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Temporal anaphora across and inside sentences: The function of participles*

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Abstract The paper offers a formal account of the discourse behaviour of participles, which to some extent behave like main clauses in having semantically undetermined relations to their matrix clause, but which should nevertheless be integrated into the compositional semantics of complex sentences. The theory is developed on the basis of Ancient Greek participles and offers an account of their syntax, semantics and discourse behaviour (focusing on the temporal dimension of discourse), integrating Lexical-Functional Grammar, Compositional DRT and Segmented DRT using Glue semantics.

Keywords: participles; discourse; aspect; temporal anaphora; Ancient Greek; LFG; DRT; Glue semantics

1 Introduction

Compare (1a) to (1c):

(1) a. Joseph turned around. He shot Mike.
b. After Joseph had turned around, he shot Mike.
c. Turning around, Joseph shot Mike.

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The three minidiscourses in (1) have the same interpretation: there is an event[1] of Joseph turning around, which is followed by a shooting event by Joseph in which Mike is shot. Nevertheless, the ways in which we get to this interpretation differ. In (1a) the interpretation that the shooting follows the turning around is a discourse phenomenon. Loosely following the framework of Segmented Discourse Representation Theory (SDRT) (Asher & Lascarides 2003), the interpreter of (1a) is supposed to reason along the following lines: For the discourse to be coherent, there has to be some discourse relation between the first and the second sentence. By default, he infers the relation *Narration*. If the discourse relation of *Narration* holds between two sentences, the event expressed by the second sentence follows the event expressed by the first sentence. Therefore, in (1a) the shooting follows the turning around. In (1b), on the other hand, the relation of succession is explicitly given with the word *after*. What about (1c)? As we will see, participles are on the one hand like main clauses and on the other hand like temporal subordinate clauses.

Participles are like main clauses in that discourse relations can be semantically undetermined (Stump 1985: chapter 6). In that case the relation is inferred on the basis of world knowledge, among other things. Participial clauses may, for example, provide the reason (as in (2a)) or the manner (as in (2b)) for the event described in the main clause:

(2) a. Not knowing where to go, he sat for a rest.
b. He opened the envelope using his thumb.

There are, however, also differences between a sequence of main clauses and a combination of a participial clause and a main clause. For one thing, the range of possible discourse relations differs:

(3) a. Max had a great evening yesterday. He had a great meal.
b. # Having had a great evening yesterday, Max had a great meal.
c. # Having a great evening yesterday, Max had a great meal.

The second sentence in (3a) provides more detail about the event in the first sentence: in SDRT terms, the second sentence attaches to the first one via the discourse relation of *Elaboration*. By contrast, the minidiscourses with (perfect and present) participial clauses in (3b) and (3c) are odd (at least in the intended reading, identical to (3a)), since the verb of a main clause cannot elaborate on a participle.

1 In this article we use *event* in a broad sense, including states, activities et cetera.

Moreover, the two constructions differ in what can function as the antecedent of a discourse relation. This is illustrated in (4):

(4) a. Max bought a new bike. He had seen it in the newspaper. He paid 300 euros for it.
b. # Max bought a new bike. Having seen it in the newspaper, he paid 300 euros for it.
c. # Max bought a new bike. When he saw it in the newspaper, he paid 300 euros for it.

(4a) shows that with a sequence of main clauses the antecedent of a discourse relation need not be provided by the sentence that is immediately preceding. In (4a) the third sentence elaborates on the buying of the bike described in the first sentence, "skipping over" the sentence in between. As (4b) shows, participial clauses can not be skipped over. The reason why (4b) is odd is exactly that we are forced to infer a discourse relation between the paying of 300 euros and the seeing of the bike in the newspaper, an inference that world knowledge does not support. In this respect participial clauses are more like temporal subordinate clauses. They cannot be skipped over either, as (4c) shows.

The fact that participles stand midway between main clauses and temporal subordinate clauses forms a challenge for linguistic theory. In the case of participles, we will see that phenomena like narrative progression that are normally thought of as occurring at the level of discourse turn out to have tight connections with syntax, information structure and semantics. In this paper we offer an account of participles that gives a formal model of the way in which these layers interact.

In order to offer a model of the interaction between layers, we need formal models of the layers themselves. For syntax there are several options on offer — we have chosen Lexical-Functional grammar (see section 3.1) which offers a formally precise and mathematically simple, declarative syntactic language. For semantics there are also many options, whereas information structure and discourse are notoriously difficult fields in formal linguistics. However, in the domain of information structure we will only need the notion of new versus given (anaphoric) information.

While anaphoricity in the nominal domain is often encoded through lexical and/or morphological material such as pronouns, articles and definiteness inflection, verbal anaphoricity typically gets a syntactic realization, namely fronting:

(5) Zipser's lack of sexual experience prevented him from formulating at all clearly what he would do then. Well, he would copulate with her. *Having arrived* at this neat if somewhat abstract conclusion he felt better. (example from Kortmann 1991: 2)

The participial adjunct *having arrived* picks up the arrival at a conclusion which is implicit in the previous sentence. For our purposes, this can be adequately dealt with in a dynamic semantics which allows discourse referents referring to events and times as well as to ordinary cabbages and kings-type individuals. For the reasons set forth in section 3.2, we have chosen Compositional DRT (CDRT) as our dynamic semantic framework.

For concreteness, our approach to discourse semantics loosely follows SDRT in its combination of dynamic semantics and discourse structure. SDRT is practical for our purposes since it commonly uses DRT as the semantic representation language (although it does not commit itself to DRT's particular version of dynamic semantics); but we do not attempt a formalization of our ideas in the SDRT language, confining ourselves instead to noting (in section 3.2) how our formalizations of tense and aspect in CDRT can partly be thought of as simplifications of corresponding SDRT constructs. On the other hand, there is also a sense in which our semantics of aspect is irreducibly more complex than what is usually assumed in SDRT: specifically, we follow Klein (1994) and others in claiming that aspect is a relation between event times and topic times, rather than just a cue for inferring discourse relations. We argue in section 4.5 that such an approach is in fact needed for Ancient Greek.

Besides the issue of aspectual semantics, there are some more practical reasons to avoid a full-fledged formalization of discourse. First, we wish to remain agnostic about the language of such a formalization. The details of the discourse theory are not important for us and it is likely that, e.g., Rhetorical Structure Theory (Mann & Thompson 1986) would be just as adequate, as we do not make specific assumptions about controversial issues such as whether discourse structures should form trees or not.

Second, there is a certain tension between SDRT and CDRT when it comes to DRS construction. SDRT deals with relations between elementary discourse units (EDUs), which are roughly pieces of discourse that describe a single event — whether these are expressed by main clauses, subordinate clauses or even PPs such as *after the meeting*. Discourse effects are then modeled as semantic consequences of relations which arise from non-monotonic

Linguistic level	Framework
Syntax	Lexical-Functional Grammar
Semantics	Compositional DRT
Anaphoricity	Compositional DRT
Discourse	SDRT (loosely)

Table 1 Frameworks for the various linguistic levels

reasoning over EDUs. This means that in SDRT a single sentence can give rise to multiple DRSs (or formulae of another dynamic language), whereas CDRT assumes that the output of a single sentence is a single (though possibly complex) DRS.

It would be possible to alter CDRT in order to have the outcome of the semantic composition be not a single DRS, but an ordered list of DRSs, which would serve as input representations of EDUs to the discourse reasoning. This could be the right approach for cases where the discourse relation between same-sentence EDUs is as underspecified as between two sentences.

However, our claim is that discourse effects that we find with participles are much more constrained than what we find between main clauses. They are to a strong degree *grammaticalized* versions of SDRT's discourse relations, so that they should be represented in the compositional semantics. To deal with this, we will assume that such grammaticalized discourse relations are constructions with their own meaning, bringing into the semantic derivation lambda terms which have much the same semantic effects on the intrasentential semantics as SDRT's relations have between EDUs. However, in order not to complicate matters too much, we model discourse relations only in so far as the temporal dimension is concerned.

Although we build on already existing frameworks for syntax, semantics, information structure and discourse (as summarised in Table 1), there is as of yet no theory that integrates all these frameworks. In interpreting participles, however, the main challenge is exactly the modelling of this interaction which, as it turns out, is not at all trivial. To achieve it we use Glue semantics (Dalrymple 1999) which is based on linear logic (Girard 1987) as a "glue logic" which can bring together information from different sources in the compositional semantics.

Glue semantics and CDRT have been combined before (van Genabith & Crouch 1999), but mostly with a focus on the formalism and the relationship to UDRT (Reyle 1993). Event semantics have also been developed within the

Glue framework, but always in a static setting (e.g., Fry 2005, Haug 2008). To our knowledge this is the first attempt to develop the combination of Glue and dynamic event semantics in such a way as to enable an extensive account of how events relate to each other inside and across sentences, drawing also on insights about how to model constructional meaning in Glue semantics (Asudeh, Dalrymple & Toivonen 2008).

We illustrate the framework with the interpretation of participles in Ancient Greek. In this language participles are particularly important in structuring the discourse and they clearly show the need for such a unified framework. Its usefulness is however not restricted to Ancient Greek, nor to participles. The developed framework makes it possible to relate four issues that are at the heart of formal semantics and pragmatics: clause linkage, temporal anaphora, narrative progression (which, as we will see, is also connected with the interpretation of aspect), and interactions between information structure, word order and semantics. This combination is arguably also needed to model the interpretation of participles and discourse structuring devices in other languages. As such it contributes to the understanding of the temporal interpretation of a discourse in general.

In section 2 we present some background on Ancient Greek and the way its participles work. Section 3 is then devoted to the development of the framework. Equipped with the necessary tools, we offer a formal analysis in section 4. Finally, some conclusions follow in section 5.

2 Ancient Greek and its participles

In section 2.1 we give some basic background on Ancient Greek and its participle system. Section 2.2 offers a more in-depth view of the various functions of predicative participles and can be skipped by readers who are primarily interested in the workings of the formal system (and are willing to take our word on the Ancient Greek facts).

2.1 Basic facts about Ancient Greek

Ancient Greek (AG) is a "free word order" language, where all permutations of the major constituents are found with some frequency, and phrases can be discontinuous. The word order is obviously influenced by information structure, and as we shall see in this paper, information structure constrains where in the sentence participles appear.

AG has a fairly complex morphology to support this freedom of word order: all nominals are marked for case and number, and gender is indicated on adjectives and articles. In the verbal domain, forms are inflected for tense, aspect, mood, person, number and voice.

AG has three aspects: perfective aspect (called aoristic aspect), imperfective aspect (called present aspect) and perfect aspect. This aspectual distinction is found throughout the verb paradigm, also with participles. Aspect is clearly distinguished from tense. The only forms that have tense morphemes are the forms of the indicative.[2] This means that participles have aspect, but not tense. Furthermore, they inflect for the verbal category of voice (active, passive and middle) and the nominal categories of case, gender and number.

AG participles can be used as attributes (*the running boy*), heads in argument position (*the running (ones)*), complements (*stop running*) and as free adjuncts, the usage we focus on here. The latter come in two types, conjunct participles, which share their subject with a participant in the matrix (typically the subject, but sometimes the object or even an oblique argument), with which they agree in case, gender and number; and absolute participles, whose subject is not present in the matrix clause. In the latter case, both the participle and the subject appear in the genitive.

(6) shows a Greek sentence with five participles, which is not uncommon. The participles as well as their English translation equivalents are set in bold face. The first two participles in (6) are examples of absolutes, the third is a head functioning as the complement of the adjective *antiên*, and the last two are conjunct participles.[3]

(6) ***siôpôntôn*** *de tôn allôn Perseôn kai ou* ***tolmôntôn*** *gnômên apodeiknusthai antiên têi* ***prokeimenêi****, Artabanos ho Hystaspeos, patrôs* ***eôn*** *Xerxêi, tôi dê kai pisunos* ***eôn*** *elege tade: …*

When the rest of the Persians **held their peace** and didn't **dare** to utter any opinion contrary to **what had been put forward**, Artabanus, the son of Hystaspes, **being** Xerxes' uncle and **relying** on him, said the following: … (Hdt. 7.10.1)

2 An exception here is the future, which exists in infinitives and participles, reflecting the fact that it is not a pure tense. Future participles typically express intention, and will not be central to our discussion here.

3 References use the abbreviations from Liddell, Scott & Jones 1940.

Ancient Greek participles show very clear connections between syntax, information structure and semantics. Used as free adjuncts, they can have three functions. We now briefly present these functions, which will be given a fuller treatment in section 2.2. A participle may function as an *elaboration* as in (7):[4]

(7) *grammata graphousi kai logizontai psêphoisi*
letters.ACC write.PRS.3PL and calculate.PRS.3PL stones.DAT
Hellênes men apo tôn aristerôn epi ta dexia
Greeks.NOM PRT from the.GEN left.GEN to the.ACC right.ACC
pherontes *tên kheira, Aiguptioi de apo*
moving.IPFV.PTCP the.ACC hand.ACC Egyptians.NOM PRT from
tôn dexiôn epi ta aristera
the.GEN right.GEN to the.ACC left.ACC
The Greeks write letters and calculate with stones by **moving** the hand from left to right, whereas the Egyptians (do so) from right to left (Hdt. 2.36.4)

Here the participial clause *apo tôn aristerôn epi ta dexia pherontes tên kheira* 'moving the hand from left to right' provides more information about the writing and calculating events described in the main clause. This is typical for participles in this function.

Participles may also function as *frames*, as in (8):

(8) (Alyattes died. Description of something he did during his life.) ...
Teleutêsantos *de Aluatteô exedexato tên*
dying.PFV.PTCP.GEN PRT Alyattes.GEN receive.PST.PFV.3SG the.ACC
basilêiên Kroisos
reign.ACC Croesus.NOM
After Alyattes **died** Croesus received the reign. (Hdt. 1.26.1)

The participle (*teleutêsantos* 'having died') provides the temporal anchor for the interpretation of the event in the main clause. Finally, Ancient Greek has participles where other languages like English would use a finite, coordinated clause. Examples are given in (9):

4 The glossing follows the Leipzig glossing rules, but often omits details that are not important in the context and uses 'PRT' for particles. In the examples, the participles that are relevant in the context and their English translations are set in bold face.

