

# Against Lexical Decomposition in Syntax\*

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## 1 Introduction

This article is concerned with the ambiguity that arises if a resultative predicate is modified by the adverb *again*. Intuitively, the semantics of the adverb either operates on the event type expressed by the main predicate, or on its result state type. This effect is illustrated in (1):

(1) John opened the window again

In its *repetitive* reading, (1) presupposes that Peter had already opened the window once before. In the *restitutive* reading, it is only presupposed that the window was open at some time before the described event. In several languages, this ambiguity can be partially resolved by means of word order or intonation.

This paper consists of two parts. In the first part, we will briefly review existing accounts of this ambiguity. It will be demonstrated that it cannot be reduced to a scope ambiguity on some

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abstract level of representation. Instead we will propose a treatment that assumes syntactic integrity of lexical items. It makes crucial use of a Davidsonian semantics both of eventive and stative predicates.

The second part deals with the partial resolution of the ambiguity by means of word order and intonation in German. We will argue that this is the result of a process of pragmatic strengthening, a mechanism that selects optimal candidates from a highly underspecified relation between form and meaning. It makes use of the evaluation mechanism of Optimality Theory but differs from the standard picture in taking both the hearer perspective and the speaker perspective into account.

## 2 The problem

As was mentioned in the beginning, the adverb *again* triggers a characteristic ambiguity between a repetitive and a restitutive reading if it co-occurs with a resultative predicate. Let us take (2) as an example.

(2) Henry cleaned the kitchen again

In its repetitive reading, it is presupposed that it wasn't the first time that Henry cleaned the kitchen. This may be paraphrased as in (3).<sup>1</sup> The relation "<" expresses temporal precedence. Material behind the colon represents presuppositions, so " $\phi : \psi$ " asserts  $\phi$  and presupposes  $\psi$ .

(3)  $\lambda i.$ CLEAN( $i$ , H, THE\_KITCHEN) :  $\exists j < i$ (CLEAN( $j$ , H, THE\_KITCHEN))

Besides, (2) has a restitutive reading where it is only presupposed that the kitchen had been clean before:

(4)  $\lambda i.$ CLEAN( $i$ , H, THE\_KITCHEN) :  $\exists j < i$ (IS\_CLEAN( $j$ , THE\_KITCHEN))

The same kind of ambiguity arises with an achievement predicate like *to reach the surface*. Sentence (5a) has the readings (5b) and (5c).

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<sup>1</sup>Throughout the paper, we use " $i, j, \dots$ " as variables over time intervals, " $e, e', e_1, e_2, \dots$ " as variables over events, and " $s, s', s_1, s_2, \dots$ " as variables over states.

- (5) a. The diver reached the surface again  
 b.  $\lambda i. \text{REACH}(i, \text{DIVER}, \text{SURFACE}) : \exists j < i(\text{REACH}(j, \text{DIVER}, \text{SURFACE}))$   
 c.  $\lambda i. \text{REACH}(i, \text{DIVER}, \text{SURFACE}) : \exists j < i(\text{IS\_AT}(j, \text{DIVER}, \text{SURFACE}))$

In German, word order and intonation may be exploited to disambiguate these constructions. There is a general agreement that the underlying word order in German is SOV, which is reflected in the surface structure of embedded clauses, while this pattern is blurred in main clauses by V2. So we will restrict attention to embedded clauses. In the German counterpart of a sentence like (1), the adverb *wieder* (“again”) may occur either between subject and object (as in (6a) and (6b)) or between object and verb (cf. (6c) and (6d)). In the unmarked intonation, the main stress usually falls on the object if it is adjacent to the verb (cf. (6a)) and on the verb otherwise (cf. (6c)). The sentence accent may be shifted to the adverb *wieder* however, resulting in de-accenting of both object and verb (6b,d)).

- (6) a. ? (weil) Hans wieder das **Fenster** öffnete  
 HANS AGAIN THE **WINDOW** OPENED  
 b. (weil) Hans **wieder** das Fenster öffnete  
 HANS **AGAIN** THE WINDOW OPENED (repetitive)  
 c. (weil) Hans das Fenster wieder **öffnete**  
 HANS THE WINDOW AGAIN **OPENED** (restitutive)  
 d. (weil) Hans das Fenster **wieder** öffnete  
 HANS THE WINDOW **AGAIN** OPENED (repetitive)  
 ‘Hans opened the window again’

None of the four patterns given in (6) is ambiguous. Without a specific contextual setting, (6a) is deviant. In (6b,d), the repetitive reading is clearly preferred, while (6c) only admits the restitutive reading.<sup>2</sup> So the patterns that arise may be summarized by the following descriptive generalizations:

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<sup>2</sup>These facts were first discussed in Fabricius-Hansen 1983.

