Aspectual Class (Under-)Specification in the Generation of Motion Event Representations – A Project Outline

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ABSTRACT

In this working paper, we outline a research program that focuses on Aspectual Class interpretation in descriptions of motion events. First, we briefly sketch the research program and motivate our endeavour by reviewing current formal semantic and psycholinguistic research in the field. We place special focus on the theoretical concept of lexical semantic underspecification. Second, we define the goals that we will pursue in this project and highlight our theoretical starting points, both from the viewpoint of formal semantics and psycholinguistics. Third, we give an outlook for the next steps to be taken.

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1 Introduction

Aspectual class (AC) information characterizes the temporal structure of situations, i.e. events, processes and states of different kinds, that are referred to in sentences. A crucial question is how this information enters the semantic representation of a complex expression: Is specific AC information stored with verbs and other lexical units in the mental lexicon, or may verbs and other units be underspecified in this respect?

Approaches that assume determinate AC specifications in the mental lexicon face the problem that AC mismatches between different lexical units, e.g., between verbs and prepositions or between verbs and particular temporal adverbials, require an accommodation process of some sort. The technical term for this kind of accommodation most often used in current research is coercion (cf., de Swart, 2011, for an overview). Approaches that deny determinate AC specifications in the mental lexicon, on the other hand, are challenged by the fact that some explanation for how temporal structure emerges in the semantic representation of a sentence must be provided. Moreover, findings from psycholinguistic

research that investigate accommodation phenomena, which suggest cognitive correlates of accommodation, must be accounted for.

To date, accounts that assume a determinate AC specification and, thus, in general make extensive use of a coercion mechanism dominate the field. However, some recent experimental work in the domain failed to replicate some of the crucial empirical findings which were originally interpreted to support the validity of the concept of coercion. Yet, a thorough account that can explain how the temporal-structural features in an event representation are derived on the assumption of AC underspecification has not been offered.

The research program that will be outlined in the following favors lexical semantic underspecification, at least in the domain to be studied. It therefore largely refrains from the concept of coercion and rather constrains use of a special mechanism to resolve AC-related mismatches to only a small set of phenomena.

This working paper is structured as follows: First, we briefly outline the research program and motivate our endeavour by reviewing current formal semantic and psycholinguistic research in the field. Second, we define the goals that will be pursued. Third, we highlight our theoretical starting points and introduce the terminology that will be used. The last section gives an outlook on the next steps in the project.

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2 Brief Outline of the Research Program

This project investigates the cognitive representation and processing of aspectual class (AC) information in descriptions of motion events. To this end, we will conduct a series of experiments to study the relevant properties of the verb, its arguments – most importantly the directional PPs that accompany motion verbs – and different types of temporal and spatial modifiers that language users rely on in order to assign an AC to a linguistic expression. Specifically, we focus on what user behaviour under controlled conditions tells us about the way AC information is stored in the mental lexicon and how this information is used online to derive a fully specified event representation. Our approach rests on a few theoretical cornerstones, which, for now, primarily serve to structure our quest. These guiding assumptions are: (1.) We are in favour of lexical underspecification, i.e., we assume that not all lexical items (verbs and prepositions) are specified with respect to AC-information. (2.) We hold that lexical semantics is an interface that mediates between linguistic form and conceptual structure. (3.) We believe that it is possible and necessary to provide a model of the phenomenon that in principle can be applied in language comprehension and language production. (4.) We acknowledge that cross-linguistic variation must not only be accounted for, but provides valuable insights.

In terms of the information stored in the mental lexicon, our primary questions are: Are verbs and directional prepositions stored with determinate information about their contribution to the AC of complex expressions in which they appear, or does their AC contributions at least in some cases have to be considered lexically underspecified? If there is indeed evidence for underspecification with regard to AC, do underspecified motion expressions form a homogeneous class or do subjects show gradual preferences towards specific AC interpretations? If so, what are the relevant semantic and conceptual factors that account for this potential diversification?

Regarding the processing of the information specified (or unspecified) in the mental lexicon, we raise the following questions: What exactly is the result of semantic composition, i.e., how does lexical information relate to an event model in terms of AC? Is aspectual coercion a phenomenon that must be assumed as an option in the dynamics of the language comprehension process, or can findings that seemingly support coercion be explained in other ways?

3 Aspectual Classes in Theoretical Semantics

3.1 Verb classes

There is a long tradition of AC research in theoretical linguistics. Current theories (e.g. Dölling, 2011, for German) typically use some extension of the classic Vendler system (Vendler, 1957) with its differentiation of expressions for states (*wissen, sitzen*; 'to know', 'to sit'), activities/processes (*brüllen, wehen* 'to holler', 'to blow'), accomplishments (*genesen* 'to recover') and achievements (*umfallen* 'to topple over'), amended with the categories of semelfactives (*blitzen* 'to flash') and intergressives (*grüßen* 'to greet'); see Löbner (1988), Herweg (1991), and Egg (1995) for verbs about instantaneous and extended non-change-of-state events.

3.2 AC composition of complex expressions

The composition of the AC-interpretation of VPs and sentences based on the AC of verbs and the semantics of their arguments and modifiers is well understood, due to the seminal work of Krifka (1989a, 1989b, 1998) and others. A variety of tests – most importantly the combination with time-span adverbials (TSA) such as *(with)in one hour*, durational adverbials (TDA) such as *for one hour* and temporal count adverbials (TCA) such as *twice* – reveals that ACs of simple and complex verbal expressions (V and its projections up to the sentence level) belong to two logico-semantic classes, namely those of bounded and unbounded predicates[1]: TDA accept without reservation only state and process/activity predicates, which are unbounded; TSA and TCA combine without constraint only with accomplishments, achievements, semelfactives and intergressives, which are bounded; see some examples in (1):

(1) *The pearl* ...

  a) ... *dropped from the table (with)in five seconds / *for five seconds / twice.*