(9) a. ***dramôn*** *de* *tis* *kai* ***gemisas***
running.PFV.PTCP.NOM PRT some.NOM and filling.PFV.PTCP.NOM
spoggon *oxous* ***peritheis*** *kalamôi*
sponge.ACC vinegar.GEN putting.PFV.PTCP.NOM stick.DAT
epotizen *auton* *legôn:*
give-to-drink.PST.IPFV.3SG him.ACC saying.IPFV.PTCP.NOM
Someone **ran** and **filled** a sponge with sour wine, **put** it on a stick, and gave him a drink, saying … (Mk. 15:36)

b. *theleis* *oun* ***apelthontes*** *sullexômen*
want.PRS.2SG so walking-away.PFV.PTCP.NOM collect.PFV.SBJ.1PL
auta
them.ACC
Do you want that we **go away** and collect them? (Mt. 13:28)

Here the participles are elementary discourse units which express new information. On the discourse level, these are coordinated rather than subordinated with the EDU containing the matrix verb. Furthermore, the participles are interpreted within the same embedding (if there is one, as in (9b)) as the finite verb. We will refer to these participles as *independent rhemes*.

2.2 Classification of participles

In this section we will present the classification of participles into three groups in more detail and discuss how they differ from each other in four parameters, information structure (given vs. new information), the relation to embeddings such as mood, negation, etc., the temporal interpretation and discourse structure.

2.2.1 Elaborations

Elaborations are participles which provide more information about the matrix event. In discourse terms, they are subordinate to their matrix clause and would attach to it via a subordinating discourse relation:[5]

5 These examples also show that the participle can constitute the sole focus domain of their matrix clause, an interesting fact which we will not pursue further here.

(10) *autên* *tênde* *elabomen* *ou*
her.ACC this.ACC obtain.PST.PFV.1PL not
biasamenoi
using-violence.PFV.PTCP.NOM
We have obtained this very (empire) without **using violence.** (Thuc. I.75.2)

(11) *ti* … ***dediotes*** *sphodra* *houtôs*
what.ACC fearing.PRF.PTCP.NOM very thus
epeigesthe
to-be-in-a-hurry.PRS.2PL
Fearing what are you in such a hurry? (Xen. Hell. I.7.26)

The type of discourse subordination induced by elaborating participles makes them temporally dependent on their matrix verb: the not using of violence in (10) and the fearing in (11) are events that held throughout the matrix events of obtaining and hasting.[6] To see how this works, compare (12) with the constructed example (13).[7]

(12) *eipe* *de* ***meidêsas*** …
say.PST.PFV.3SG PRT smiling.PFV.PTCP.NOM
He said **smiling** … (Ant. Gr. 12.126.3)

(13) *eipe.* *emeidese.*
say.PST.PFV.3SG smile.PST.PFV.3SG
…he said. He smiled.

The subordination of the participle to the matrix clause in (12) has the effect of enforcing a reading where the participle is temporally dependent on the matrix verb. By contrast, the interpretation is freer in (13): a co-temporal reading is still possible, but so is a sequential reading. In main clauses, then, the temporal interpretation relies on an interpretation of the context,

6 Notice that in terms of discourse structure, this means that it is not enough to say that an elaborating participle attaches to its matrix via just any subordinating relation, since there are subordinating relations which do not imply temporal overlap, such as *Consequence*. Elaboration in our sense must put constraints on the actual subordinating relation, but we refrain from being more specific, as this would lead us into details of discourse theory.

7 Obviously, we are extrapolating from the interpretation of attested Ancient Greek sentences here. Moreover, to be proper Ancient Greek, this sentence would probably need a connective particle, which would possibly provide cues for the correct interpretation of the temporal sequence.

whereas an elaborating participle, on the other hand, never interacts with the context, but just picks up the event time of the matrix verb.

As a consequence of being temporally dependent on the matrix verbs, elaborations cannot have their own temporal adverbials, at least so far as it is possible to see from the data in a dead language.[8]

A further consequence of the integration is that elaborating participles are modally dependent on their matrix verb. If the matrix is imperative, the participle is interpreted as part of the command:

(14) *sôson* *seauton* ***katabas*** *apo*
save.PFV.IMP.2SG yourself.ACC going-down.PFV.PTCP.NOM from
tou *staurou*
the.GEN cross.GEN
Save yourself (by) **going down** from the cross. (Mk. 15:30)

Finally, elaboration participles do not provide a new temporal anchor which can be picked up in the following discourse. This effect is similar to, but stronger than, the right frontier constraint in SDRT (Afantenos & Asher 2010), which says that a new discourse unit must attach to the last discourse unit in the previous discourse, or to a unit which dominates the last discourse unit. With elaborating participles it is as if the discourse moves from the matrix down to the elaborating participle and up again, thus closing that branch of discourse.

2.2.2 Frames

Framing participles are anaphoric in the wide sense of either referring to events that have been mentioned in the previous discourse (15), or to events that are easily inferred (16).

(15) *ebouleusan* *...* *Kuaxarêi* *dounai* *...,*
decide.PST.PFV.3PL Kuaxares.DAT give.PFV.INF
dontes *de* *tên* *takhistên* *komizesthai* *para*
giving.PFV.PTCP.NOM PRT the.ACC rapidest.ACC travel.IPFV.INF to
Aluattên
Alyattes.ACC

8 A possible exception is the adverb *hama* ‘at the same time’. But it is possible to see this not as a temporal adverb, but rather a particle specifying the adverbial function of accompanying circumstances.

They decided to give (this) to Kuaxeres and, once they **had given** it, to travel to Alyattes as rapidly as possible (Hdt. 1.73.5)

(16) (Jesus heals a woman)

kai	***paragonti***	*ekeithen*	*tôi*	*Iêsou*
and	going.IPFV.PTCP.DAT	thence	the.DAT	Jesus.DAT

êkolouthêsan	*autôi*	*duo*	*tuphloi*
follow.PST.PFV.3PL	him.DAT	two.NOM	blind.NOM

As Jesus **walked** from there, two blind men followed him. (Mt. 9:27)[9]

In the latter example, there is no explicit mention of Jesus setting off from the location where he healed the woman, but we easily bridge this gap and infer a motion event.

Anaphoric, framing participles behave like presuppositions in projecting from embeddings like negation, mood etc. as we see in (17) and (18).

(17)

mête	***nikôn***	*amphadên*	*agalleo,*
not	winning.IPFV.PTCP.NOM	publicly	boast.IPFV.IMP.MED.2SG

mête	***nikêtheis***	*en*	*oikôi*	*...*
not	being won over.PFV.PASS.PTCP.NOM	in	house.DAT	

odureo
lament.IPFV.IMP.MED.2SG

Do not boast publicly when you **win**, nor lament at home when you **lose**. (Archil. 128.4)

(18) (Demosthenes sets out to attack a city, bringing masons, carpenters, arrows and ...)

hosa	*edei*	*ên*	*kratôsi*
REL.ACC	be-necessary.PST.IPFV.3SG	if	win.PFV.SBJ.3PL

teikhizontas	*ekhein*
building-fortifications.PFV.PTCP.ACC	have.IPFV.INF

everything else they would need to have when **building fortifications** if they should be victorious. (Thuc. 7.43.2)

The winning in (17) is not interpreted as part of the command ('Don't win and boast publicly'), nor is the losing. Similarly, the building in (18) is not interpreted under 'need' (which would yield the strange 'things which you need to build fortifications and have'). Contrast these examples with ones like (20)-(22) below, where the participle does not project out of mood or negation.

9 Notice the 'resumption' of Jesus by a dative pronoun in the matrix clause.

Although always anaphoric, framing participles can nevertheless be focused and serve as constrative frames, as example (17) shows. But even if contrastive, the participles in (17) are predictable in their context, which is a poem about war. Similarly in (18), the mention of masons and carpenters, as well as domain knowledge that capture of a city is often followed by (re-)fortification, makes the event denoted by the participle inferable.

Temporally, frames depend on the context for their own temporal reference since they refer to events that are either previously mentioned or easily inferable. Their anaphoric nature enables them to set the stage for and so provide temporal anchoring for the matrix event.[10]

(19) = (8) (Alyattes died. Description of something he did during his life.)

Teleutêsantos	*de*	*Aluatteô*	*exedexato*	*tên*
dying.PFV.PTCP.GEN	PRT	Alyattes.GEN	receive.PST.PFV.3SG	the.ACC
basilêiên	*Kroisos*			
reign.ACC	Croesus.NOM			

After Alyattes **died** Croesus received the reign.

Here, the dying of Alyattes does not introduce a new time into the discourse: this event has already been mentioned and placed in the narrative sequence. On the other hand, Alyattes' death does serve to locate in time the event of Croesus receiving the reign. Specifically, it does this by moving the narration forward so that we understand the matrix event takes place (just) after the adjunct event. This narrative progression is associated with perfective aspect and is not present in (18), which has an imperfective participle; we return to this in section 3.2.

2.2.3 Independent rhemes

Independent rhemes are perhaps the most foreign usage of participles from the perspective of modern European languages. These are participles which present information that is new, just like main verbs, but unlike elaborations they are not discourse subordinated to their matrix, but rather coordinated and interpreted within the same embedding as the main verb:

10 In this they are similar to *stage topics* or *frame setters*, which provide "the frame in which the following expression should be interpreted" (Krifka 2008: 269).

(20) *alla moi dokei* ***stantas*** *enthade . . .*
but me.DAT seem.PRS.3SG staying.PFV.PTCP.ACC here
auton ekkalein
him.ACC call-out.IPFV.INF
But I think we should **stay** here and call him out. (Aristoph. Wasps 271)

(21) *apaggeilate moi, opôs kagô* ***elthôn***
tell.PFV.IMP.2PL me.DAT, so-that I-too going.PFV.PTCP.NOM
proskunêsô autôi
adore.PFV.SBJ.1SG him.DAT
Tell me, so that I too can **go** there and adore him. (Mt. 2:8)

(22) ***egertheis*** *paralabe to paidion*
waking-up.PFV.PTCP.NOM take.PFV.IMP.2SG the.ACC child.ACC
Wake up and take the child with you (Mt. 2:13)

Such independent rheme participles are typically translated (as above) by coordinations in English. In many cases it is simply not possible to use a participle in English:

(23) *I think we should staying here call him out.

or the participle will have to be detached to the right, which seems to have much the same effect in English as independent rhemes do in Greek:

(24) I think we should call him out, staying here.

But this linearization has effects on the temporal structure, which makes (25) impossible as an attempted translation of (21).

(25) ?? . . . so that I too can adore him, going there.

Finally, a participle construction is sometimes grammatical in English, but gives a different reading:

(26) #Waking up, take the child with you.

Here (unlike in the Greek (22)) the participle is not part of the command, but rather functions as a frame.

Ancient Greek, by contrast, makes extensive use of such independent rheme participles. They can also be used in narrative contexts, i.e., outside any embeddings:

(27) *en têi hêmerai ekeinêi* ***exelthôn*** *ho*
on the.DAT day.DAT that.DAT going-out.PFV.PTCP.NOM the.NOM
Iêsous ek tês oikias ekathêto para tên
Jesus.NOM from the.GEN house.GEN sit.PST.IPFV.3SG by the.ACC
thalassan
sea.ACC
On that day, Jesus **went out** of the house and sat by the sea. (Mt. 13:1)

It is even possible to have long sequences of participles describing events leading up to the matrix event in what we will refer to as a serial construction. An example of this is (9a), repeated here with a minor omission as (28):

(28) ***dramôn*** *de tis kai* ***gemisas***
running.PFV.PTCP.NOM PRT some.NOM and filling.PFV.PTCP.NOM
spoggon oxous ***peritheis*** *kalamôi*
sponge.ACC vinegar.GEN putting.PFV.PTCP.NOM stick.DAT
epotizen auton
give-to-drink.PST.IPFV.3SG him.ACC
Someone **ran** and **filled** a sponge with sour wine, **put** it on a stick, and gave him a drink . . . (Mk. 15:36)

When it comes to temporal relations, independent rhemes, like frames, relate to the preceding context. However, since they introduce new events, their time reference is not purely anaphoric, as is the case for frames. Instead they can introduce new times and thus move the narration forward. With regard to the matrix verb, they provide the temporal context, just like in normal narrative sequences where each verb refers to an event which follows the previous one. Thus, in (28), each event, including that of the matrix verb, is understood as taking place (just) after the previously expressed event, due to the phenomenon of narrative progression. In the data of the corpus study in Haug (forthcoming), whose findings are summarized in section 2.2.4, stacked perfective independent rhemes *always* induce narrative progression, unlike what is the case between main clauses where this is only a default.

When the participle is imperfective, there is no narrative progression:

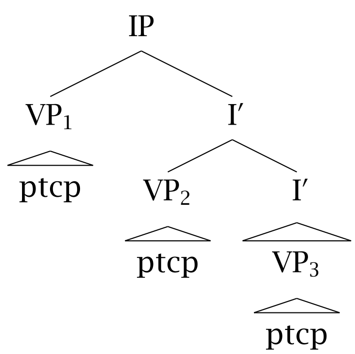
(29) *heteroi de* ***peirazontes*** *sêmeion ex ouranou*
others.NOM PRT tempting.IPFV.PTCP.NOM sign.ACC from heaven.GEN
ezêtoun par' autou
seek.PST.IPFV.3PL from him.GEN
Others **were tempting** (him) and seeking a sign from heaven from him. (Lk. 11:6)

Since participles of this type are temporally independent of the matrix verb, they can easily take a temporal adverbial:

(30) *kai euthus* ***aposteilas*** *ho basileus*
and immediately sending.PFV.PTCP.NOM the.NOM king.NOM
spekoulatora epetaxen enegkai tên
executioner.ACC order.PST.PFV.3SG bring.PFV.PASS.INF the.ACC
kephalên autou
head.ACC him.GEN
And the king immediately **sent** an executioner and ordered that his head be brought (to him). (Mk. 6:27)

2.2.4 Mapping to syntax

Haug (forthcoming) argues that the three types of participles are distinguished syntactically in Greek. Elaborations appear inside the I′ projection, whereas independent rhemes are adjoined to I′ and frames appear in spec, IP. The three positions are illustrated in (31):

(31)


VP_1 is a frame, VP_2 is an indepedendent rheme and VP_3 is an elaboration.

The surface string will often be ambiguous between one or more of the syntactic analyses. For example, an initial participle can either be a frame in the specifier of IP, or left-adjoined to IP. If no material follows which clearly must be outside I′, it could even be an elaboration. However, there is a clear tendency for elaborating participles to occur to the right of their heads. Furthermore, although independent rhemes are sometimes right-adjoined, left adjunction is by far the most common option. In practice, then, the major ambiguity is that between frames and independent rhemes in sentence initial position.

