The cheering is roaring up.'

All such 'forceful movement' BVs have an intransitive frame that has as subject in the literal sense (a) the entity being moved (e.g., *Schiff* 'ship'), or (b) a mass which is in motion (e.g., *Wasser* 'water'). The metaphorical reading can involve strong emotions (*Blut* 'blood'), intense activity (*Verkehr* 'traffic'), or both (*Gerüchteküche* 'rumor mill'); the activity in the latter is also showing up in the term for those involved in spreading rumors, namely 'busybodies'.

verbs	frames	complements	connotations	properties
schaukeln 'swing'	intrans	*Schiff* 'ship'	intense,	internally caused
brausen 'roar/crash'	intrans	*Sturm* 'storm' / *Verkehr* 'traffic'	sweeping motion,	motion
wallen 'undulate/surge'	intrans	*Nebel* 'fog' / *Blut* 'blood'	emotions	
brodeln 'seethe'	intrans	*Wasser* 'water'	heat,	internally caused
		Gerüchteküche 'rumor mill'	bubbling,	motion (with heat),
kochen 'boil'	intrans	*Wasser* 'water'	motion	emotion

Table 9: Base verbs that combine with *auf* to mean *initialization/intensification of emotions*.

verbs	frames	complements	connotations	properties
aufschaukeln 'build up'	intrans	*Papierboot* 'paper boat'	to and fro,	
		Konflikt 'conflict'	intense	
aufwallen 'surge up'	intrans	*Staub* 'dust' / *Zorn* 'fury'	motion,	intensification
aufbrausen 'flare up'	intrans	*Sturm* 'storm' / *Jubel* 'cheering'	strong	
aufbrodeln 'bubble up'	intrans	*Milch* 'milk' / *Hass* 'hate'	negative	
aufkochen '(bring to a) boil'	intrans	*Wasser* 'water' / Wut 'anger'	emotion	

Table 10: *Initialization/intensification of emotions* particle verbs with *auf*.

The shared property between the visual BV group and these motion verbs is that heat is understood to be conceptually linked to emotions (Lakoff and Johnson, 1980). The contribution of *auf* in this context is a notion of surging up, i.e., things are coming from below (hidden) to the surface (perceivable). These are terms that are commonly used to describe emotions, when they cannot be perceived (i.e., when they are not intense enough), they are 'hidden'. If they grow in intensity, they are said to 'surface' (*Gefühle aufwühlen* 'churn up feelings'). It is worth noting that *aufschaukeln* gives rise to a 'discussion' image, as it describes a constant to and fro between two opposing sides.

The compositional reading is dispreferred, since it is not typical to have both a back and forth and an upwards motion combined. As expected, base verbs that describe a subsiding of motion (e.g., *flachen* 'flatten', *ebben* 'ebb', *sinken* 'sink') combined with the particle expressing the opposite of this *auf* reading (i.e., *ab*), give exactly the opposite meaning, namely to lessen, abate, diminish; both in a physical as well as emotional sense.

Although it is not attested in the corpus, there exists the same metaphor in German and English *Das bringt mich zum Kochen* 'It makes my blood boil', of an intense emotion—in this case, fury—being conceptualized as something seething within the experiencer.

3.5 *ab*: Successive Tasks

One of the multiple meanings of the particle *ab* involves the concept of a sequence of similar actions leading to the completion of a complex task. Kliche (2011) terms this the 'mereological reduction' sense of *ab*. On the one hand, this meaning can come from verbs that generally entail some form of work (e.g., *arbeiten* 'work', *leisten* 'perform'). On the other hand, there are verbs that suggest the actual event structure of the chain of sub-tasks being completed.

verbs	frames	complements	connotations	properties
klappern 'clatter'	intrans	*Storch* 'stork'	sharp, short,	rapid succession
rattern 'clatter'	intrans	*Nähmaschine* 'sewing machine'	repetitive,	
stottern 'stutter'	intrans	*Motor* 'motor'	sound/action	

Table 11: Base verbs that combine with *ab* to mean *successive task completion*.

This can arise when (a) the actions are performed on an area that is successively covered along the event chain (e.g., *grasen* 'graze', *kämmen* 'comb', *suchen* 'search'); or (b) when the verb that is combined with *ab* suggests a mass that diminishes progressively due to the performed action until it is completely gone (e.g., *abbezahlen, abstottern* 'pay off'). The successive character of the mereological reduction sense is thus already inherently present in these verbs.

verbs	frames	complements	connotations	properties
abklappern 'check all'	trans	*Sehenswürdigkeit* 'tourist sight'	successive	successive reduction
abrattern 'pay off (a debt)'	trans	—	accomplishing,	
abstottern 'pay off (a debt)'	trans	*Schuldenberg* 'mountain of debt'	stepwise reduction	

Table 12: *Successive task completion* particle verbs with *ab*.