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[1] Different terms are used in the literature for the bounded-unbounded dichotomy, among them 'quantized vs. cumulative' (Krifka, 1989a,b, 1998), 'heterogeneous vs. homogeneous' (e.g., Reyle, 1987; Herweg, 1990, 1991), 'quantized vs. homogeneous' (de Swart, 1998), 'perfective vs. imperfective' (Fabricius-Hansen, 1986) and, most prevalently, 'telic vs. atelic' (see the overview in Filip, 2011). While we do not have a fundamental issue with most of these different nomenclatures, we dissociate ourselves, however, from the latter one, because semelfactives and intergressives cannot be adequately classified as either telic or atelic.

b) ... *lay on the table ?(with)in five seconds / for five seconds / ?twice.*

c) ... *rolled on the table ?(with)in five seconds / for five seconds / ?twice.*

d) ... *rolled onto the cloth (with)in five seconds / *for five seconds / twice.*

3.3 Context and reinterpretation/coercion

On top of compositional semantics, context, in particular the above mentioned criterial adverbials, may trigger non-compositional effects of reinterpretation (see Herweg, 1991), often termed 'coercion' (cf., Moens and Steedman, 1988; de Swart, 1998; van Lambalgen and Hamm, 2008; de Swart, 2011). So, if an unbounded predicate is combined with a TSA or TCA, the interpretation of the predicate may be 'coerced' into a bounded reading (*in einer Stunde/zwei mal schlafen*; *to sleep within one hour/twice*; also possibly in (1.b) and (1.c)), and if a bounded predicate is combined with a TDA, its predication may be 'coerced' into an unbounded reading (*stundenlang blitzen/umfallen*; 'to flash/ to topple over for hours'; note that the VPs in (1.a) and (1.d) are quite resistent to this type of 'coercion'). These types of 'coercion' or reinterpretation serve to resolve a semantic conflict between the AC of the verb and the AC requirements of the adverbial by means of adjusting the interpretation of the V or VP to the requirements of the adverbial. The interpretation of the V/VP can only be successfully adjusted if this is tolerated by (our knowledge and assumptions about) the type of situation it describes. Judgements about acceptable coercions thus typically vary between language users. Although coercion is recognized as a relevant phenomenon and dealt with in quite a few studies (e.g., de Swart, 1998, 2012), its theoretical status and especially the details of its range and limitations are far from being fully understood.

3.4 The concept of underspecification

While there is agreement by and large on what the relevant ACs are (at least on what the core set of ACs is), there is debate on whether or not all Vs are assigned a determinate AC in the lexicon or whether for some verbs or verb classes – and even the VPs and sentences headed by these verbs – AC information may be semantically underspecified.

Nicolay (2007) argues that all German Vs are assigned a specific AC in the lexicon. Krifka (1989a, 1989b, 1998) lays down the compositional procedures by which a V with a certain AC is expanded into a VP

and eventually into a sentence yielding a different AC depending on the thematic role(s) of its argument(s) and their referential properties. As an example, the unbounded (Krifka: cumulative) V *to write* can be expanded into a bounded (Krifka: quantized) VP *to write a book* or into an unbounded (cumulative) VP *to write books*, depending on the corresponding referential properties of the object NP.

Herweg (2014), on the other hand, argues for the domain of German motion verbs (MV) that the AC class of quite a number of simple (non-compound) MVs is underspecified and the AC of their verbal and sentential projections is determined by the AC contribution of their directional PP argument[2]. So, the AC of a manner of motion V such as *laufen* 'to walk' is considered to be underspecified and it is the AC contribution of the directional PP argument that renders the resulting PP bounded, as in *in den Park laufen* 'walk into the park', or unbounded, as *in längs des Baches laufen* 'to walk alongside of the brook'. What is more, also the AC contribution of a PP may be underspecified, like in *durch den Park laufen* 'to walk through the park' and *über die Wiese laufen* 'walk across/over the meadow', which are equally open to bounded and unbounded interpretations (cf. Maienborn, 1990, p91).

Following Bott's (Bott, in press) proposition that experimental methods can yield significant insights into semantic issues, one of the objectives of our present research is to seek additional experimental evidence for and against the underspecification approach.

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[2] To our knowledge, Maienborn (1990) was the first who argued that the AC of the majority of intransitive motion verbs is underspecified. Maienborn considers only a handful of intransitive motion verbs in German to be unbounded (atelic in her terminology), namely *streunen* ('stray'), *schweifen* ('ramble'), *streifen* ('wander'), *streichen* ('prowl') *stromern* ('roam') and *wandeln* ('stroll'). The class of bounded intransitive motion verbs is also limited: In addition to *kommen* ('to come') it includes only prefix verbs such as *abfahren* ('depart'). Fabricius-Hansen (1986, p325ff) may be seen as a predecessor of this view: In addition to bounded and unbounded verbs (perfective and imperfective verbs, in her terminology) she assumes a third group of verbs, namely those which are neutral with regard to AC ("aktionsartneutral", in her terms). Examples are *schreiben* 'write', *bauen* 'build', *schwimmen* 'swim', *fliegen* 'fly' and *gehen* 'walk, go'. See also Filip (2011, p1208), who characterizes incremental verbs like *to eat* as "unspecified for telicity".

4 The investigation of Aspectual Classes in Psycholinguistics

Processing of aspectual class information has been studied employing several different empirical methods, ranging from reading time studies, lexical decision tasks (cf. the seminal work by Piñango et al., 1999) over judgement and cloze tasks (cf. Bott, 2010) to neurobehavioral and neuroimaging techniques (cf. Piñango and Zurif, 2001). While some work has focused on the conditions for specific types of reinterpretation/coercion (cf. Pickering et al., 2006, on iterative reinterpretations of semelfactives) other studies have looked into the nature of the real-time processes involved, as well as their neural correlates (cf. Pylkkänen and McElree, 2006). Note that in all studies that use time-sensitive measures (e.g., reaction times, RT) it is assumed that higher reaction times reflect higher cognitive demands, always in comparison to some baseline. Since it has been shown that processing linguistic structures that can be analysed as involving coercion, the phenomenon has been considered to be cognitively real. In the following we will selectively review some of the results obtained in the field which are representative of the state-of-the-art.