	Elaborations	Independent rhemes	Frames
Information status	new	new	old
Discourse relation	subordinated	coordinated	coordinated
Modal dependency	yes	yes	no
Temporal anchor	matrix	context (loose relation)	anaphoric (strict relation)

Table 2 Overview of participle types

Despite these ambiguities and the ensuing imperfect match between surface string and syntactic analysis, it is possible to observe some distributional patterns in corpora, as Haug (forthcoming) argues on the basis of data from the PROIEL corpus.[11] For example, participles to the right of main verb are much more likely to be imperfective than those to the left, in line with the tendency of elaborations to occur to the right of their governing verb, since elaborations are more likely to be imperfective. Sentence-initial participles, on the other hand, are often perfective. More interestingly, there is also much less lexical variation among participles in this position and the phrases they head are on average significantly shorter. So we get simpler and more predictable event descriptions, in line with our analysis of framing participles as presuppositions.

2.3 Summing up

Table 2 sums up the main properties of the different types of participles. In this paper we focus on the dimension of temporal anchoring. Although it should be clear from the preceding that we do believe these effects are ultimately due to information structure, we can bypass information structure in our analysis since, as we have seen, there seems to be a relatively straightforward mapping to syntax in this particular case.

However, it is likely that some of our results could be generalized to languages with other expressions for information structure categories if we rather think of the phrase structure correspondences noticed in section 2.2.4 as language specific encodings of information structure categories, which then in turn interact with semantic composition. For example, the presuppositional effect found with frames could be signalled by deaccentuation

11 The PROIEL corpus contains the texts of the New Testament and is downloadable from http://foni.uio.no:3000/site/public_data.

instead of fronting, a strategy which, if it was available, is beyond our reach in Ancient Greek. But to develop the theory in this direction would require an explicit theory of the information structure component of grammar. Although there is work to build on in this direction within Glue semantics (Dalrymple & Nikolaeva 2011), it is beyond the scope of this paper to develop this line of research.

Our focus on the temporal connections leads us to ignore other aspects, perhaps most notably the participant sharing which there always is between the events expressed by a conjunct participle and its matrix verb. This is an effect of the syntactic phenomenon of control, but there are also discourse effects we do not model: in particular, independent rheme participles often describe events leading up to that of the matrix verb and belong to the same *discourse topic*, as would follow from the rhetorical relation *Narration* in SDRT. Elaborating participles are often related to the matrix events by subsumption or even event identity. All these effects are left out of our treatment here.

The phenomena we do want to account for, then, are the temporal ones. In particular,

- the temporal anchoring of events inside and across sentences, both what anchors they can relate to and with what temporal relations;
- the obligatory narrative progression with independent rhemes and frames;
- the obligatory intrasentential bindings of all participles except the leftmost one in a serial construction;
- the effects of participles on the further narration and the extent to which they provide anchors for it.

3 The framework

3.1 Semantics for LFG

We have chosen Lexical-Functional Grammar (LFG; Kaplan & Bresnan 1982, Bresnan 2001, Dalrymple 2001) as the syntactic framework for the analysis of Ancient Greek participles, because we believe that a flexible syntactic model is required for free word order languages such as Ancient Greek. However, nothing crucial hinges on the choice of syntactic framework (except of course the ability to distinguish the three types of participles). Our assumptions about the syntax-semantics interface are more explicit.

Glue semantics is the theory of the syntax-semantics interface which has emerged as the standard mechanism for coupling LFG syntactic representations with semantic representations.[12] In itself, Glue semantics is agnostic about both syntactic and semantic representations, as long as the syntactic language provides labels for the meaning-bearing units and the semantic language supports abstraction and functional application. Glue analyses have been proposed for HPSG, Context-free grammar, Categorial grammar and Tree-adjoining grammar. Although Glue puts no restriction on the syntactic framework, it is as we will see especially suited for unordered, flat representations that do not lend themselves as easily to Montague-style compositionality, which requires a binary branching input.

Glue has also been used with several semantic formalisms, including different kinds of type theory and various versions of Discourse Representation Theory such as, as we saw in the introduction, CDRT. In this section we will use simple extensional lambda calculus by way of illustration, and in section 3.2 we will discuss the choice of a proper semantic framework.

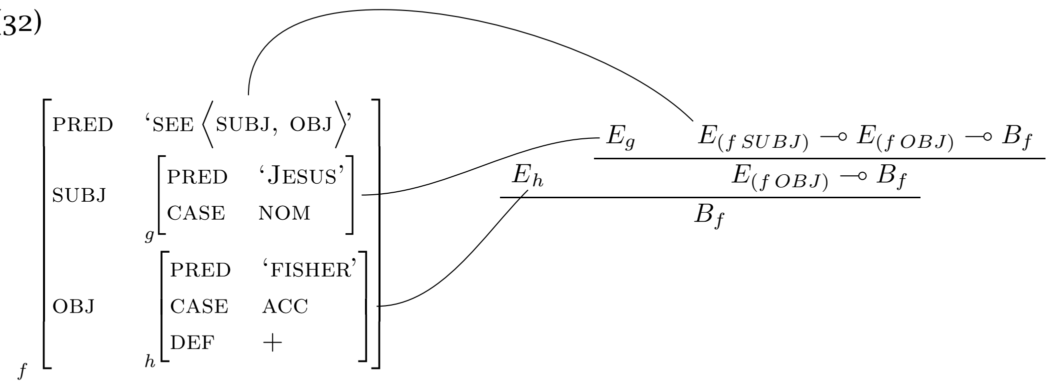
In LFG there are two levels of syntactic description, c(onstituent)-structure, which deals with the linear and hierarchical organization of words into phrases, and f(unctional)-structure, which encodes more abstract information such as predicate-argument structure and grammatical relations, and is the basis for semantic interpretation. F-structures take the form of attribute-value matrices (AVMs), such as the left side of (32) below, which gives a simplified representation of a sentence like 'Jesus saw the fisher' (in a language with case).

The outer AVM, labeled *f*, has three attributes. The first, PRED, takes as its value a *semantic form*, which among other things encodes subcategorization features.[13] The other two are the grammatical roles of SUBJ and OBJ. These take AVMs as values, resulting in a nested structure of AVMs. Finally there are simple attributes such as CASE and DEF, which take atoms (symbols) as values.

12 For more thorough treatments of LFG + Glue, see Dalrymple 1999, 2001 and the background presentations in Asudeh 2005a,b. The system presented here is the so-called *first-order Glue* system described in Kokkonidis 2008. For an introduction to linear logic with a view to linguistic applications, see Crouch & de Paiva 2004.

13 The name *semantic form* for the values of PRED features is traditional in LFG and stems from before LFG was equipped with semantics. When LFG is extended with a real semantic projection through Glue, the PRED features no longer play an important semantic role.

(32)



The f-structures in (32) are labeled *f, g, h*, but notice that it is also possible to refer to them using ‘paths’ through the f-structure. For example g can be referred to as $(f$ SUBJ$)$ and h as $(f$ OBJ$)$.

The f-structures are paired via a semantic projection with *glue terms*, which are expressions of linear logic, which will themselves be paired with expressions in a semantic formalism, as we will see.

The terms of the linear logic are f-structure labels (*f, g, h* in the current example). We then have a set of constant predicates of f-structure labels, *type constructors*. Such a predicate and its argument form a proposition, which as we will see acts as a type under the *propositions as types interpretation* (also known as the *Curry-Howard isomorphism*) which is available for constructive logics. The type constructors have a similar function to the base types in classical typed lambda calculus: in the above derivation we have two base type constructors, B for booleans (truth values) and E for entities. So $B(f)$ will be a boolean type associated with the f-structure labelled *f*. For brevity and to avoid parenthesis clutter we write B_f. As we will see, the fact that the types are constructed from syntactic entities allow us a purely type-driven semantic composition.

Beside these basic types/atomic propositions, we need the connective linear implication, $\multimap$. Unlike, e.g., the case of material implication of classical logic, the modus ponens (elimination) rule for linear implication consumes the antecedent. In other words, from $A \multimap B$ and A we can conclude B, but not A and B. Although we will not consider model theory for linear logic here, we can note that on a natural interpretation, linear logic is a logic of resources, which disappear when consumed, rather than truths, which can be reused at will. This resource sensitivity makes linear logic particularly apt to model semantic composition, where each element can be used only once.

Proof-theoretically, we need the following two natural deduction rules for $\multimap$ elimination and introduction:

(33)

$$\frac{A \qquad A \multimap B}{B} \qquad\qquad \frac{\begin{matrix}[A] \\ \vdots \\ B\end{matrix}}{A \multimap B}$$

We see how the elimination rule consumes the antecedent. The introduction rule states that if, from a temporary assumption (indicated by the brackets) A we can derive B, then we can, without hypotheses, conclude $A \multimap B$. Notice in particular how these rules allow "currying":

(34)

$$\cfrac{\cfrac{\cfrac{\cfrac{A \multimap B \multimap C \qquad [A]}{B \multimap C} \qquad [B]}{C}}{A \multimap C}}{B \multimap A \multimap C}$$

We can now see how such linear logic proofs can be paired with terms of the lambda calculus under the Curry-Howard isomorphism. For example, suppose P represents a proof of $A \multimap B$, which we write $P : A \multimap B$, and x represents some arbitrary proof of A, which we write $x : A$. Now if we have both a proof of A and a proof of $A \multimap B$, we can construct a proof of B. But this proof is dependent on the assumption of A: if we discharge the assumption, we are again left with a conditional proof of B from A. This means that we can regard $A \multimap B$ as a function from arbitrary proofs of A to a proof of B, or in lambda notation $\lambda x.P(x)$. Schematically we have:

(35)

$$\cfrac{\cfrac{x : [A] \qquad P : A \multimap B}{P(x) : B}}{\lambda x\ P(x) : A \multimap B}$$

In other words, the elimination rule for $\multimap$ corresponds to functional application, and the introduction rule corresponds to lambda abstraction.

Going back to our original example (32), we can now pair the derivation with lambda terms:

(36)

$$\cfrac{\mathbf{f} : E_h \qquad \cfrac{\mathbf{j} : E_g \qquad \lambda x \lambda y\ P(x,y) : E_{(f\,SUBJ)} \multimap E_{(f\,OBJ)} \multimap B_f}{\lambda y\ P(\mathbf{j},y) : E_{(f\,OBJ)} \multimap B_f}}{P(\mathbf{j},\mathbf{f}) : B_f}$$

Notice that there is another possible derivation involving currying:

(37)
$$\dfrac{\mathbf{j} : E_g \qquad \dfrac{\dfrac{\mathbf{f} : E_h \qquad \dfrac{[\mathbf{x}] : E_g \qquad \lambda x \lambda y\ P(x,y) : E_{(f\,SUBJ)} \multimap E_{(f\,OBJ)} \multimap B_f}{\lambda y\ P(\mathbf{x},y) : E_{(f\,OBJ)} \multimap B_f}}{P(\mathbf{x},\mathbf{f}) : B_f}}{\lambda x\ P(x,\mathbf{f}) : E_{(f\,SUBJ)} \multimap B_f}}{P(\mathbf{j},\mathbf{f}) : B_f}$$

The subject and the object have been applied in the opposite order. This happens through hypothetical reasoning: we assume we have a subject meaning (type $E_{(f\,SUBJ)}$, or equivalently, E_g) which we represent by **x**. Then we can use the object meaning to construct a meaning for the sentence (type B_f). Now we discharge the hypothetical subject meaning: the result is a function from subject meanings to sentence meanings. To this we apply the non-hypothetical subject meaning represented by the constant **j**.

In this particular case, the net result is the same, but this is not the case whenever there are several quantified NPs involved. In other words, a set of Glue premises allowing several proofs can be thought of as an underspecified representation of sentence meaning: scope ambiguities follow directly from the inference rules. Since we will not consider quantificational data in this paper, we do not go into the details, but we will briefly present the quantificational mechanism Glue uses for scopal ambiguity, since it will occasionally be useful for us as well.

Since type constructors are predicates of f-structure labels, we can use the quantifier $\forall$ ranging over such labels to represent scopal ambiguity. For example, generalized quantifers, which are of type $\langle\langle e,t\rangle,\langle\langle e,t\rangle,t\rangle\rangle$ in "classical" formal semantics, have the type $\forall\alpha\ (E_r \multimap B_r) \multimap ((E_r \multimap B_\alpha) \multimap B_\alpha)$, reflecting the fact that although the restrictor of a generalized quantifier is fixed (to the f-structure labelled r in this case), its scope (the f-structure labeled α) may vary. Notice that the meaning of $\forall$ in linear logic is closer to *any* than to *all*: α above can be instantiated to any f-structure label we want, but only to one. Also, it is important to recognize that $\forall$ on the Glue side has nothing to do with the type of quantifier (any, some, no-one etc.) on the meaning side, but simply reflects that the scope is underspecified.

The quantifier $\forall$ will be useful in modelling temporal anchoring: the fact that we have a finite main clause tells us that something needs to be anchored in the discouse context; but it is not necessarily the finite verb itself that must be anchored, but rather the leftmost verb in a possible serial construction - which is unknown from the point of view of the finite verb.

Another linear logic connective which will occasionally be useful is the exponential ? (read 'why not'). ? signals that a resource is optional and can be dropped, so it offers a controlled way of relaxing resource sensitivity.[14]

Although Glue semantics is very apt at modeling underspecification in the syntax-semantics interface, there is another advantage which is more important for our purposes, and that is its ability to bring together information from several sources. Typically, meaning constructors like $\mathbf{j} : E_g$ and $\lambda x \lambda y\ P(x, y) : E_{(f\,SUBJ)} \multimap E_{(f\,OBJ)} \multimap B_f$ come from lexical items, and the syntax is only responsible for instantiating f SUBJ to g, so that the pieces can be put together.

Within Glue, however, it is possible to have the syntax contribute meaning constructors itself (see in particular Asudeh, Dalrymple & Toivonen 2008). Consider depictives like *naked* in *He ate the meat naked* and assume for concreteness that *naked* is right adjoined to the VP *ate the meat*. In an event semantics, the meanings would be more or less as in (38).

(38) a. **eat:** $\lambda x \lambda e\ \text{ate}(e) \wedge \text{agent}(e, x) \wedge \text{theme}(e, \mathbf{m}) : E_{(f\,SUBJ)} \multimap B_f$
b. **naked:** $\lambda x \lambda e\ \text{naked}(e, x) : E_{(r\,SUBJ)} \multimap B_r$.

These two meanings cannot be directly combined, of course, but we can have the syntactic rule which inserts *naked* into the sentence provide a meaning constructor:

(39) VP → VP AP
dep

where **dep** is an abbreviation for

(40) $\lambda P \lambda Q \lambda x \lambda e \exists e'\ P(x) \wedge Q(x) \wedge e \subseteq e' :$
$(E_{(r\,SUBJ)} \multimap B_r) \multimap ((E_{(f\,SUBJ)} \multimap B_f) \multimap (E_{(f\,SUBJ)} \multimap B_f))$

The meaning constructor takes the semantics of the depictive and that of the VP and returns their conjunction plus the information that the event in the depictive continues throughout the VP event.[15] This semantics is similar to

14 ? is in fact not crucial to our approach. The linear logic terms appear in the annotations on the nodes of the syntax tree and are couched in LFG's description logic, which already supports optionality. Representing the optionality in the description logic would offer the considerable advantage of simplifying our linear logic fragment, but for perspicacity we found it easier to model the optionality directly in the glue terms.