Interestingly enough, it is sufficient for the mereological reduction *ab* to be available that only the event structure itself to be conveyed, even without the concept of work being present in the base verb. In our everyday experience, the rapid succession of similar short events can give rise to a particular repetitive acoustic pattern, which is captured in the onomatopoetic verbs: *klappern/rattern* 'clatter' and *stottern* 'stutter'. These verbs combined with *ab* then give the expected reading, namely a chain of similar actions being performed. However, this does not work with semelfactive sound verbs like *klicken* 'klick' or *ticken*, even if they can provide a repetitive reading by multiplying the single verb events. The verbs in this class are iterative and cannot be interpreted as semelfactive.

It is clear that the acoustic signal lends itself to a mapping to the event structure, since both are organized linearly in time. This also explains the inaccessibility of the same meaning for a visual signal, since there is no straightforward mapping of the visual field to the time axis. The only counterexample of a visual mereological reduction verb that we are aware of is *absuchen* 'scan'; which suggests a linear process of visual perception; e.g., along a linear path through a room, or via the linear searching through a telescope or magnifying glass.

4 Discussion

The previous section provided an extensive analysis of 6 different cases of BV–PV meaning shifts, with regard to 3 different particles. We briefly summarize these meaning shifts, concentrating on the

main conceptual properties only. The presentation is done according to the pattern in Equation (1) as introduced in Section 1.

(1) **BV** $\{pBV_1, pBV_2, \ldots, pBV_n\}$ **+ PM** $\rightarrow$ **PV** $\{pPV_1, pPV_2, \ldots, pPV_m\}$

Meaning shift classes:

1. ***an: "positive emotional communication"***
   BV {pleasing, emission} **+ PM** {dir+com} $\rightarrow$ **PV** {positive directed communication}
   with BVs *funkeln, grinsen, lächeln, strahlen*

2. ***an: "negative emotional communication"***
   BV {displeasing, uncivilized} **+ PM** {dir+com} $\rightarrow$ **PV** {negative directed communication}
   with BVs *bellen, kläffen, pissen, scheißen*

3. ***auf: "negative social pressure"***
   BV {loud/heavy pressure} **+ PM** {vert. contact} $\rightarrow$ **PV** {negative social pressure}
   with BVs *brummen, bürden, donnern, lasten, zwängen*

4. ***auf: "initialization of perceivables (vision & emotion)"***
   BV {bright, vision} **+ PM** {sudden, initial}$\rightarrow$ **PV** {initialization of visual perceivable}
   with BVs *flammen, glimmen, glühen, lodern*

5. ***auf: "intensification of perceivables (emotion)"***
   BV {int. caused motion} **+ PM** {sudden, initial} $\rightarrow$ **PV** {intensification of emotions}
   with BVs *brausen, brodeln, kochen, schaukeln, wallen*

6. ***ab: "successive task completion"***
   BV {repetitive, sound} **+ PM** {mereol. reduction}$\rightarrow$ **PV** {successive task completion}
   with BVs *klappern, rattern, stottern*

The analyses were performed across several semantically coherent groups of verbs. We demonstrated that corpus-based information on the verbs' subcategorization frames and nominal complements (combined with intuitions about generalizations of the noun complements) is a sufficient basis for defining BV–PV meaning shifts. We thus confirmed our initial hypothesis that there are regular mechanisms with regard to the syntax-semantic interface that trigger a meaning shift of a base verb in combination with a particle meaning and that do not only apply to the individual verb but across a semantically coherent set of verbs. The identified meaning shift classes are effectively larger than those presented in the tables in Section 3 because the classes are productive. Relying on the productivity, we could easily enlarge our meaning shift classes with new members (which will be discussed below).

We briefly summarize the main findings from our analyses, with regard to the BV, PV and particle properties: (i) There is a very strong agreement across verbs (both BVs and PVs) within a meaning shift class with regard to the subcategorization frame types. This is a very impressive indicator for semantically coherent groups, where we had expected more diversity. (ii) Even restricting the nominal complements to only the 10-20 most strongly *LMI*-based associated types is a sufficient basis for investigating the conceptual properties that determine the respective slot. (iii) To our knowledge, a new aspect to meaning shifts in (German) particle verbs has been discovered: We found that particles actually adopt meaning aspects from the base verbs they combine with. For example, the particle *an* in meaning shift classes 1 and 2 a priori refers to a *direction* meaning. However, it obviously incorporates meaning aspects from communication base verbs that it typically combines with (when no meaning shift is involved), such as *ansprechen* 'speak to' and *anreden* 'address someone'. As a result, the particle meaning within the particle verbs in classes 1 and 2 contributes meaning aspects of *direction* as well as *communication*. To go deeper into this issue, future work will investigate the diachronic development of particle roots with regard to the particle meanings.