4.1 Bott on Aspectual Interpretation

By far the most elaborate work on the comprehension of AC that we are aware of has been carried out by Bott in a series of studies with different experimental methods. We will take the following major results of Bott's work as a point of departure for our research.

4.1.1 Cross-linguistic aspectual variation and incremental aspectual interpretation

Bott and Hamm (2014) report that no reliable reaction time differences were found in a self-paced-reading (SPR) experiment with German native speakers between so-called subtractive coercion of an accomplishment into an activity reading (*Der Architekt errichtete das Haus zwei Jahre lang* 'the architect built/erected the house for two years') vs. aspectual controls (*Der Architekt errichtete das Haus in zwei Jahren* 'the architect built/erected the house in two years'). This differs from findings with English native speakers, where *for*-modification of an accomplishment in the simple past form (*The architect built the monument for two years*) leads to higher reaction times. Based on the assumption that coercion causes additional processing effort which results in longer reading times, the authors take these findings as

evidence for their 'Cross-Linguistic Aspectual Variation Hypothesis (CAVH)': If a language has/does not have the grammatical means to express an aspectual distinction, the processor does/does not immediately commit to an aspectual interpretation.

This means that English speakers immediately commit to a full aspectual specification, whereas aspectual interpretation is delayed for German speakers. These findings support the assumption that English is subject to the 'Incremental Aspectual Interpretation Hypothesis (IAIH)': Lexical aspect is computed incrementally, on a word-by-word basis.

4.1.2 Late aspectual interpretation

Results reported in Bott (2013) shed light on the question at what processing stage German speakers indeed commit to an aspectual interpretation. SPR and reading studies with eye tracking (ET), in which word order was varied (SVOA, SVAO, AVSO; S: subject NP, O: object NP, V: verb, A: TSA or TDA), revealed that an aspectually mismatching adverbial (TDA, TSA) only showed semantic effects after the verb had received all of its arguments, i.e., only when the predication was complete. Bott takes this as evidence that German speakers follow a strategy which is predicted by a strong variant of a 'Late Aspectual Interpretation Hypothesis (LAIH)': Lexical aspect is not computed before the verb has received all its arguments.

4.1.3 Bott on underspecification

In several publications, Bott argues against the conjecture that mental representations of verb meanings may be underspecified with regard to AC. He refers to findings in different linguistic domains that suggest that there are always additional factors – such as frequency of particular word meanings as well as additional linguistic and extra-linguistic considerations on the side of the language user – that render one interpretation more salient than a competing interpretation. Put differently, it is assumed that verb meanings contain AC specifications, but the strengths of a coercion effect (where coercion must be assumed) is influenced by additional factors.

Bott (2010, 2013, in press) reports on SPR studies which showed differences between typical activity verbs such as *to jog* (Bott only cites this highly specific manner-of-motion verb) and typical accomplishment verbs such as *to write*: Even in situations where the *in*-TSA did not produce a semantic mismatch already at the time of its occurrence, its processing was delayed after *to jog*. So, the TSA in *Peter joggte*

in 15 Minuten 'Peter jogged (with)in 15 minutes' was processed more slowly than in the variant with a TDA, *Peter joggte 15 Minuten lang* 'Peter jogged for 15 minutes', although the first sentence (with the TSA) could be appropriately continued with *drei km* 'three kilometers' or *bis ans Ende des Parks* 'up to the end of the park'. This effect did not show with *schreiben* 'to write': There was no significant difference between *Peter schrieb eine Stunde lang an einem Brief* 'Peter was writing a letter for an hour' (TDA) vs. *Peter schrieb in einer Stunde einen Brief* 'Peter wrote a letter (with)in an hour' (TSA) at the time of processing the adverbial.

Bott takes these findings as evidence against underspecified mental representations of aspectual class. He hypothesizes that readers rather immediately assign an interpretation due to frequency effects, which strongly bias a verb like *to jog* towards an activity reading. However, It is not clear at all how these findings relate to the evidence for LAIH reported in Bott (2013).

Bott et al. (2011) cite studies on quantifier scope ambiguities as additional evidence against underspecification: Off-line questionnaire studies showed that there is always a variety of factors that support one scope reading more than a competing one. So, even if all possible interpretations are available up to the point where disambiguating information arrives, there must be some inherent ranking of the various scope-determining factors that results in certain interpretations being more activated than others.

However, in their methodological considerations, Bott et al. (2011) point out that the differences in processing time found in their studies could also be explained within an approach based on underspecification: When some disambiguating context for a potentially ambiguous construction is encountered, the underspecified representation needs to be enriched in order to allow only one reading and exclude all others. It is conceivable that updating/enriching the representation may require more or less effort depending on the ultimate interpretation that is required; i.e., different ways to turn an underspecified representation into a specified interpretation may involve different levels of processing load.

Bott et al. (2011) conclude that more research is needed in order to decide for or against an approach based on underspecification. Current on-line methods are not able to decide for or against specification of an initially underspecified representations vs. full initial specification plus revision if required. Different and new methodologies are needed.