15 The analysis is of course simplified and does not generalize for example to cases where the depictive attaches to the object, as in *He ate the meat raw.*

that of *covert operators* often assumed in formal semantics, e.g., the *depictive operator* of Pylkkänen (2008). The advantage of the Glue approach is that it forces us to pin down the source of these operators, and thus makes the syntax-semantics interface more explicit.

It is useful at this point to consider the differences between Glue semantics and "classical" formal semantics. In the Montagovian tradition, types act merely as constraints on semantic composition; they do not by themselves drive composition. Instead semantic composition is driven by a tree structure, which in the Chomskyan tradition is often identified with logical form (LF). Ambiguity then arises whenever a sentence can be associated with several LFs.

For free word order languages such as Ancient Greek, the mapping from surface structure to a logical form can be extremely complex and lead to very abstract syntactic structure. This shows one advantage of having type-driven semantic composition. Lambda terms come paired with types which can be used to construct the semantic composition tree, which therefore does not need to be isomorphic to any syntactic representation. In this approach, it becomes an empirical question how isomorphic syntax and semantics are in a given language.

A further advantage for our purposes is that Glue semantics can give a better representation of constructional meaning. In Montagovian semantics only terminal nodes contribute meanings, leading to a proliferation of covert operators whose presence in LF is often unaccounted for.[16] In Glue semantics non-terminal nodes can contribute semantic terms, opening the possibility to associate meaning with specific syntactic configurations. This will play a large role in the analysis that we develop in this paper.

3.2 Choosing a meaning language

Glue semantics itself is, as we noted, agnostic about the syntactic and semantic frameworks it combines. In this section we motivate our choice of Compositional Discourse Representation Theory (CDRT) as the meaning language. In the course of our motivation we also present the semantics of tense and aspect that we will use in our account of participles.

As has already become clear in section 2.2, the function of participles cannot be fully understood when looking at sentences in isolation. Instead

16 Of course, terminal nodes in LF could correspond to non-terminal nodes in another structure, but as far as we know no such theory has been worked out.

we need to take the whole discourse into account. Let's illustrate this with (41) (= (8) and (19)).

(41) (Alyattes died. Description of something he did during his life.)

Teleutêsantos *de* *Aluatteô* *exedexato* *tên*
dying.PFV.PTCP.GEN PRT Alyattes.GEN receive.PST.PFV.3SG the.ACC
basilêiên *Kroisos*
reign.ACC Croesus.NOM
After Alyattes **died** Croesus received the reign.

Teleutêsantos 'having died' is a framing participle, the function of which is to pick up an event that is previously mentioned. Although it may not be absolutely impossible to deal with intersentential binding in a so-called static way (see, e.g., Cresswell 2002), it is more natural to deal with it in a dynamic framework, which takes as its starting point the observation that the interpretation of a sentence often depends on information given in the preceding discourse. One of the first dynamic frameworks,[17] Discourse Representation Theory (DRT), was developed by Kamp and Rohrer when they observed that the contribution of aspect is clearer in a discourse than in sentences in isolation, as (42) and (43) show (from Kamp & Rohrer 1983: 253):

(42) a. *Marie téléphona.*
Marie phone.PST.PFV.3SG
Marie made a phone call

b. *Marie téléphonait.*
Marie phone.PST.IPFV.3SG
Marie was making a phone call

(43) a. *Pierre entra.* *Marie téléphona.*
Pierre enter.PST.PFV.3SG. Marie phone.PST.PFV.3SG
Pierre entered. Marie made a phone call.

b. *Pierre entra.* *Marie téléphonait.*
Pierre enter.PST.PFV.3SG. Marie phone.PST.IPFV.3SG
Pierre entered. Marie was making a phone call.

It is hard to state in truth-conditional terms what the difference in meaning between the passé simple sentence (42a) and the imparfait sentence (42b) is. However, in a discourse, as in (43), we see the contribution of aspect

17 Heim's File Change Semantics was developed simultaneously (Heim 1982).

more clearly. Aspect influences the interpretation of the order of events described: the most natural interpretation of (43a) is that the two events are consecutive: Marie starts telephoning after Pierre has come in. In (43b), Marie is already talking on the phone when Pierre comes in. In order to show how this observation is formalised in DRT, we first have to discuss the semantics of tense and aspect.

Partee (1973) notices that tenses are anaphoric just like pronouns. In the same way in which when (44a) is uttered it is about a specific individual and cannot be fully understood without knowing who *he* refers to, (44b) is uttered about a specific time and cannot be fully understood without knowing about which time the utterance is made.

(44) a. He is ill
b. John was ill

We will follow Klein (1994) and use the term *topic time* for the time about which the utterance is made. Tense then indicates the relation between the topic time and the moment of utterance. More in particular, past tense indicates that the topic time precedes the moment of utterance, present tense indicates that the topic time is the moment of utterance, and future tense that the topic time follows the moment of utterance. Aspect also concerns the relation between the topic time and a second time, namely the time of the event (the time that an event actually takes up) (see, for example, Klein 1994, Gerö & von Stechow 2003, Paslawska & von Stechow 2003). More precisely, perfective aspect indicates that the event is completed, hence the time of the event is included in the topic time ($\tau(\mathtt{e}) \subset \mathtt{t}$, where τ is the function that maps events onto their temporal traces). Imperfective aspect, on the other hand, indicates than the event may continue after the topic time ($\tau(\mathtt{e}) \supseteq \mathtt{t}$). For a motivation of this kind of temporal analysis of aspect in Ancient Greek, we refer the reader to Bary 2009, although the exact temporal relations used there are somewhat different from the ones we use in this paper.

With this semantics of tense and aspect let us return to the examples in (43) and their formalisation in DRT.[18] The idea of DRT is that the hearer constructs incrementally a logical form for the discourse as it unfolds. This logical form is called a Discourse Representation Structure (DRS), traditionally depicted as a box. The DRS of the first sentences of (43a) and (43b) is given

18 The analysis presented here is mainly based on the pulling account of temporal cohesion as presented in Kamp, van Genabith & Reyle 2005. It is slightly adapted to our purposes in this paper.

in (45) (which ignores the arguments of the verb):

(45)
$$\begin{array}{|c|}\hline \mathtt{n}\ \mathtt{e}_1\ \mathtt{t}_1 \\ \hline \mathtt{enter}(\mathtt{e}_1) \\ \tau(\mathtt{e}_1) \subset \mathtt{t}_1 \\ \mathtt{t}_1 \prec \mathtt{n} \\ \hline \end{array}$$

Since this sentence is in the passé simple (perfective aspect), the event of Pierre entering $\mathtt{e}_1$ is included in the topic time $\mathtt{t}_1$, which in its turn precedes the moment of utterance $\mathtt{n}$, as is indicated by the past tense.

(45) functions as the context for the interpretation of the second sentences of (43a) and (43b). Let's focus on (43a). We first construct a preliminary DRS for the sentence itself:

(46)
$$\begin{array}{|c|}\hline \mathtt{e}_2\ \mathtt{t}_2 \\ \hline \mathtt{phone}(\mathtt{e}_2) \\ \tau(\mathtt{e}_2) \subset \mathtt{t}_2 \\ \mathtt{t}_2 \prec \mathtt{n} \\ \partial\ \begin{array}{|c|}\hline \mathtt{t}_3 \\ \hline \rho(\mathtt{t}_3, \mathtt{t}_2) \\ \hline \end{array} \\ \hline \end{array}$$

Since the sentence has perfective aspect again, the event described of Marie phoning $\mathtt{e}_2$ is included in the topic time $\mathtt{t}_2$, and the past tense again indicates that the topic time precedes the moment of utterance. In addition, (46) contains a new condition, in the form of a box preceded by ∂. This box can be read as the instruction to relate the topic time $\mathtt{t}_2$ to some other time $\mathtt{t}_3$, the reference time, which is provided by the context. ρ is this temporal relation with which the two times are related and is to be specified in the context. This new condition captures the observation that more often than not events described in a discourse are interpreted in the temporal setting established by the context.[19]

We merge this preliminary DRS in (46) with (45), the representation of the context of (46). This merge (indicated by '$\oplus$') is an operation which returns a new DRS, the universe and conditions of which are the unions of the universes and conditions to be merged:

19 We have simplified the construction of the representation of the first sentence by assuming that tense in discourse-initial sentences does not introduce an instruction to bind to a previously introduced time. It is, of course, more natural to assume that it does introduce such an instruction, but that this time is made available by an accommodation process.

(47) (45) ⊕ (46) =

$$
\begin{array}{|c|}
\hline
\mathtt{n}\ \mathtt{e}_1\ \mathtt{t}_1\ \mathtt{e}_2\ \mathtt{t}_2 \\
\hline
\mathtt{enter}(\mathtt{e}_1) \\
\tau(\mathtt{e}_1) \subset \mathtt{t}_1 \\
\mathtt{t}_1 \prec \mathtt{n} \\
\mathtt{phone}(\mathtt{e}_2) \\
\tau(\mathtt{e}_2) \subset \mathtt{t}_2 \\
\mathtt{t}_2 \prec \mathtt{n} \\
\partial \begin{array}{|c|} \hline \mathtt{t}_3 \\ \hline \rho(\mathtt{t}_3, \mathtt{t}_2) \\ \hline \end{array} \\
\hline
\end{array}
$$

In the second stage anaphoric elements are resolved. $\mathtt{t}_3$ is to be identified with a previously established time and ρ is to be specified. It is often the topic time of the last mentioned event which serves as the reference time. In that case $\mathtt{t}_3$ binds to $\mathtt{t}_1$. We have already seen in the introduction, however, that this need not be the case. In (4a), repeated here for convenience as (48), the event of paying described in the third sentence is intuitively related to the event of buying mentioned by the first sentence rather than to the event of seeing the bike in the newspaper, mentioned in between.

(48) Max bought a new bike. He had seen it in the newspaper. He paid 300 euros for it.

Therefore, the resolution to the topic time of the last mentioned event cannot be more than a default.

Aspect plays a role in the specification of the temporal relation ρ. This explains the difference in interpretation between (43a) and (43b). With perfective aspect the default is that ρ is specified as $\prec$ (the reference time precedes the topic time of the current utterance), with imperfective as $\subseteq$ (the reference time is included in the topic time).[20] Again, this cannot be more than a default. As (49) (from Asher & Lascarides 2003) shows, aspect does not uniquely determine the temporal relation, as a sentence in perfective aspect can refer to a time *preceding* that of the previous sentence: the natural interpretation of (49) is that the pushing precedes the falling.

20 Note that aspect now plays a role in determining two temporal relations. Apart from determining the temporal relation between the event time and the topic time of that utterance, it also plays a role in determining the relation between the topic time and the reference time provided by the context. Only the former relation is part of the semantics of aspect itself, but aspect can be a (non-monotonic) cue to the specification of the latter.

(49) Max fell. John pushed him.

Here, the anaphoric topic time of the second sentence does resolve to the topic time of the last mentioned event, like in (43) and unlike in (48); however, the underspecified ρ relation does not resolve to $\prec$, which would be the default for a sentence in the perfective aspect, but rather to $\succ$. What happens is that other factors beyond aspect, in particular knowledge of the "normal course of events", influence the interpretation. Loosely following the SDRT framework, we can assume that the interpreter of (49) connects the two sentences with the rhetorical relation Explanation, which has the semantic consequence that the second event precedes the first.

The ρ can be seen as the temporal dimension of a discourse relation which is inferred in the context and which might have other semantic consequences that we do not model. Similarly, resolving the anaphoric topic time (e.g., $\mathtt{t}_3$ in (47)) can be seen as the result of inferring a discourse relation between the DRSs containing the anaphor and the antecedent respectively. If we apply this to (47), we can see that the result of the desired resolutions are as in (50):

(50)

$\mathtt{n}\ \mathtt{e}_1\ \mathtt{t}_1\ \mathtt{e}_2\ \mathtt{t}_2$
$\mathtt{enter}(\mathtt{e}_1)$
$\tau(\mathtt{e}_1) \subset \mathtt{t}_1$
$\mathtt{t}_1 \prec \mathtt{n}$
$\mathtt{phone}(\mathtt{e}_2)$
$\tau(\mathtt{e}_2) \subset \mathtt{t}_2$
$\mathtt{t}_2 \prec \mathtt{n}$
$\mathtt{t}_1 \prec \mathtt{t}_2$

In (50), the representation of (43a), the event of Marie telephoning follows the event of Pierre entering. As the reader may check himself, for (43b) we get that the phoning event overlaps with the entering event. In SDRT terms, then, we can think of DRS merger such as (45) $\oplus$ (46) as a simplification of the SDRT term $\pi_1 \wedge \pi_2 \wedge \exists R\ R(\pi_1, \pi_2)$ where π_1 labels (45), π_2 labels (46) and R is a variable over discourse relations. A fully resolved merger as (50) can be thought of as a simplification of $\pi_1 \wedge \pi_2 \wedge R(\pi_1, \pi_2)$ where R is some discourse relation compatible with the temporal relation $\prec$.[21]

21 Note, however, that in our representations ρ relates topic times, which are themselves related to event times through aspect whereas in SDRT, the semantics of discourse relations are normally thought to impose (often temporal) relations between events directly. We return to this matter in section 4.5.

Although SDRT representations will make different predictions about, e.g., the further anaphoric possibilities of discourses like (43) and also contain information about the non-temporal dimensions of discourse relations, the DRT representations contain all the information we need for modelling the temporal interaction of participle and matrix clauses, including the specifically anaphoric participles such as *teleutêsantos* in (41), which picks up an event-type discourse referent introduced before.

Unfortunately, however, standard DRT will not fit into the framework we are using here. In the previous section we motivated our choice of Glue semantics as a theory of the syntax-semantics interface and noted that Glue semantics leaves open the choice for any meaning language, as long as it supports abstraction and functional application. Standard DRT with its unification-based construction algorithm does not satisfy this requirement.

However, a version of DRT has been developed which does satisfy this requirement: Compositional DRT (Muskens 1996). It combines the DRSs of DRT with lambdas of Montague Semantics. As a result, CDRT gives us both the end result that we want (DRSs) and the required way to get to this result (via functional application).

The formalism used in CDRT is that of classical type logic. Muskens shows that, if we adopt certain first-order axioms, DRSs are already present in this logic in the sense that they can be viewed as abbreviations of certain first-order terms. Moreover, the merge operator of DRT is definable in type logic as well, which means type logic provides everything needed to mimic DRT. For our purposes we only need to replace the GB-style grammar Muskens (1996) uses as the syntactic input by our Glue interface fed by LFG syntactic representations, as we argued for in section 3.1.