Our strategy can easily be replicated for another BV–PV data set in German or other languages, given that parsed corpus data is available. In addition, there are easy extensions to the strategy that however make the identification and factors of meaning shifts more objective: (i) co-occurrence of the BVs and PVs with particular *adverbs* should be useful as indicators of meaning shifts, as they are expected to agree across the respective base and particle verbs but might be different between the literal and shifted meanings of the particle verbs. (ii) Similarly, we expect *2nd-order co-occurrence adjectives*, i.e., those adjectives that modify the nominal complements of the verbs (Schulte im Walde,

2010), to be useful indicators of the kinds of connotations we so far collected manually. For example, concerning meaning shift class 4 above, strong adjectival modifiers of both *Feuer* 'fire' and *Flamme* 'flame' are *ewig* 'eternal' *lodernd* 'blazing', and *offen* 'open', while strong adjectival modifiers of both *Konflikt* 'conflict' and *Diskussion* 'discussion' are *aktuell* 'current', *politisch* 'political', and *weit* 'wide'. (iii) Instead of subjective definitions of conceptual generalizations over nominal complements, one could apply *GermaNet* (Kunze, 2000), the German pendant to *WordNet* (Fellbaum, 1998). For example, both *Feuer* 'fire' and *Flamme* 'flame' are generalized to *Ereignis* 'event' by GermaNet on level 3 (starting from the top node level) and to *Phänomen* 'phenomenon' on level 4, while both *Konflikt* 'conflict' and *Diskussion* 'discussion' are generalized to *Kommunikation* 'communication' and *Gespräch* 'conversation' on levels 3 and 4, respectively. (iv) A simple way to enlarge meaning shift classes is by looking up synonyms of the base and/or particle verbs in dictionaries. For example, Bulitta and Bulitta (2003) defines *aufdrängen*, *aufnötigen*, and *aufoktroyieren* as near-synonyms to *aufzwängen*, so we could check whether these three particle verbs fall into meaning shift class 3.

A long-term goal of our work is to extend it toward a more automatically driven identification of meaning shifts in particle verbs. Three examples of approaches that are potentially useful to complement our corpus-based search are the following: Reisinger and Mooney (2010) presented a multi-prototype vector-space model that discriminates multiple senses of a word by clustering contexts, an idea adopted from Schütze (1998). We could reduce their "contexts" to the crucial information about the BV and PV properties we identified, i.e., subcategorization frame types and concept properties, possibly refined by further meaning aspects as suggested above. The framework would then allow us to determine the similarity between the "contexts" of base verbs and particle verbs, and thus to identify the semantically coherent groups of base verbs as well as literal meanings of particle verbs with regard to their base verbs. To do this we could use a clustering approach similar to Reisinger and Mooney (2010). Birke (2005) also relied on clustering to discover literal and non-literal uses of English verbs in context. However, while her approach required a manually labeled set, we could envision an automatic detection of literality as done by Turney et al. (2011). Boleda et al. (2012) presented an approach to regular polysemy where meta-alternations capture regularities in meaning shifts. In a first step, the meta-alternations are instantiated by monosemous words exhibiting the respective meaning shift. In a second step, the meta-alternations are used to predict a meaning shift for a new item. With regard to our research, a meta-alternation should capture the BV and PV properties of a certain meaning shift. As in Boleda et al. (2012), we would instantiate the meta-alternations through monosemous base and particle verbs. For a new BV–PV pair, we could then predict the (non-)existence of the meaning shift by comparing the pair's conceptual properties to the properties of the meta-alternation. Note that this approach requires prior knowledge about some seed BV–PV pairs and their meaning shifts.

Last but not least, a major challenge in the automation of our work is in distinguishing between BV and PV verb polysemy vs. meaning shift. That is, most computational approaches such as Reisinger and Mooney (2010) will provide us with knowledge about the various meanings of the base and/or particle verbs. However, we not only want to detect different senses (e.g., the particle verb *abnehmen* has several senses with overlapping subcategorization properties that all but one differ from the literal meaning), but in addition which of the senses is a meaning shift, and why. Our goals are more addressed by the Boleda et al. (2012) approach, which however requires manual work in the outset.

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