4.2 Lukassek et al. on aspectual underspecification

In a recent plea for an underspecified AC of standard motion verbs, as advocated in Maienborn (1990), Lukassek et al. (2016) tested the processing predictions of a radical (in our terms) coercion account of AC composition as originally put forward by Moens and Steedman (1988) and adopted in various theories, among them the 'Event Calculus' of van Lambalgen and Hamm (2008). On this account, motion verbs such as *to walk* and *to run* are prototypical activity verbs, i.e. they are inherently unbounded (atelic). When combined with a goal PP like *into the house*, a culmination is added to the activity, which renders the resulting VP *to walk/ to run into the house* bounded (a telic accomplishment expression, in Vendler's 1957 terms). Moens and Steedman (1988) and their followers call this transition from an unbounded/atelic activity predicate to a bounded/telic accomplishment predicate 'additive coercion'. This means that advocates of this approach apply the mechanism of aspectual coercion not only to instances of what we consider as non-compositional adjustments of interpretation (see above, 2, on reinterpretation). Rather, they extend this approach to cases which are commonly considered to be handled by the principles of compositional semantics (see Krifka, 1989a,b, 1998, on AC composition for incremental verbs, which comprise the majority of motion verbs). Note, however, that neither of these theories originally made assumptions about how the respective semantic mechanisms would be reflected in real-time cognitive processing.

Lukassek et al. base their argument in favour of underspecified AC on the assumption that aspectual coercion, as indicated by the results of experiments conducted by Bott (2010) and others, should require additional processing effort, as compared to linguistic stimuli that do not involve any coercion. They conjecture that this effect should be demonstrable for both the resolution of an aspectual conflict between a TDA and a bounded verb (see our examples in 2) and for the transition from an unbounded activity verb to a bounded accomplishment VP, if Moens and Steedman (1988) and their followers were right.

Lukassek et al. tested this 'Coercion Account' hypothesis vs. their own 'Underspecification Account' hypothesis (henceforth: CA and UA) for standard motion verbs in a self-paced reading study combined with an acceptability judgement task (these main experiments were complemented by a corpus study and a completion task). Test sentences with typical

motion verbs such as *gehen* 'to go', *rennen* 'to run', *fahren* 'to drive' and *segeln* 'to sail' were presented in four conditions that were derived by crossing the factors 'type of directional PP' and 'type of temporal adverbial' (see Table 1).

The type of the directional PP	
TEL	telic (*zur Nordsee* 'to the North Sea')
AMB	ambiguous/unspecific (*über die Nordsee* 'over the North Sea')

The type of the temporal adverbial	
DUR	durative (*drei Tage lang* 'for three days')
COMPL	completive (*in drei Tagen* '(with)in three days')

Table 1: *Experimental factors in Lukassek et al.'s study*

The sentences in (2 a-d) are examples that illustrate the four conditions in Lukassek et al.'s study.

(2) *Der Pirat segelte* ('The pirate sailed') ...

    a) ... *über die Nordsee, und zwar drei Tage lang.* 'over the North Sea, namely for three days.' (AMB-DUR)

    b) ... *zur Nordsee, und zwar drei Tage lang.* 'to the North Sea, namely for three days.' (TEL-DUR)

    c) ... *über die Nordsee, und zwar in drei Tagen.* 'over the North Sea, namely in three days.' (AMB-COMPL)

    d) ... *zur Nordsee, und zwar in drei Tagen.* 'to the North Sea, namely in three days.' (TEL-COMPL)

Reading times (RT) were measured at the noun of the directional PP and at the temporal adverbial. RT predictions of CA and UA differ considerably[3]: Regarding processing load at the PP, CA predicts that RT is higher for a telic PP than for an ambiguous (or unspecific) PP because the telic PP triggers an additive coercion of the activity verb. UA does not assume any kind of coercion, but rather a smooth integration of the telic PP with the interpretation of the verb, whose AC is underspecified. For durative temporal adverbials (TDA), CA and UA make the

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[3] As regards the full test sentences, the same holds for predictions of acceptability judgements. Just read '<' as 'less processing time' in the case of RT and as 'less concerns about acceptability' in the case of acceptability judgements. Note, however, that acceptability was judged only for complete sentences, so no acceptability ratings are available for the SUBJ-V-PP expression alone.

same RT predictions: When the adverbial modifies a telic VP, it triggers a coercion of the VP into an unbounded predicate (e.g., by way of an iterative reinterpretation) in order to resolve the AC conflict, so processing load should be higher than in the case of a VP which is not decidedly telic (atelic in CA, underspecified in UA), where no coercion is needed.

The theories differ, however, in the case of completive temporal adverbials (TSA): CA postulates a coercion when the adverbial modifies an atelic VP but no AC conflict and hence no coercion when the adverbial modifies a telic VP. As opposed to this, UA predicts that RT would not be impacted by the AC of the VP: Neither AC of the VP, telic or underspecified, is in conflict with the AC requirements of the adverbial.

CA predictions	
RT at N of PP	AMBx < TELx
RT at T-ADV	AMB-DUR < TEL-DUR
	TEL-COMPL < AMB-COMPL

UA predictions	
RT at N of PP	AMBx = TELx
RT at T-ADV	AMB-DUR < TEL-DUR
	TEL-COMPL = AMB-COMPL

Table 2: *Predictions derived from the Coercion Account (CA) and the Underspecification Account (UA)*

The experimental results reported by the authors add up to a strong case against CA:

Result R1: There were no RT effects of the PP, which contradicts the CA prediction but corroborates the UA prediction. This suggests that the formation of a telic/bounded VP by means of combining a standard motion verb with a telic directional PP should not be explained in terms of additive coercion, at least as long as the position is maintained, that proven additive coercion always causes observable processing load.

Result R2: Both RT and acceptability judgements suggest that subjects perceive an AC mismatch between a durative adverbial and a telic VP, as opposed to a non-telic (atelic or underspecified) VP. So the assumption AMB-DUR < TELD-UR, uniformly predicted by CA and UA, is clearly borne out by the test results. This shows that in the case of an AC clash between a temporal modifier and its argument, some costly coercion process may well be conjectured.