In CDRT terms, the semantics of aspect can be recast as follows:

(51) a. $\lambda P \lambda t[\begin{array}{|c|}\hline e \\ \hline \tau(e) \supseteq t \\ \hline \end{array} \oplus P(e)]$ (imperfective aspect)

b. $\lambda P \lambda t[\begin{array}{|c|}\hline e \\ \hline \tau(e) \subset t \\ \hline \end{array} \oplus P(e)]$ (perfective aspect)

Aspect is now a function from sets of events to sets of (topic) times such that a certain relation (as specified above) holds between the time of the events and the topic times.[22]

22 Properly speaking, *t* is not a variable over times, but over registers for temporal type individuals. See Muskens 1996 for details.

The past tense then becomes:

(52) $\lambda P \lambda t[\boxed{\begin{array}{c} \\ \hline t \prec n \end{array}} \oplus P(t)]$

The role of temporal morphology is to intersect the set of times it gets as its input after the application of aspect with the set of all past, present or future times, respectively.

But as we saw, the indefinite time introduced by tense is normally not precise enough to allow for an interpretation; the time variable also needs to be anchored in the context, unless there are specific clues inside the sentence, such as frame adverbials or as we shall argue, framing participles, which already fulfill this purpose. To model this, sentences come with the following semantics, which for lack of a better term, we shall refer to as the semantics of finiteness:

(53) $\lambda P[\boxed{\begin{array}{c} t \\ \hline \partial \boxed{\begin{array}{c} t_r \\ \hline \rho(t, t_r) \end{array}} \end{array}} \oplus P(t)]$

The complex condition prefixed with ∂ signals a presupposition and can be informally read as an instruction to find a suitable reference time t_r and a relation ρ to anchor the topic time t in the context. However, original CDRT does not deal with presuppositions and assumes for anaphors such as t_r that the syntax supplies coindexation with the antecedent. Therefore there is no model-theoretic interpretation for such complex conditions, unlike the other expressions of our meaning language. While this is less than satisfactory for a final account, we believe a full treatment of presuppositions in CDRT would complicate matters too much.[23]

As we shall see later, it is important that finiteness only is a default case which applies when there is no overt anchoring of the topic time through

23 There are several options one could entertain. First, we could actually use coindexation as in Muskens 1996. Second, Haug 2011 recasts CDRT in a partial theory of types which allows for underspecification of anaphoric dependencies. Third, van Noor & Muskens 2003 show how the procedural aspect of DRT, which is important in DRT's treatment of presuppositions, can be mimicked in a declarative way, using a hybrid theory combining the binding and satisfaction theories of presuppostion. Note that although we do not use coindexation here, we implicitly assume that the syntax provides unique indices on tokens, i.e., it is able to discern different tokens of the same type. This justifies the use of e and f in Figure 1 and the ensuing calculations (and subscripts in other examples), giving the impression of variable renaming, although these terms are in fact constants.

adverbs or framing participles. Glue semantics will offer us the possibility to model this as “anchoring of last resort”.

Going back to our example, the combination of these meanings gives us the following representation of the second sentence of (43a):

(54) $$\lambda P[\begin{array}{|c|}\hline \mathtt{t} \\ \hline \partial \begin{array}{|c|}\hline \mathtt{t}_r \\ \hline \rho(\mathtt{t},\mathtt{t}_r) \\ \hline \end{array} \\ \hline \end{array} \oplus P(\mathtt{t})](\lambda P \lambda \mathtt{t}[\begin{array}{|c|}\hline \\ \hline \mathtt{t} \prec \mathtt{n} \\ \hline \end{array} \oplus P(\mathtt{t})]$$
$$(\lambda P \lambda \mathtt{t}[\begin{array}{|c|}\hline \mathtt{e} \\ \hline \tau(\mathtt{e}) \subset \mathtt{t} \\ \hline \end{array} \oplus P(\mathtt{e})](\lambda \mathtt{e} \begin{array}{|c|}\hline \\ \hline \mathsf{phone}(\mathtt{e}) \\ \hline \end{array})))$$

Applying the semantics of aspect to the predicate gives us:

(55) $$\lambda \mathtt{t}[\begin{array}{|c|}\hline \mathtt{e} \\ \hline \tau(\mathtt{e}) \subset \mathtt{t} \\ \hline \end{array} \oplus \begin{array}{|c|}\hline \\ \hline \mathsf{phone}(\mathtt{e}) \\ \hline \end{array}]$$

which reduces to (56) through merging:

(56) $$\lambda \mathtt{t} \begin{array}{|c|}\hline \mathtt{e} \\ \hline \tau(\mathtt{e}) \subset \mathtt{t} \\ \mathsf{phone}(\mathtt{e}) \\ \hline \end{array}$$

Then tense applies to (56) and we get (57) (through functional application and merging again):

(57) $$\lambda \mathtt{t} \begin{array}{|c|}\hline \mathtt{e} \\ \hline \tau(\mathtt{e}) \subset \mathtt{t} \\ \mathsf{phone}(\mathtt{e}) \\ \mathtt{t} \prec \mathtt{n} \\ \hline \end{array}$$

Finally finiteness applies and we end up with (58):

(58) $$\begin{array}{|c|}\hline \mathtt{t}\ \mathtt{e} \\ \hline \tau(\mathtt{e}) \subset \mathtt{t} \\ \mathsf{phone}(\mathtt{e}) \\ \mathtt{t} \prec \mathtt{n} \\ \partial \begin{array}{|c|}\hline \mathtt{t}_r \\ \hline \rho(\mathtt{t},\mathtt{t}_r) \\ \hline \end{array} \\ \hline \end{array}$$

which is equivalent to (46).

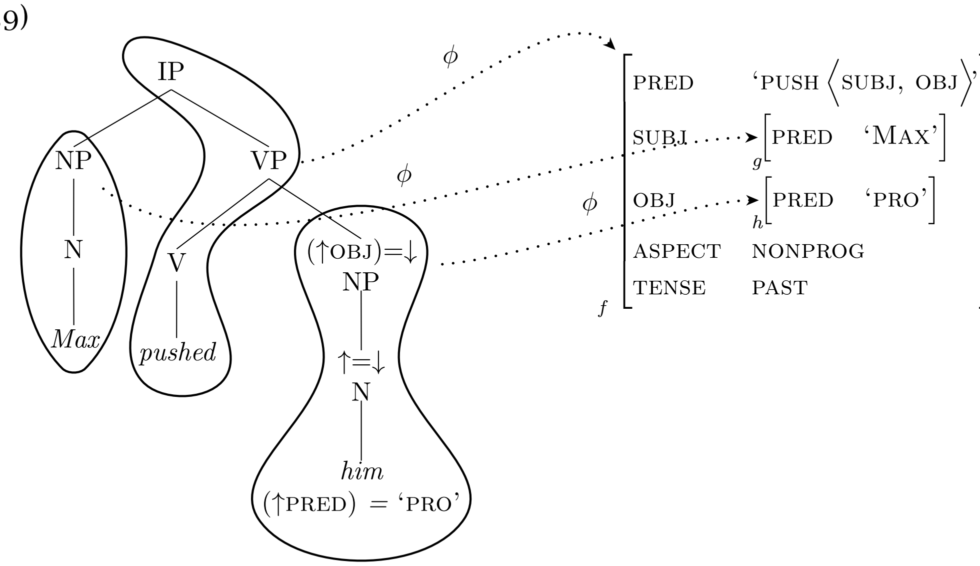
CDRT makes it possible to deal with intra- and intersentential binding in a uniform way. This is an advantage for our purpose since the participle *teleutêsantos* in (41) not only picks up an entity introduced before, but it also functions itself as an antecedent for the interpretation of the main clause. We could in principle deal with the latter anaphoric relation in a static way, but since, as we have seen in the introduction, there are many similarities between the interpretation of a combination of participle and main clause and that of two subsequent main clauses, we would like to model these similarities and it would be artificial to treat the two in different ways.

3.3 An example worked out

Let us now look at how an analysis of a simple sentence such as *Max pushed him* will work out, illustrating how the information flows from the lexicon, through the constituent structure and the functional structure to the semantics as well as the correspondence (the ϕ projection) between the two.

(59) illustrates the c-structure and (simplified) f-structure of *Max pushed him*.

(59)



For ease of representation, only the object nodes are annotated with functional information. We see that such information can appear on both terminals and non-terminals. ↑ and ↓ are metavariables for f-structures: ↓ refers to the ϕ-projection of a node, and ↑ to the ϕ-projection of its mother node. So the annotation on the object NP means 'the ϕ-projection of this NP's mother node has an object attribute whose value is the ϕ-projection of the NP itself'. Using the labels of the given f-structure, the constraint can be rewritten (f OBJ) = h. The ↑=↓ annotation, which typically appears on heads, means that a node's ϕ-projection is the same as that of its mother node, thus "passing up" the information from the lexical item *him*. It is good to note already at this point that this also means that the ϕ-projection of the VP-node is the same as that of the V-node. This ensures that information about aspect is accessible at the VP-level, a fact that is crucial for our account of narrative progression in section 4.3.

In this case, all the semantic information also comes from the lexicon. Notice in particular that unlike what happens in principles and parameters theory, the c-structure does not contain nodes corresponding to abstract material such as tense and aspect (except when it is encoded lexically), although these features may be represented at f-structure.

Tense and aspect are therefore simply associated with the verbal node itself, and the terminal nodes of the tree will be annotated with the following semantic information (to simplify, the pronoun is represented as a constant):

(60)

$$
\begin{array}{lll}
\text{Max:} & \mathbf{m} & E_{\uparrow} \\[2ex]
\text{pushed:} & \lambda x \lambda y \lambda e \begin{array}{|c|}\hline \mathtt{x\ y\ e} \\ \hline \mathtt{push(e)} \\ \mathtt{agent(e,x)} \\ \mathtt{theme(e,y)} \\ \hline \end{array} & E_{\uparrow SUBJ} \multimap E_{\uparrow OBJ} \multimap EV_{\uparrow} \multimap B_{\uparrow} \\[2ex]
\textbf{pfv} & \lambda P \lambda t [\begin{array}{|c|}\hline \mathtt{e} \\ \hline \tau(\mathtt{e}) \subset \mathtt{t} \\ \hline \end{array} \oplus P(\mathtt{e})] & (EV_{\uparrow} \multimap B_{\uparrow}) \multimap (T_{\uparrow} \multimap B_{\uparrow}) \\[2ex]
\textbf{past} & \lambda P \lambda t [\begin{array}{|c|}\hline \\ \hline \mathtt{t} \prec \mathtt{n} \\ \hline \end{array} \oplus P(\mathtt{t})] & (T_{\uparrow} \multimap B_{\uparrow}) \multimap (T_{\uparrow} \multimap B_{\uparrow}) \\[2ex]
\textbf{finite} & \lambda P [\begin{array}{|c|}\hline \mathtt{t} \\ \hline \partial \begin{array}{|c|}\hline \mathtt{t_r} \\ \hline \rho(\mathtt{t_r},\mathtt{t}) \\ \hline \end{array} \\ \hline \end{array} \oplus P(\mathtt{t})] & ?(\forall \alpha (T_{\alpha} \multimap B_{\uparrow}) \multimap B_{\uparrow}) \\[2ex]
\text{him:} & \mathbf{h} & E_{\uparrow}
\end{array}
$$

In these linear logic terms we have introduced some new type constructors compared to the discussion in section 3.1, namely EV for the type of events and T for the type of times.[24]

The meaning constructor **finite** deserves some discussion. First, the quantification over f-structures ($\forall\alpha$) means that it can apply to a dependency on a temporal type meaning associated with any f-structure. This is necessary because of the possibility of participle stacking: as we have seen, in sentences where there are several participles to the left of the matrix verb, they each provide the reference time for the next verb, and only the leftmost verb needs to be anchored to the context. So we do not know what finiteness should apply to, but we do know that the result should be a boolean type meaning associated with the sentence as a whole, i.e., the f-structure of the finite verb. Second, finiteness is only a default case that applies just in case there is no overt anchoring, so its meaning constructor is prefixed with the ? exponential.

Again, we can instantiate the f-structure labels for the arrows, yielding the following:

(61)
$$
\begin{array}{l}
E_g \\
E_g \multimap E_h \multimap EV_f \multimap B_f \\
(EV_f \multimap B_f) \multimap (T_f \multimap B_f) \\
(T_f \multimap B_f) \multimap (T_f \multimap B_f) \\
?(\forall\alpha(T_\alpha \multimap B_f) \multimap B_f) \\
E_h
\end{array}
$$

These can be combined in the following straightforward way:

(62)
$$
\dfrac{\dfrac{\dfrac{E_h \qquad \dfrac{E_g \qquad E_g \multimap E_h \multimap EV_f \multimap B_f}{E_h \multimap EV_f \multimap B_f}}{EV_f \multimap B_f} \qquad (EV_f \multimap B_f) \multimap (T_f \multimap B_f)}{T_f \multimap B_f} \qquad \dfrac{?(\forall\alpha(T_\alpha \multimap B_f) \multimap B_f)}{(T_f \multimap B_f) \multimap B_f}}{B_f}
$$

Notice in particular that the contribution of finiteness, although optional, is in fact necessary for the proof. By the Curry-Howard isomorphism, the proof corresponds to the following lambda term:

24 There is also a technical difference in the meaning of the B type constructor as the lambda terms we use in CDRT are actually abbreviations for a reconstruction of context change potentials, namely relations between states (aka assignments), rather than actual booleans/type t terms. Similarly, EV and T are actually the types for *registers* for events and times, respectively.