Result R3: No differences were observed when a completive adverbial (TSA) modifies a telic VP, as

compared with a VP which is not decidely telic. This contradicts the CA prediction TEL-COMPL < AMB-COMPL and underpins the UA prediction TEL-COMPL = AMB-COMPL. This finding can be considered a case for underspecification, because it can convincingly be explained if we assume that the AC of the verbs under consideration is underspecified and that adding an ambiguous PP leaves the AC underspecified until a temporal adverbial moves the AC of the expression into a specific direction.

In order to exclude the effect of a potential telicity bias of particular motion verbs, whether determined in the lexicon or just by language use (e.g., as the effect of frequency of occurrence), Lukassek et al. (2016) also performed a reanalysis of their data to explore the validity of the so-called Modified CA which would predict an effect of a verb's telic/atelic bias on processing durative and completive adverbials. On the basis of the results from a corpus study and a sentence completion task, the verbs used in their SPR study were divided into two subsets; one subset containing verbs with a strong bias for atelic uses and one containing verbs with a strong bias for telic uses. However, again no effect was observed in the RT data. The three results summarized here allow us to draw two important conclusions:

Conclusion C1: The concept of coercion appears to be a valid explanation of certain semantic phenomena, but it needs to be limited to cases were a semantic conflict, such as the clash of a verb's AC with aspectual requirements of its context, has to be resolved. These cases were outlined in section 3.3. The ways in which the interpretation of a particular linguistic item can be adjusted to contextual requirements are manifold, they differ in accessibility and acceptability, and they are far from being well understood. However, this non-compositional adaptation of an interpretation should be distinguished from compositional mechanisms where semantic properties of a VP or sentence are computed solely on the basis of the lexico-semantic properties of a verb and its complements, as in the case of a motion verb and its directional PP complement. Whenever necessary, we will henceforth call the former notion of coercion 'Type U Coercion' and the latter notion of (alleged) coercion 'Type D Coercion', alluding the distinction in Lukassek et al. (2016) between 'undisputed' and 'disputed' coercion.

Conclusion C2: To our mind, the results reported in Lukassek et al. provide the strongest empirical case so far in favour of aspectual underspecification of certain classes of verbs that we are aware of. Note, however, that an underspecification ac-

count would not necessarily be the only candidate for explaining result R1. The findings could likewise be explained in terms of a compositional semantics in the style of Krifka (1989a, 1989b, 1998), who assumes that verbs such as *to run* and *to write* are indeed atelic activity verbs (i.e. unbounded). They introduce an incremental event structure into the semantic representation to which the verbs complements can contribute a potential termination, as in *to run a mile*, *to run into the house*, *to write a book* (all bounded), or they can leave any termination open, as in *to run miles*, *to run through the jungle*, *to write books* (all unbounded). As long as there is no proof that Krifka-style composition implies additional processing effort, Krifka-style semantics would be an equal candidate for explaining result R1.

The case for underspecification becomes much stronger with result R3, though still not yet absolutely conclusive. In a Krifka-style semantics (note that Krifka himself does not make any assumptions about real-time processing!), one could argue that an aspectually ambiguous PP induces two alternative interpretations at the same time when it complements an atelic activity verb: Standard compositional operations would yield an atelic or telic interpretation of the VP, depending on the reading of the PP. So, in Lukassek et al.'s study, when subjects read the completive temporal adverbial, they just choose the compatible option, i.e. the telic interpretation. As long as there is no empirical proof that for the phenomena under consideration here[4], selecting from two alternative interpretations which come about by standard compositional principles inevitably, involves increased processing effort, Krifka-style semantics would still be a fair – albeit admittedly not the most plausible – candidate for explaining result R3, as well.

We conclude that in the absence of cogent results on processing implications of compositional mechanisms like the ones set forth by Krifka and others, underspecification is a strong, but not the only candidate for coping with the results in Lukassek et al. (2016).

In sum, the case for or against underspecification, to our mind, remains unsettled. On the one hand, Bott and colleagues present some evidence, mainly from English, against underspecification. However, while pointing out that several additional factors (factors not included in the lexical representation)

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4 We conjecture that empirical results about increased costs for processing structural or lexical ambiguities should not per se be seen as compelling evidence, because aspectual ambiguity appears to be quite different.

may play a role during the generation of an event representation, Bott does not completely rule out underspecification. On the other hand, Lukassek et al. (2016) present findings that are interpreted as a case for underspecification. However, as we have pointed out, there are alternative theoretical models that may allow to account for the results presented. As long as the processing implications of semantic models mainly derived from theoretical linguistic considerations are not fully understood, no pronounced judgement on the issue at hand can be made. We believe that one important step toward deciding the case for or against underspecification is to carefully embed linguistic theories in the present domain into psycholinguistic models of real-time processing. Thus, in the this project we place focus on both, empirical evidence and theoretical elaborations.

5 Defining Our Area of Research

Our research will initially focus on the assignment of AC in the domain of intransitive verbs of motion (IMV) plus their directional PP arguments. This field is well studied from a typological point of view (Talmy, 1983; Slobin, 2006; von Stutterheim et al., 2012; Flecken et al., 2015; Gerwien and Stutterheim, 2016). Cross-linguistic comparisons revealed manifold fine-grained semantic distinctions, which must be considered in theories on motion event construal. Significantly, a strong interrelation between space and time has been revealed (cf. von Stutterheim et al., 2016). Given this complexity, it is surprising that no systematic studies on AC interpretation have been performed specifically in this domain. Instead, IMVs were only used as examples for AC types among verbs from other domains. To the best of our knowledge, so far there is no systematic study of the aspectual impact of directional prepositions employing psycholinguistic methods.

The situation is quite similar in theoretical semantics: AC-related phenomena involving IMVs are in general treated within the broader context of a whole variety of different domains, and comprehensive studies of the AC contribution of directional PPs are rare. Notable exceptions are Maienborn (1990), Kaufmann (1995) and Zwarts (2005, 2008). For further references see Herweg (2014).

We will start by exploring the AC properties of those IMVs which are strong candidates for an underspecification account from a logico-semantic point of view. We will investigate user behaviour under controlled conditions in order to determine to what

extent empirical data underpin logico-semantic hypotheses about underspecification of the verbs' contribution to the AC of complex expressions in which they appear. If we indeed find such supporting evidence, the question arises whether underspecified IMVs form a homogeneous class or whether subjects show substantial tendencies regarding their preferred interpretation, placing some semantically underspecified verbs closer to the clearly bounded ones and others closer to the clearly unbounded ones, while possibly a subset of verbs may form the core of the underspecification spectrum.

If we find evidence for such graded AC representations in the mental lexicon, the impending task will be to identify the relevant semantic and conceptual factors that account for this diversification. To this end, the psycholinguistic approach will be complemented by corpus research, which will allow to look more closely into the contexts in which the respective items appear. From these corpus data, we expect to gain additional insights into the the inherent properties of the verbs in question.

This research program has implications for the theoretical and empirical framework. In particular, we need:

- a sufficiently rich format for representing AC and AC composition, including means to represent aspectual underspecification;

- a powerful integrated framework that allows to represent the presumably quite diverse factors that affect the semantic and conceptual interpretation of complex motion expressions, including typological variation;

- valid empirical methods for testing hypotheses derived from the framework.

5.1 Theoretical Starting Points

5.1.1 A Phase-Theoretical Account of Aspectual Classes

As the point of departure for the representation of AC and AC composition in the domain of motion expressions we will use the phase-theoretical framework outlined in Herweg (2014), which will be refined according to the results of our forthcoming research. This approach to the AC semantics of different types of motion verbs and directional prepositions receives its theoretical fundament in the phase-theoretical semantics of tense, aspect and temporal modification which was established in Löbner (1988, 1989) and

AC Contribution		Sentence AC: BOUNDED		
			⟶ CoS ⟶	
[BD: ingressive]	*in z*		< μ: ~INz ,	ω: INz >
[UNBD: process]	*längs y*		< μ: ALy >	
[underspecified]	*über x*	< α: \OVx ,	μ: OVx,	ω: \OVx >
[underspecified]	*eilen*	< α: \HURRY,	μ: HURRY,	ω: \HURRY >

Figure 1: *AC composition for sentence (3) using the phase array account (Herweg 2014). 'Φ:P' means that the (situation described by the) predicate P holds for the entire phase Φ ('Φ' is a variable ranging over phases α, μ, ω and 'P' is variable for predicates). 'Φ:~P' means that the negation of the predicate P holds for the phase and 'Φ:\P' means that it is underspecified whether the predicate P or its negation ~P holds for the phase Φ. 'OV', 'AL' and 'IN' are simplified representations of the predicates corresponding to the spatial relations 'over', 'along' and 'in'. 'BD' and 'UNBD' are short for 'bounded' and 'unbounded', resp., and 'CoS' indicates a change of state.*

expanded in Herweg (1990, 1991), Egg (1994, 1995), Egg and Herweg (1994), Kaufmann (1993, 1995), among others[5]. In this approach, various semantic properties of expressions of different categories are described in terms of characteristic arrangements of phases and operations on these. Phases in this sense are segments of a scale, i. e., convex partitions of any set with a linear ordering, which are characterized by the fact that a certain predicate holds for them. As a simple illustration, take the ingressive verb *to enter*: this verb states that there is a transition from a phase when the moving figure is not located in a specific region to a phase when s/he is in fact located in this region. The underlying scalar structure to which the localization predicate in question is applied in this case is a set of times.

To model AC and AC composition, Herweg (2014) introduced the notion of a Phase Array (PA). PAs are abstract tripartite structures $<\alpha, \mu, \omega>$ consisting of an initial phase α, an intermediate phase μ, and a final phase ω. PAs serve to model both static and dynamic situations. The segments of a PA can be related to multi-layered conceptual dimensions such as time, changing positions in space, developmental stages of processes and events and the involved incremental and decremental objects, which yield the dynamic elements of the represented concepts (cf. Herweg and Gerwien, 2016).

By way of illustration, Figure 1 shows how the AC composition of a complex motion expression like (3) is captured in terms of PAs.

(3) *Max eilte über den Hof längs der Fahrradständer ins Bunsen-Gebäude.* 'Max hurried across the yard along the bicycle stands into the Bunsen-Building'

It is assumed that the AC of the German IMV *eilen* 'to hurry' is underspecified, as is the directional preposition *über* 'over'/'across'. The prepositions *aus* 'out of' and *in* 'into' are bounded (BD), more specifically egressive and ingressive, resp., whereas *längs* 'along' is unbounded (UNBD), i.e. process-like in the context of motion (for details see Herweg, 2014).

In this analysis as displayed in Figure 1, the PAs that represent the AC contribution of the individual items are combined via unification. The VP *über den Hof eilen* 'to hurry over/across the yard' is underspecified; only the addition of an egressive or ingressive PP (or both) results in a bounded AC for the entire clause.

This approach to AC, with its crucial notion of underspecification, decidedly refrains from any application of what we called 'Type D Coercion' in section 4.2. However, Herweg (2014) – as well as Herweg (1990, 1991) – utilizes different instances of what we called 'Type U Coercion' to quite some extent, but does not go into any substantial detail. In particular, barring some rather informal considerations, there is no advanced theory of what kinds of coercion – like ingressive (*The plate lay on the table in two seconds*) and holistic/intergressive (*The plate lay on the table three times this morning*) – are typically licensed in a specific context. To our knowledge, a comprehensive theory of the scope of and constraints on type U coercion is still a desideratum.

[5] In addition to these references, see Löbner (2011) for an overview of linguistic phenomena to which he applies his phase-theoretical notion of phase quantification.