(63)
$$\lambda P[\begin{array}{|c|}\hline \mathtt{t} \\ \hline \partial\ \begin{array}{|c|}\hline \mathtt{t_r} \\ \hline \rho(\mathtt{t_r},\mathtt{t}) \\ \hline \end{array} \\ \hline \end{array} \oplus P(\mathtt{t})](\lambda P[\begin{array}{|c|}\hline \\ \hline \mathtt{t} \prec \mathtt{n} \\ \hline \end{array} \oplus P(\mathtt{t})]$$
$$(\lambda P \lambda \mathtt{t}[\begin{array}{|c|}\hline \mathtt{e} \\ \hline \tau(\mathtt{e}) \subset \mathtt{t} \\ \hline \end{array} \oplus P(\mathtt{e})](\lambda x \lambda y \lambda e \begin{array}{|c|}\hline \mathtt{x\ y\ e} \\ \hline \mathtt{push(e)} \\ \mathtt{agent(e,x)} \\ \mathtt{theme(e,y)} \\ \hline \end{array}(\mathtt{m})(\mathtt{h}))))$$

As the reader may verify, this reduces to

(64)
$$\begin{array}{|c|}\hline \mathtt{m\ h\ e\ t} \\ \hline \mathtt{push(e)} \\ \mathtt{agent(e,m)} \\ \mathtt{theme(e,h)} \\ \tau(\mathtt{e}) \subset \mathtt{t} \\ \mathtt{t} \prec \mathtt{n} \\ \partial\ \begin{array}{|c|}\hline \mathtt{t_r} \\ \hline \rho(\mathtt{t},\mathtt{t_r}) \\ \hline \end{array} \\ \hline \end{array}$$

4 Analysis

4.1 Introduction

We argued in section 2.2.4 that the three different types of participles are syntactically distinct. Each of these constructions has some semantic consequences that are always found with that construction: to repeat the most salient ones, frames introduce anaphoric event discourse referents, frames and independent rhemes always provide the topic time for the verb to their right, and elaborations do not have a separate topic time, but use the matrix event time instead. These properties always hold for a given construction. Therefore we believe that they should be represented in the semantics of these constructions.

On the other hand, our semantics is not fully specified: participles can have several discourse properties that do not follow from our interpretations. In particular, **frame** and **indrheme** are both compatible with many of SDRT's coordinating rhetorical relations: in addition to *Narration*, one of the more frequent ones is *Result*, which has the semantic effect that the event denoted by the participle is the cause of the event denoted by the matrix verb. This, however, is an inference arising from default discourse reasoning, so we do not attempt to model it in our compositional semantics. It would be possible to integrate such inferences in the semantics, since our framework allows for optional semantic resources: but we have followed the principle that only invariant properties of constructions should be encoded in the semantics and the rest left to (discourse) pragmatics.[25]

4.2 Elaboration

We will now look at how the apparatus we have developed can deal with elaborating participles, such as in (65) and (66).

(65)

elalei	***eulogôn***	*ton*	*theon*
speak.PST.IPFV.3SG	praising.IPFV.PTCP.NOM	the.ACC	god.ACC

He was speaking **praising** god. (Lk. 1.64)

(66)

hêmarton	***paradous***	*haima*	*athôon*
sin.PST.PFV.1SG	betraying.PFV.PTCP.NOM	blood.ACC	innocent.ACC

I have sinned (by) **betraying** innocent blood. (Mt. 27.4)

From the perspective of temporal relations, the important fact about this construction is that the participle is temporally dependent on the matrix event. A consequence of this is that we infer temporal overlap between the events, even when the participle is perfective. Mutatis mutandis,[26] the same holds in English, as shown in (67).

(67) Bilbo made his fortune killing a dragon.

As shown in section 2.2.4, such participles are phrase structurally distinct in Ancient Greek (and possibly in English as well). In other words, we are dealing with a *construction* with semantic content. Its semantic contribution is to *intersect* a set of times and a set of events such that the result is a subset of the input event set, containing only those events whose run times are in the input set of times:

25 The apparent optionality of the **finite** meaning constructor is of a different kind, since it always clear whether it should apply or not: in valid derivations of sentence meanings, **finite** can only be applied when the topic time of the sentence is not overtly anchored, and in that case it has to apply. So no ambiguities are predicted.

26 Strictly speaking, the ing-participle in English is probably aspectually neutral. So *killing* is not perfective, but since the predicate is telic, the interpretation is perfective nevertheless.

(68) **elab:** $\lambda P \lambda Q \lambda e[P(\tau(e)) \oplus Q(e)]: (T_{\downarrow} \multimap B_{\downarrow}) \multimap (EV_{\uparrow} \multimap B_{\uparrow}) \multimap (EV_{\uparrow} \multimap B_{\uparrow})$

To understand the meaning constructor on the right side, it is important to realize that this term appears on a non-terminal node. The idea is that every time a syntactic rule inserts an adjunct VP into a verb's projection, this semantic resource is generated on the VP node which the participle projects.[27]

In this context $\downarrow$ refers to the f-structure of the participle and $\uparrow$ to the f-structure of the matrix verb, as is more easily seen in the tree in Figure 1. What the elaboration construction does, then, is to take the set of times associated with the participle after application of aspect, i.e., a object of type $T_{\downarrow} \multimap B_{\downarrow}$, and construct something which can intersect with the set of events denoted by the matrix verb *before* application of aspect, i.e., an object of type $(EV_{\uparrow} \multimap B_{\uparrow}) \multimap (EV_{\uparrow} \multimap B_{\uparrow})$.

Before we can produce a proof from the terms, we must instantiate the f-structure variables. If we label the f-structure of *elalei*, the matrix verb, m and that of the participle p, we see that the type of the elaboration construction ends up as $(T_p \multimap B_p) \multimap (EV_m \multimap B_m) \multimap (EV_m \multimap B_m)$. In the terminal nodes, $\uparrow$ gets instantiated to T_p and T_m, respectively; and for α, we choose m. This gives us the meaning constructors in (69):

(69)

speak	$EV_m \multimap B_m$
impf	$(EV_m \multimap B_m) \multimap (T_m \multimap B_m)$
past	$(T_m \multimap B_m) \multimap (T_m \multimap B_m)$
finite	$(T_m \multimap B_m) \multimap B_m$
elab	$(T_p \multimap B_p) \multimap (EV_m \multimap B_m) \multimap (EV_m \multimap B_m)$
praise	$EV_p \multimap B_p$
impf	$(EV_p \multimap B_p) \multimap (T_p \multimap B_p)$

There is only one way of putting these together in a proof of B_m. First, *praise* combines with **impf** and **elab** as in (70).

(70)

$$\dfrac{\dfrac{\begin{array}{c}\textit{praise}\\ EV_p \multimap B_p\end{array} \qquad \begin{array}{c}\textbf{impf}\\ (EV_p \multimap B_p) \multimap (T_p \multimap B_p)\end{array}}{(T_p \multimap B_p)} \qquad \begin{array}{c}\textbf{elab}\\ (T_p \multimap B_p) \multimap (EV_m \multimap B_m) \multimap (EV_m \multimap B_m)\end{array}}{(EV_m \multimap B_m) \multimap (EV_m \multimap B_m)}$$

27 More precisely, since the framework is declarative rather than generative, VP participles can exist inside the projection of the matrix only when equipped with this semantic resource.

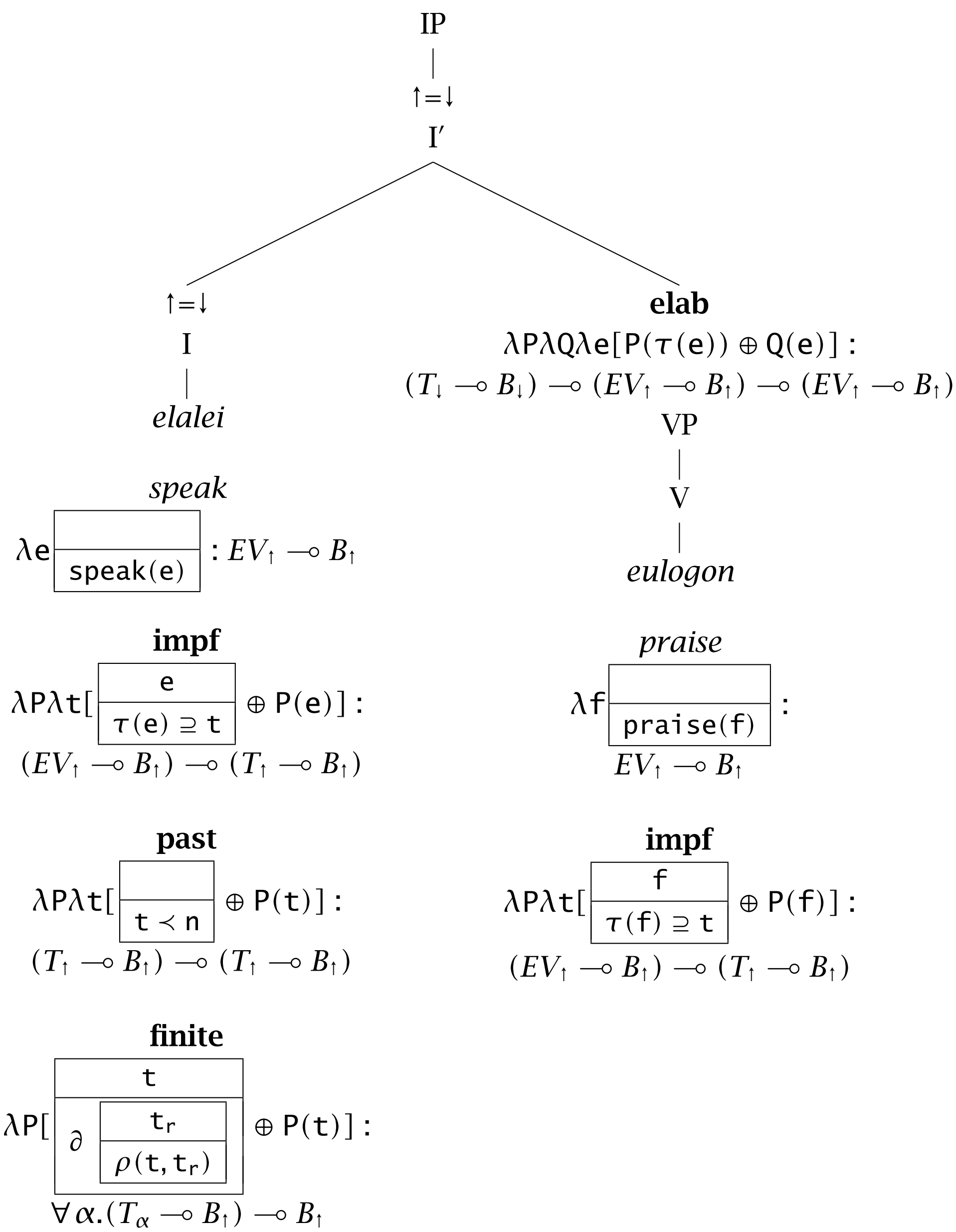

IP
↑=↓
I′
↑=↓
I
elalei
elab
λPλQλe[P(τ(e)) ⊕ Q(e)] :
(T↓ ⊸ B↓) ⊸ (EV↑ ⊸ B↑) ⊸ (EV↑ ⊸ B↑)
VP
V
eulogon
speak
λe
speak(e)
: EV↑ ⊸ B↑
impf
λPλt[
e
τ(e) ⊇ t
⊕ P(e)] :
(EV↑ ⊸ B↑) ⊸ (T↑ ⊸ B↑)
praise
λf
praise(f)
:
EV↑ ⊸ B↑
past
λPλt[
t ≺ n
⊕ P(t)] :
(T↑ ⊸ B↑) ⊸ (T↑ ⊸ B↑)
impf
λPλt[
f
τ(f) ⊇ t
⊕ P(f)] :
(EV↑ ⊸ B↑) ⊸ (T↑ ⊸ B↑)
finite
λP[
t
∂
tr
ρ(t, tr)
⊕ P(t)] :
∀α.(Tα ⊸ B↑) ⊸ B↑

Figure 1

By the Curry-Howard isomorphism, this corresponds to the lambda term in (71).

(71) $$\lambda P \lambda Q \lambda e[P(\tau(e)) \oplus Q(e)](\lambda P \lambda t[\begin{array}{|c|}\hline \mathtt{f} \\ \hline \tau(\mathtt{f}) \supseteq \mathtt{t} \\ \hline \end{array} \oplus P(\mathtt{f})](\lambda \mathtt{f} \begin{array}{|c|}\hline \\ \hline \mathtt{praise}(\mathtt{f}) \\ \hline \end{array}))$$

which reduces to (72):

(72) $$\textbf{praise-impf-elab}: \lambda Q \lambda e[\begin{array}{|c|}\hline \mathtt{f} \\ \hline \tau(\mathtt{f}) \supseteq \tau(\mathtt{e}) \\ \mathtt{praise}(\mathtt{f}) \\ \hline \end{array} \oplus Q(e)]$$

As we can see, **elab** has turned the participle into an event modifier, which intersects a set of events with the set of events whose run time is included in the run time of a praising event. Therefore, **praise-impf-elab** must apply *before* matrix aspect, as in (73).

(73) $$\dfrac{\dfrac{\begin{array}{c}\textbf{praise-impf-elab}\\ (EV_m \multimap B_m) \multimap \\ (EV_m \multimap B_m)\end{array} \quad \begin{array}{c}\textit{speak}\\ (EV_m \multimap B_m)\end{array}}{(EV_m \multimap B_m)} \quad \begin{array}{c}\textbf{impf}\\ (EV_m \multimap B_m) \multimap \\ (T_m \multimap B_m)\end{array}}{T_m \multimap B_m}$$

This corresponds to the lambda term in (74):

(74) $$\lambda P \lambda t[\begin{array}{|c|}\hline \mathtt{e} \\ \hline \tau(\mathtt{e}) \supseteq \mathtt{t} \\ \hline \end{array} \oplus P(e)](\lambda Q \lambda e[\begin{array}{|c|}\hline \mathtt{f} \\ \hline \tau(\mathtt{f}) \supseteq \tau(\mathtt{e}) \\ \mathtt{praise}(\mathtt{f}) \\ \hline \end{array} \oplus Q(e)](\lambda e \begin{array}{|c|}\hline \\ \hline \mathtt{speak}(\mathtt{e}) \\ \hline \end{array}))$$

After application of **past** and **finite** and subsequent reduction, this yields the semantics in (75).

(75) $$\begin{array}{|c|}\hline \mathtt{e\ f\ t} \\ \hline \mathtt{speak}(\mathtt{e}) \\ \tau(\mathtt{e}) \supseteq \mathtt{t} \\ \mathtt{t} \prec \mathtt{n} \\ \partial \begin{array}{|c|}\hline \mathtt{t_r} \\ \hline \rho(\mathtt{t}, \mathtt{t_r}) \\ \hline \end{array} \\ \mathtt{praise}(\mathtt{f}) \\ \tau(\mathtt{f}) \supseteq \tau(\mathtt{e}) \\ \hline \end{array}$$

There are a couple of observations to be made about the analysis. First, we noted that the derivation requires that the contribution of the participle is consumed *before* the application of matrix aspect. This ensures that the participle is in the scope of matrix aspect, which is correct as we can see from cases like (76) where imperfective aspect in the matrix is interpreted iteratively.