5.1.2 Psycholinguistic Cornerstones

Psycholinguistic accounts differ with respect to how form is assumed to be mapped onto meaning and vice versa. While in most theories no difference is explicitly made between a semantic and a conceptual layer (e.g., Jackendoff, 1983), other approaches distinguish between two levels of representation (2-level-model, cf. Bierwisch and Schreuder, 1992; Gerwien, 2015)[6], highlighting the interface character of what is traditionally considered semantics.

In our view, it is this latter theoretical stance that offers some advantages in the study of aspectual class composition. First, it allows to assume some universal characteristics of how humans represent objects and events in space and time on the conceptual layer while it leaves room for typological variation on the semantic level. At the same time the possibility is not excluded that experience with language over time (frequent use of specific semantic structures) may shape specifications on the conceptual level. Second, the 2-level-approach makes it possible to commit to precise hypotheses about (a) what information is in the mental lexicon, and thus primarily linguistic, (b) what information comes from (non-)linguistic context and (c) what information is computed online during the integration of all information available in a given situation. Third, to our mind, a 2-level-approach offers the best potential to develop a theory that is capable of explaining event representation and event encoding, in both, language production and language comprehension.

We assume that the representation at the conceptual level roughly corresponds to what is elsewhere labelled "situation model" (Johnson-Laird, 1983) or "event model" (Radvansky and Zacks, 2011), that is a multimodal unit of cognitive processing inherently greater than what can be expressed by one single word. In language comprehension, for example, single units or complex structures on the semantic level activate such event models as a whole, and, most importantly, profile this model, i.e., specific aspects of the event model may be highlighted, while others can be defocused.

With respect to the nature of the real-time processes involved in mapping form onto meaning and vice versa, as a starting point, we choose a highly incremental approach that makes use of prediction (cf. Altmann and Mirković, 2009). From this it follows that every piece of information is used as soon

as it becomes available and that the cognitive system, if necessary, calculates preferred and alternative representations which are evaluated on the basis of probability values. If online integration of information fails, probability values for the preferred commitment decrease and probability values for an alternative increase. Prediction helps to maintain speed.

Given these theoretical consideration, our main goals from a psycholinguistic perspective are:

- Derive the format and characteristics of the conceptual structure(s) underlying motion events from empirical findings in both, verbal and nonverbal event cognition.

- Develop hypotheses and methods to test how semantic specification (and underspecification) in the lexicon, combinatorial rules in the grammar, and context interact with conceptual structure, thereby acknowledging the dynamics, i.e. the incremental nature, of the processes involved.

- As a long-term goal, develop a cognitive model that captures motion event interpretation, as well as motion event encoding. One possible first step in this regard is to investigate cases which appear as requiring accommodation from the perspective of language production.

5.2 Terminology

Our approach brings together theoretical concepts in the field of formal semantics and cognitive science. Because we wish to work out a theory that is useful in both domains, we will delineate here the terminology that we will use in our subsequent work. The following specification serves to obviate potential confusion due to the frequent usage of the same terms to designate different things in the two fields. We think that a proper level of terminological clarity is required for a model at the interface of formal semantics and cognitive science to achieve a satisfying degree of descriptive and predictive power.

Levels of Representation

Lexical semantic information: This term refers to abstract word meanings in the mental lexicon which are representational invariants in the sense that they are stable to changing contextual conditions. Lexical semantic information concerns structural and content meaning. Con tent meaning is information which relates to qualitative properties that can be

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[6] see Bierwisch (1989), Lang (1989), Herweg (1990, 1991), Lang and Maienborn (2011) for the perspective of theoretical linguistics
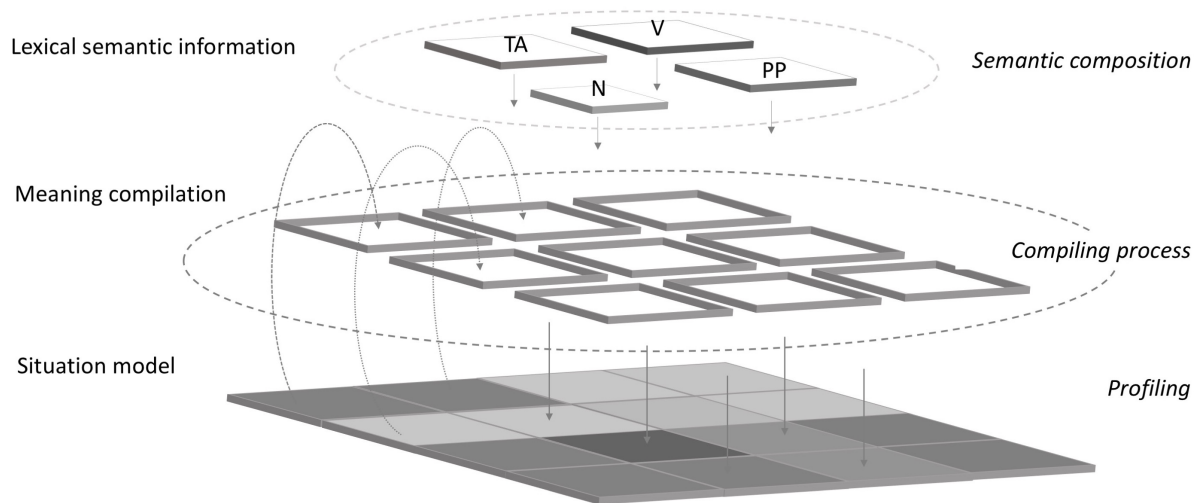
Figure 2: *Major representational levels and processes in the current approach. N, V, PP, and TA refer to lexical elements, where TA means time adverbial of any kind. Arrows going upward from the situation model to the meaning compilation illustrate that event and situation knowledge can impact the compiling process. Arrows going down from the meaning compilation to the situation model illustrate profiling.*

used to describe extralinguistic entities. Structural meaning relates to all dimensions by which content meaning is structured within each lexical unit. These dimensions cover temporal characteristics - therefore AC specifications can be considered as structural meaning -, as well as causal characteristics. This view is inspired by Klein's Argument-Time-Structure approach to verb semantics (cf. Klein, 1999; Gerwien, 2011).