(76) (John the Baptist appears in the desert. People arrive from Jerusalem and the whole of Judea.)

ebaptizonto	*hup'*	*autou*	*en*	*tôi*	*Iordanêi*	*potamôi*		
baptize.IMPF.PAS.3P	by	him.GEN	in	ART.DAT.SG	Jordan	river.DAT		
exomologoumenoi	*tas*	*hamartias*	*autôn*					
confessing.PP	ART.ACC.PL	sins.ACC.PL	their.GEN					

They were baptized by him in the river Jordan **confessing** their sins. (Mk. 1:5)

The iterative interpretation of the matrix imperfective *ebaptizonto* clearly extends to *exomologoumenoi*, i.e., it is the complex event of being baptized while confessing sins which is iterated.

Second, although the participle *does* introduce an event discourse referent, there is no temporal discourse referent for the topic time of that event because the run time of the matrix event is used instead. This correctly predicts that the time interval associated with an elaborating participle cannot be picked up in the further discourse.[28]

Notice that this prediction is stronger than what one would get in SDRT if the participle attached to the matrix verb with a subordinating discourse relation such as *Elaboration*. If the participle appears to the right of the matrix, as it most often does, SDRT's right frontier constraint would predict that the further discourse could pick up either on the elaborating participle or on the finite verb. So we see that the constraints imposed by intra-sentential relationships are typically stronger than discourse inferences.

Summing up the temporal dimension of elaborating participles, they pick up the time of their matrix verb instead of a time from the context, and they do not provide a time referent which can be picked up in later discourse.

28 Negative data are of course always problematic in a language with no native speakers such as Ancient Greek, but this generalization builds on a rather solid number of examples.

4.3 Independent rhemes

Independent rheme participles are those which are discourse coordinated with their matrix. This means that they are independent assertions of events tied to their own topic times, and so they *do* introduce time referents into the discourse, as witnessed by the fact that unlike elaborations they can have temporal adverbials and connectors as in (30). In this, sequences of participles followed by a finite verb are equivalent to sequences of finite verbs.

However, there is a difference in that in sequences of participles and finite verbs such as (9a) each verb obligatorily relates to the preceding verb. Unlike the case with main clauses, it is not possible to skip a verb in the sequence. We can capture both this fact and the possibility of having several independent rheme participles by having the independent rheme construction require that

(77) the participle provides the reference time for the head of the verbal projection to its right.

To formalize the concept of *verbal projection to the right*, we define a function S taking nodes to nodes. S is a partial function, only defined for nodes that have a sister node to the right. If that is the case, $S(n)$ refers to

i. the left-most daughter of the sister to the right if the sister to the right results from an adjunction,

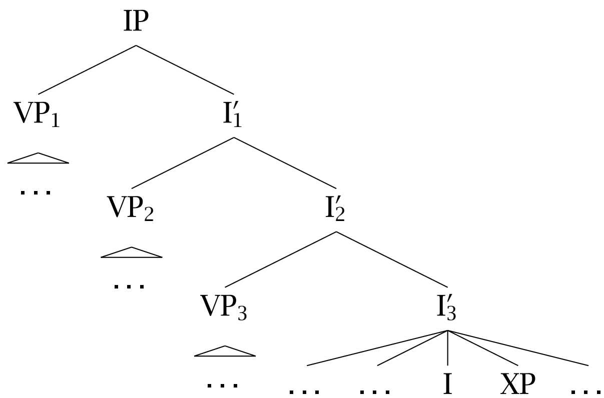
ii. or else, the sister to the right.

We write $>$ for $\phi(S(n))$, i.e., the f-structure corresponding to $S(n)$.[29] As one reviewer observes, the intuitive purpose of $>$ is to imitate tree structure-driven semantic composition. However, it is no coincindence that the semantics follows the c-structure here: Greek word order is free *inside* clauses, making tree-driven composition difficult; but it is relatively strict *across* clauses — words cannot appear outside their own clause except in well-defined cases of long distance dependencies. For this reason, it is natural that semantic composition of clauses with each other is isomorphic to the syntax tree.

29 $>$ is not standard LFG notation, but rather a convenient abbreviation which could be expressed, if somewhat clumsily, in standard notation.

Consider the following tree:

(78)



$>$ in an annotation on the independent rheme participle in VP_2 gets instantiated to the f-structure of VP_3; in VP_3, to the f-structure I'_3 (the same as that of I); and in I, to the f-structure of XP. Notice that the definition of $>$ also covers the framing participle VP_1, where it refers to the VP_2. On IP, I'_1, I'_2 or I'_3, $>$ would fail to get instantiated since these nodes do not have sisters to the right.

Furthermore, we need to be able to refer to the f-structure of which another f-structure is an adjunct. We use standard LFG notation here, viz. ADJ $\in \downarrow$, meaning 'the f-structure which contains an ADJ attribute whose value is a set containing $\downarrow$'. Appearing in either VP_1 or VP_2, this would be the f-structure of the whole sentence.

With this notation in place, we can formalize (77) as in (79).

(79) **indrheme:** $\lambda P \lambda Q \lambda t[P(t) \oplus Q(t)]$:
$$(T_{\downarrow} \multimap B_{\downarrow}) \multimap (T_{>} \multimap B_{\mathrm{ADJ}\in\downarrow}) \multimap (T_{\downarrow} \multimap B_{\mathrm{ADJ}\in\downarrow})$$

I.e., both DRSs should be interpreted with respect to the same time interval. However, as discussed in section 4.3, we get narrative progression whenever the participle is perfective, as captured by the meaning constructor in (80).

(80) **narprog** $\lambda R \lambda P \lambda Q[R(P)(\lambda t[\boxed{\begin{array}{c} t' \\ \hline t \supset\!\!\prec t' \end{array}} \oplus Q(t')])]$:
$$((T_{\downarrow} \multimap B_{\downarrow}) \multimap (T_{>} \multimap B_{\mathrm{ADJ}\in\downarrow}) \multimap (T_{\downarrow} \multimap B_{\mathrm{ADJ}\in\downarrow})) \multimap$$
$$((T_{\downarrow} \multimap B_{\downarrow}) \multimap (T_{>} \multimap B_{\mathrm{ADJ}\in\downarrow}) \multimap (T_{\downarrow} \multimap B_{\mathrm{ADJ}\in\downarrow}))$$

It is important, of course, that (80) only appears on independent rhemes and frames, and only when the aspect is perfective. We ensure that by using an (exclusive) disjunction in the syntactic rule for adjunction to I′, which is the one licensing **indrheme**:

(81) $\text{I}' \rightarrow \underset{\substack{\uparrow \text{XADJ} = \downarrow \\ \textbf{indrheme} \\ (\downarrow \text{ASPECT} \neq \text{PFV}) \veebar \textbf{narprog}}}{\text{VP}} \quad \underset{\uparrow = \downarrow}{\text{I}'}$

The annotation on the nodes are statements of LFG's description language. In this case there are two mutually exclusive ways in which the actual linguistic structure can satisfy the description, namely either by having non-perfective aspect in the f-structure of the VP node (recall that the f-structures of a phrase and its head are unified, passing information about aspect upwards) or by inserting the semantic resource **narprog**.

This meaning constructor ensures that perfective participles push the reference time forward in serial constructions. It appears only in cases of independent rheme and framing participles, as these constructions seem to have grammaticalized narrative progression. Narrative progression here quantifies into the second argument of the independent rheme construction and ensures that it does not pick up the topic time of the first, but rather a time immediately following ($\mathtt{t} \supset\!\prec \mathtt{t}'$ indicates that $\mathtt{t}'$ immediately follows $\mathtt{t}$). The reader can verify that the effect of applying (80) to (79) is (82).

(82) **narindrheme:** $\lambda P \lambda Q \lambda t[P(t) \oplus \boxed{\begin{array}{c} t' \\ \hline t \supset\!\prec t' \end{array}} \oplus Q(t')]$:
$(T_{\downarrow} \multimap B_{\downarrow}) \multimap (T_{>} \multimap B_{\text{ADJ}\in\downarrow}) \multimap (T_{\downarrow} \multimap B_{\text{ADJ}\in\downarrow})$

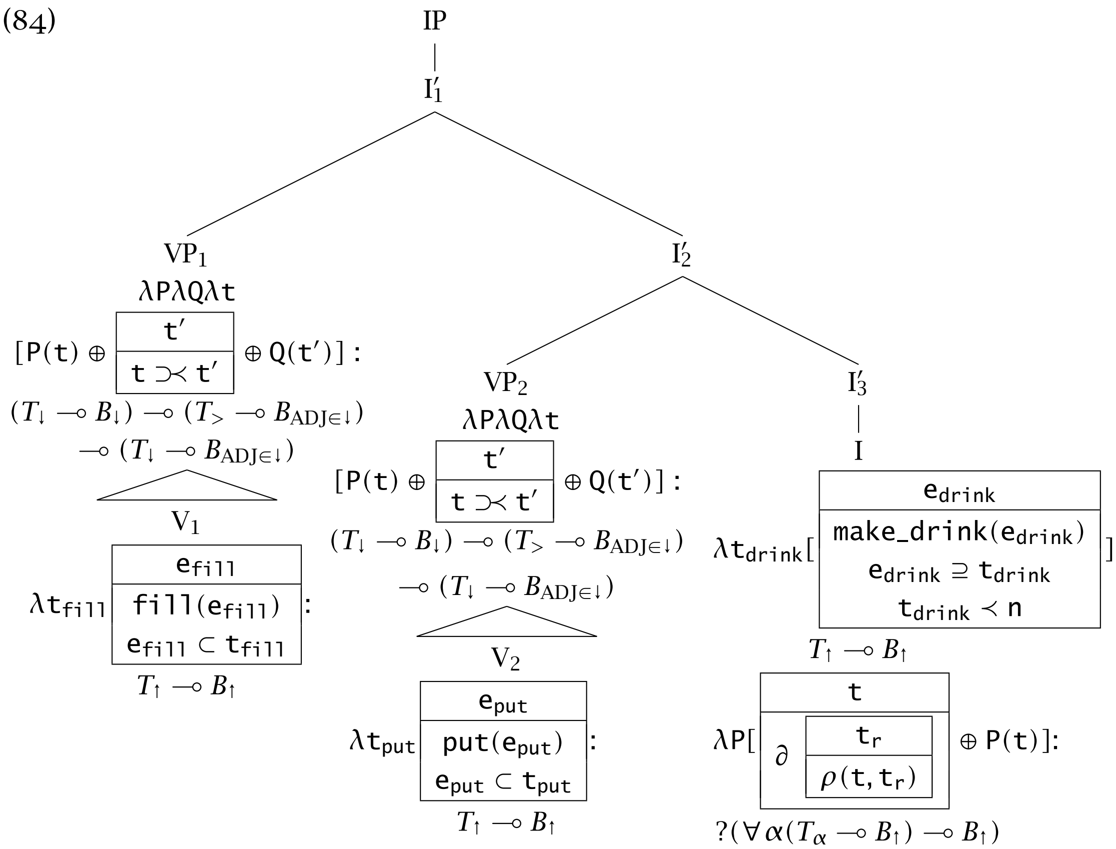
In general we will use this meaning constructor directly in our trees to avoid unnecessary calculations.

Let us work out an example. (78) from I'_1 and down is in fact a simplified tree of a sentence with two independent rheme participles in front of the finite verb, e.g., the part of (9a) repeated here:

(83) ***gemisas*** *spoggon* *oxous* ***peritheis***
filling.PFV.PTCP.NOM spunge.ACC vinegar.GEN putting.PFV.PTCP.NOM
kalamôi *epotizen* *auton*
reed.DAT give-to-drink.PST.IPFV.3SG him.ACC
(Someone ran and) **filled** a sponge with sour wine, **put** it on a reed, and gave him a drink, (saying) . . .

Ignoring the thematic arguments, this sentence has the c-structure and semantic annotation in (84). To reduce clutter, aspect has already been combined with its verb; for the matrix verb, tense but not finiteness has been applied.

(84)



The meaning constructors get instantiated in the following way, using f for the f-structure of *fill*, p for that of *put* and d for that of *make drink*:

(85)

node	constructor
V_1	$T_f \multimap B_f$
VP_1	$(T_f \multimap B_f) \multimap (T_p \multimap B_d) \multimap (T_f \multimap B_d)$
V_2	$T_p \multimap B_p$
VP_2	$(T_p \multimap B_p) \multimap (T_d \multimap B_d) \multimap (T_p \multimap B_d)$
I	$T_d \multimap B_d$
	$?(\forall \alpha (T_\alpha \multimap B_d) \multimap B_d)$

There is only one way to put these constructors together:

(86)

$$\dfrac{\dfrac{\dfrac{T_f \multimap B_f \qquad (T_f \multimap B_f) \multimap (T_p \multimap B_d) \multimap (T_f \multimap B_d)}{(T_p \multimap B_d) \multimap (T_f \multimap B_d)} \qquad \dfrac{\dfrac{T_p \multimap B_p \qquad (T_p \multimap B_p) \multimap (T_d \multimap B_d) \multimap (T_p \multimap B_d)}{(T_d \multimap B_d) \multimap (T_p \multimap B_d)} \qquad T_d \multimap B_d}{(T_p \multimap B_d)}}{T_f \multimap B_d} \qquad \dfrac{\forall \alpha (T_\alpha \multimap B_d) \multimap B_d}{(T_f \multimap B_d) \multimap B_d}}{B_d}$$

Corresponding to the two top splits in the middle branch of this proof tree, we get the following corresponding functional application

(87)
$$\lambda P \lambda Q \lambda t[P(t) \oplus \begin{array}{|c|}\hline t' \\ \hline t \supset\!\prec t' \\ \hline \end{array} \oplus Q(t')](\lambda t_{put} \begin{array}{|c|}\hline e_{put} \\ \hline put(e_{put}) \\ e \subset t_{put} \\ \hline \end{array})$$
$$(\lambda t_{drink} \begin{array}{|c|}\hline e_{drink} \\ \hline make\_drink(e_{drink}) \\ e \supseteq t_{drink} \\ t_{drink} \prec n \\ \hline \end{array})$$

which gives

(88)
$$\lambda t_{put} \begin{array}{|c|}\hline t_{drink}\ e_{put}\ e_{drink} \\ \hline t_{put} \supset\!\prec t_{drink} \\ put(e_{put}) \\ e_{put} \subset t_{put} \\ make\_drink(e_{drink}) \\ e_{drink} \supseteq t_{drink} \\ t_{drink} \prec n \\ \hline \end{array}$$

Further combination with *fill* (the left part of the proof tree) and finiteness (the right part, which again is necessary for the proof of a sentence meaning) yields (89).