Conceptual information: We use this term to refer to information from the conceptual system that contributes to the constitution of meaning in a particular situation, but is not directly provided by word meanings as they are specified in the lexicon (i.e., lexical semantic information in the above sense). Relevant conceptual information comprises of general world knowledge and experience as well as elements of the utterance situation, assumptions about mental attitudes such as intentions and emotions, etc.

A meaning compilation: A meaning compilation is the result of processing both types of information mentioned above. We will use an approach in the spirit of frame semantics to capture the content of this representation. The input of a meaning compilation is both linguistic and non-linguistic information. A compilation in its ultimate state corresponds to all meaning information triggered during processing a sentence. It is constructed in real time, and hence

this representation must account for the dynamics of the compiling process (see below). One characteristic of a meaning compilation is that it feeds into a situation model, but that in turn the situation model also provides information that is processed during the compiling process. We assume that in discourses consisting of multiple utterances meaning compilations are transient in the sense that they are not held in short term memory over a particularly long period of time.

A situation model: A situation model is a multi-modal representation of some (potentially complex) state of affairs. It is first activated and then shaped a meaning compilation. However, situation models may include way more information than only the sum of all information provided by associated compilations. We assume that situation models play an important role in providing key information during the compiling process, because it is only through situation models that relevant world knowledge is retrieved from long-term memory.

Operations and Processes

Semantic composition: Semantic composition is a technical term that is used to analyze and describe the generation of complex semantic units exclusively on the basis of the meanings of the involved words and the way in which these are syntactically com-

bined. We thus use this term in the way it is defined in formal semantics; it is not meant to refer to anything that concerns cognitive real-time processing.

Non-compositional semantic mechanisms: The term Non-compositional semantic mechanisms is used to analyze and describe combinatorial semantic operations that cannot be explained by semantic composition in the above sense alone. The term refers to semantic operations that depend on additional elements beyond pure lexical meanings and their syntactically driven combination in order to fit together lexical and phrasal meanings when producing complex semantic representations.

Compiling: This term will be used to generally refer to all cognitive online processes that we assume are at play during the construction of a complex representation of the meaning of a single sentence (see also above, compilation). Compiling includes the retrieval of lexical semantic information, cognitive correlates of semantic composition and non-compositional semantic operations and the integration of conceptual information as provided top-down by the situation model. Also, compiling covers all other technical terms that relate to dynamic aspects of the frame-like representational format that will be thoroughly introduced at a later point in this project.

Profiling: Profiling will be used as the term that refers to the process by which a meaning compilation shapes, or modulates, the current situation model (over time) by means of highlighting or defocusing certain elements.

5.3 Synopsis and Outlook

In this project we aim at providing a comprehensive theory for Aspectual Class composition in the domain of motion events. As is apparent from the outline above, we focus on both, the semantic specifications of the relevant lexical elements in the mental lexicon, as well as the dynamics of the mapping process from form to meaning and vice versa. Given the complex nature of the topic under investigation this inherently requires cycling through systematic exploration, modeling, and testing, and presumably re-modeling.

We will start by exploring the possibility that most intransitive motion verbs in German are aspectually underspecified in the mental lexicon, but that underspecification does not rule out the existence of verb-specific preferences for bounded/unbounded interpretations. Thus, our first step is to develop and apply a method that allows us to draw conclusions concerning this issue. If, as we expect, gradual differences between the verbs along the two dimension (bounded/unbounded) can be detected, we may conclude that previously unconsidered factors are at play determining the preferences. Potential findings of this exploration will then allow us to derive the first version of our model. On the basis of this model we will formulate hypothesis for testing.

If results indeed suggest underspecification we may in parallel start to explore the cognitive component of our theory. As a first step in this direction we plan to evaluate what characteristics must be assumed with regard to mapping from the semantic to the conceptual level and vice versa. To this end, we will use the same semantic representations in two different sequences of trials which allow us to test whether, or not different event models can be triggered by pre-activation.

Furthermore, since we assume incremental processing, as well as prediction we will start to test this by comparing real-time processing in different contexts. These contexts will differ with respect to the point in time at which semantic information becomes available for the compiling process; i.e., a manipulation of word order.

It is our aim to capture the findings of the project in an integrated framework that is both cognitively motivated and formally well-defined. To this end we will utilize an extended frame-theoretical format, FAMEu ("A Frame-Semantic Account of Motion Expressions with Underspecification"). The basic design of FAMEu is in the spirit of the Barsalou-Duesseldorf frame approach (cf. Barsalou, 1992; Löbner, 2013; Gamerschlag et al., 2014). For the purposes of the present project, this elaborate approach is enhanced in FAMEu, inter alia, with an extended concept of profiling (cf. Gawron, 2011; Langacker, 2013), a representation of AC in terms of phase-theoretical semantics (cf. Herweg, 2014), a dynamic semantics for frame elements based on notions from Dynamic Logic, in particular Dynamic Interval Temporal Logic (DITL, cf. Pustejovsky and Moszkowicz, 2011; Mani and Pustejovsky, 2012), and an assignment of weights to frame elements, plus a mechanism that allows to propagate weights among different frame elements. Weight propagation and weight shifting are the technical means that will be utilized to model those factors that, as per our experimental findings, may induce particular interpretation preferences under specific circumstances, as well as semantically induced effects on profiling.

We hypothesize that the expressive power of frames facilitates representing a whole variety of elements

that may have an impact on the interpretation of motion expressions, such as the nature of moving entities and reference objects (Figure and Ground; cf. Talmy, 1983), various kinds of manners performed and forces exerted in the execution of motion, multifaceted properties of paths, etc. Finally, over and above these pivotal features, we consider frames to be perfectly suited to capture cross-linguistic variation in the expression of motion in an integrated format.

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