(89)
$$\begin{array}{|c|}\hline \mathtt{t_{fill}\ t_{put}\ t_{drink}\ e_{fill}\ e_{put}\ e_{drink}} \\ \hline \mathtt{t_{put}} \supset\!\prec \mathtt{t_{drink}} \\ \mathtt{put(e_{put})} \\ \mathtt{e_{put}} \subset \mathtt{t_{put}} \\ \mathtt{make\_drink(e_{drink})} \\ \mathtt{e_{drink}} \supseteq \mathtt{t_{drink}} \\ \mathtt{t_{drink}} \prec \mathtt{n} \\ \mathtt{t_{fill}} \supset\!\prec \mathtt{t_{put}} \\ \mathtt{e_{fill}} \subset \mathtt{t_{fill}} \\ \partial \begin{array}{|c|}\hline \mathtt{t_r} \\ \hline \rho(\mathtt{t_{fill}}, \mathtt{t_r}) \\ \hline \end{array} \\ \hline \end{array}$$

We see that we correctly get a sequence of events, with each participle providing the reference time for the next verb; only the left-most participle interacts with the context, in the sense that its reference time (t_r) must be anaphorically bound. This is an effect of the Glue logic: after consuming the participles contribution, the independent rheme construction is of the type $(T_{>} \multimap B_{\text{ADJ}\in\downarrow}) \multimap (T_{\downarrow} \multimap B_{\text{ADJ}\in\downarrow})$: this means it is looking for a sentence meaning ($B_{\text{ADJ}\in\downarrow}$) dependent on the topic time of the verb to its right ($T_{>}$) to produce a sentence meaning dependent on its own topic time ($T_{\downarrow}$).

4.4 Frames

Framing participles are like independent rhemes in many respects. They always induce narrative progression when perfective and they always set the reference time for the next verb in line. They differ, however, in that not only the time variable, but also the event must be bound or accommodated in the context. In this way it serves as the anchor for the interpretation of the event in the main clause. In contrast to the semantics of the independent rheme construction (79), the frame construction (90) introduces a presupposition/anaphoric element, as ∂ indicates.

(90) **frame:** $\lambda \mathtt{P} \lambda \mathtt{Q} [\partial [\begin{array}{|c|}\hline \mathtt{t} \\ \hline \\ \hline \end{array} \oplus \mathtt{P(t)}] \oplus \mathtt{Q(t)}] :$
$(T_{\downarrow} \multimap B_{\downarrow}) \multimap (T_{>} \multimap B_{\text{ADJ}\in\downarrow}) \multimap B_{\text{ADJ}\in\downarrow}$

Notice that the final output of this constructor differs from that of independent rhemes: the end result is a boolean type meaning, $B_{\text{ADJ}\in\downarrow}$, i.e., a meaning which is already anchored in the context without using the default **finite** constructor.

Again, narrative progression (80) can apply to the frame construction to yield (91).

(91) **narframe:** $\lambda P \lambda Q[\begin{array}{|c|}\hline t_q \\ \hline t_p \supset\!\prec t_q \\ \partial[\begin{array}{|c|}\hline t_p \\ \hline \\ \hline\end{array} \oplus P(t_p)] \\ \hline\end{array} \oplus Q(t_q)]$:

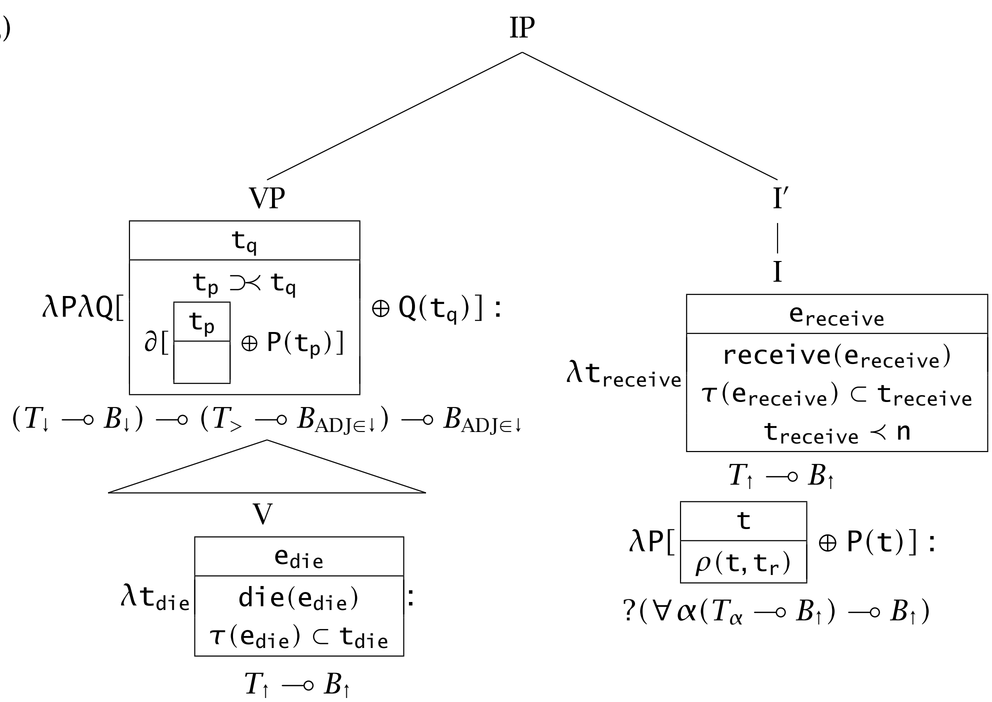
$(T_\downarrow \multimap B_\downarrow) \multimap (T_> \multimap B_{\mathrm{ADJ}\in\downarrow}) \multimap B_{\mathrm{ADJ}\in\downarrow}$

For our example (8), here repeated as (92), this gives the annotated tree in (93):

(92) (Alyattes died. Description of something he did during his life.) …

Teleutêsantos *de Aluatteô exedexato tên*
dying.PFV.PTCP.GEN PRT Alyattes.GEN receive.PST.PFV.3SG the.ACC
basilêiên Kroisos
reign.ACC Croesus.NOM
After Alyattes **died** Croesus received the reign.

(93)



The condition

(94) $$\partial[\begin{array}{|c|}\hline \mathtt{t_p} \\ \hline \\ \hline\end{array} \oplus \mathtt{P(t_p)}]$$

can informally be read as an instruction to find a time *and* an event satisfying P in the context: it instructs to bind to a time, but since (94) applies to the semantics of the participle, the instruction actually becomes binding to a time that serves as the topic time of an event of the type described by the participle, and, as such, involves finding an event. Here, with the participle *teleutêsantos* 'having died', this is a dying event.

In the semantic derivation, the lexical semantics of both verbs combine with its aspect (as well as tense for the matrix verb), and then **pfv-die**, **pfv-past-receive** and **frame** combine as in (95):

(95)
$$\dfrac{\begin{array}{c}\textbf{pfv-receive}\\ T_r \multimap B_r\end{array} \qquad \dfrac{\begin{array}{c}\textbf{frame}\\ (T_d \multimap B_d) \multimap (T_r \multimap B_r) \multimap B_r\end{array} \qquad \begin{array}{c}\textbf{pfv-die}\\ T_d \multimap B_d\end{array}}{(T_r \multimap B_r) \multimap B_r}}{B_r}$$

Notice that in this case, unlike for elaborations and independent rhemes, there is actually no room for finiteness to apply: the **frame** construction leaves a type B meaning rather than a type $T \multimap B$. The prooftree in (95) corresponds to the lambda term in (96).

(96) $$(\lambda P \lambda Q[\begin{array}{|c|}\hline \mathtt{t_q} \\ \hline \mathtt{t_p} \supset\!\prec \mathtt{t_q} \\ \partial[\begin{array}{|c|}\hline \mathtt{t_p} \\ \hline \\ \hline\end{array} \oplus \mathtt{P(t_p)}] \\ \hline\end{array} \oplus \mathtt{Q(t_q)}](\lambda \mathtt{t_{die}} \begin{array}{|c|}\hline \mathtt{e_{die}} \\ \hline \mathtt{die(e_{die})} \\ \tau(\mathtt{e_{die}}) \subset \mathtt{t_{die}} \\ \hline\end{array}))$$
$$(\lambda \mathtt{t_{receive}} \begin{array}{|c|}\hline \mathtt{e_{receive}} \\ \hline \mathtt{receive(e_{receive})} \\ \tau(\mathtt{e_{receive}}) \subset \mathtt{t_{receive}} \\ \mathtt{t_{receive}} \prec \mathtt{n} \\ \hline\end{array})$$

which reduces to

(97)
$$\begin{array}{|c|}\hline t_{receive}\ e_{receive} \\ \hline t_{die} \supset\!\prec t_{receive} \\ \partial \begin{array}{|c|}\hline e_{die}\ t_{die} \\ \hline \mathrm{die}(e_{die}) \\ \tau(e_{die}) \subset t_{die} \\ \hline \end{array} \\ \mathrm{receive}(e_{receive}) \\ \tau(e_{receive}) \subset t_{receive} \\ t_{receive} \prec n \\ \hline \end{array}$$

Since **finite** does not apply, there is no ρ relation: the temporal relation to the context is instead specified directly by the framing construction.

4.5 Summary

We have seen how the three constructions that Greek participles can enter into can be analysed in terms of constructional semantics. These constructions all share a common semantic core in that they take two sets as input and return a new set which somehow results from combining the two input sets. This can broadly be thought of as similar to inferring a discourse relation in SDRT. However, the sets combined are sets of times, rather than events as in SDRT.[30] This is because the Greek data require a temporal semantics of aspect. In particular, the simpler theory of tense and aspect often adopted in SDRT won't do. In this theory, aspect merely constraints discourse relations between events. Perfective aspect will for example be a (non-monotonic) cue for *Narration*. The problem with this approach for the Greek participles is that we *always* find narrative progression with perfective frames and independent rhemes, but *never* with perfective elaborating participles. Since these participles are distinguished syntactically, it is unwanted to leave to pragmatic reasoning what seems to be part of the compositional semantics.

5 Conclusions

The temporal interpretation of a discourse is an intricate process. The interpreter combines information from various linguistic sources (tense, aspect, verb meaning, temporal adverbs, to mention just a few) and reasons about plausible scenarios. This paper adds to the understanding of this

30 With the exception of **elab** which takes a set of events as its second input argument since it is still to combine with matrix aspect which is a function from sets of events to sets of times.

process by investigating the role of participles in the construction of the temporal structure of a discourse. We developed our theory on the basis of Ancient Greek, where participles play a particularly important role.

We have shown that it is important to make a distinction between three different functions of participles. These functions are in some respects similar to rhetorical relations in SDRT although we have only modeled their temporal dimension. Also, the effects are typically more deterministic as they are encoded in the syntax rather than coming from reasoning about scenarios.

In their function as elaborations, participles give information about the event described by the matrix verb, as independent rhemes they are very much like main clauses from an information structural point of view, and as frames their function is to anchor the matrix event in time. This difference in function is reflected in these five aspects: a difference in (1) the temporal relations with respect to the event of the matrix clause, (2) the possibilities of stacking, (3) scope relations with mood and other operators, (4) the relation to the preceding discourse (old versus new information), and (5) to the following discourse (whether the time of the participle event is available for anaphoric uptake).

We argued that the difference in function follows from a difference in syntactic position. Elaborations appear inside the I′ projection, whereas independent rhemes are adjoined to I′ and frames appear in spec, IP. From this it follows that independent rhemes but not frames can be stacked whereas elaborations can be multiplied but not stacked in the same way as independent rhemes. These differences also appear in the semantics as elaborations simply intersect temporally with their matrix verbs whereas independent rhemes leave a dependency on their own topic time, which must be anchored in the context (or provided by a participle further to the left) and frames anchor the topic time of the whole sentence leaving a complete meaning, but one dependent on resolving a presupposition. From this presuppositional effect it also follows that frames are interpreted outside the scope of mood operators, unlike independent rhemes and elaborations.

The three syntactic positions of participles are each associated with a particular constructional meaning. That of the elaboration construction relates the time of the participle event to the time of the matrix event. Crucially, no relation is established between the time of the participle event and the preceding discourse. It is rather the topic time of the matrix event that stands in a temporal relation (established on the basis of a discourse relation) to the preceding discourse.

This is different with participles functioning as independent rhemes or frames. Here we do find a relation between the participle and the preceding discourse, but the type of relation and the way in which this relation is established differ between the two types. The close similarity between participles in their function as independent rhemes and main clauses lies in the fact that the mechanisms for relating the information introduced by the participle to the preceding discourse on the one hand and to the following discourse (inside the sentence in the case of a participle, in the next sentence in the case of a main verb) on the other are very much like the mechanisms for main clauses.

Regarding the relation to the preceding discourse, the mechanism is in fact exactly the same: it is the event time of the leftmost element (participle or main verb) that looks for a time introduced before to which it stands in a temporal relation that has to be specified in the context. The relation to what follows, however, is more determinate than what we find with main clauses: whereas with main clauses the preceding clause *often* functions as the antecedent, this is not always the case: they can be skipped, which is impossible for independent rheme participles. This means that in a sequence of independent rheme participles each participle functions as the antecedent for the interpretation of the participle or matrix verb to its right. Similarly, whereas with a sequence of perfective main clauses we often, but not always, have narrative progression, we always find it with independent rheme participles. In both respects participles expose a grammaticalised version of phenomena we find at discourse level and we modeled this in our account.

The relation that framing participles establish with the context is different in two respects. First, it is not the topic time of the participle event that looks for an antecedent, but the event itself. And second, this event is *identified* with a previously introduced event rather than linked to it via some rhetorical relation. As a result, with framing participles there is a very close connection to the preceding discourse. We modeled this as a presupposition. The relation to the matrix clause is the same as with independent rhemes. The function of framing participles as locators in time of the matrix event follows directly from the fact that they refer to events that are known already.

The combination of LFG and CDRT using Glue semantics made it possible to provide an analysis of these phenomena all the way from syntax to discourse incorporating both intersentential and intrasentential binding. The latter is captured via explicit meaning constructors for the various constructions that participles can enter into: the governing verb for elaborations, the verb to the left for frames, independent rhemes and matrix verbs. Only in the case that there is no intrasentential time to bind to will finiteness do its work and provide for intersentential binding, exploiting the underlying dynamic semantics.

Our work can be extended in various directions. As we have mentioned, the syntactic placement of participles that we find in Ancient Greek is largely driven by information structure. By combining our theory with a formal model of information structure interfacing with syntax and prosody on the one hand and semantics on the other, the account could be extended to other phenomena, perhaps signalled by other means in other languages. *Framing* in particular is not something restricted to Ancient Greek, but rather appears to be a mechanism for improving discourse cohesion in many languages. It is also not restricted to free adjunct participles, but certainly appears with other types of adverbials, in particular temporal ones. The semantics we have developed for **frame** generalize nicely to these, and in fact to all items that can be analyzed as descriptions of time intervals.

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