1. Unmarked intonation goes with the restitutive reading, while main accent on *wieder* leads to the repetitive interpretation.
2. The restitutive reading obtains if the adverb precedes the object. If the object precedes the adverb, the repetitive reading is preferred.

### 3 Decomposition approaches

In Generative Semantics, the ambiguity in question was used as an argument for lexical decomposition of achievements at an underlying of syntactic representation (cf. McCawley 1971 and Morgan 1969). According to this view, the underlying representation of (7a) and (b) is (7c) and (d) respectively.

- (7)
- a. John opened the window again
  - b. The diver reached the surface again
  - c. [<sub>S</sub> [<sub>NP</sub> John] [<sub>VP</sub> CAUSE [<sub>S</sub> BECOME [<sub>S</sub> [<sub>NP</sub> the window] be\_open ]]]]
  - d. [<sub>S</sub> BECOME [<sub>S</sub> [<sub>NP</sub> the diver] [<sub>VP</sub> be\_at [<sub>NP</sub> the surface]]]]]

If we assume that *again* may attach both to the matrix S-node and to embedded S-nodes, the two readings of (1) naturally correspond to two different underlying scope positions of the adverb.

- (8)
- a. [<sub>S</sub> Again [<sub>S</sub> [<sub>NP</sub> John] [<sub>VP</sub> CAUSE [<sub>S</sub> BECOME [<sub>S</sub> [<sub>NP</sub> the window] be\_open ]]]]]]
  - b. [<sub>S</sub> [<sub>NP</sub> John] [<sub>VP</sub> CAUSE [<sub>S</sub> BECOME [<sub>S</sub> again [<sub>S</sub> [<sub>NP</sub> the window] be\_open ]]]]]]

A similar story can be told about (5), where *again* may be attached either above or below *BECOME*.

With this syntactic background, the desired readings can easily be derived in a compositional way if we assume that the meaning of *again* is as in (9), i.e. *again* does not affect the assertion of the sentence, and it triggers a presupposition that the proposition in its scope has been true at some time before the evaluation time.<sup>3</sup>

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<sup>3</sup>We have to add the unproblematic assumption that *CAUSE* and *BECOME* are transparent for presupposition projection.

$$(9) \lambda p \lambda i . p(i) : \exists j < i(p(j))$$

In sum, lexical decomposition of resultative predicates into “BECOME + result state” or “CAUSE + BECOME + result state” allows us to reduce the ambiguity of *again* to a mundane scope ambiguity—if *BECOME* takes scope over *again*, we get the restitutive reading, otherwise the repetitive one. We thus expect that no ambiguity arises if such a decomposition is impossible, for instance in the case of stative predicates. This is in fact born out; the only reading of (10a) is the one in (10b), as one would expect given the lexical meaning (9) for *again*.

(10) a. John is in Israel again.

$$b. \lambda i . \text{IS\_IN}(i, J, \text{ISRAEL}) : \exists j < i(\text{IS\_IN}(j, J, \text{ISRAEL}))$$

The basic idea of the Generative Semantics style explanation was revived in von Stechow 1996, where it is combined with a modern syntactic analysis. Since it is impossible to do full justice to the merits of von Stechow’s overall program within the limits of this paper, we restrict discussion to those aspects that are of immediate relevance to the issues discussed here. Simplifying somewhat, von Stechow analyzes the semantic building blocks of Generative Semantics as lexical or functional heads in the sense of X-bar theory. *BECOME* is syntactically realized as Verb and the predicate of the result state (BE\_OPEN in (7a)) as some lexical head  $X^0$ , while—following a proposal from Kratzer 1994—*CAUSE* is a possible interpretation of the head of a projection called “VoiceP” that embeds the highest VP shell. VoiceP in turn is dominated by AgrOP, TP and AgrSP. Crucially, von Stechow assumes that both subject and object are moved to their respective SpecAgr positions on S-structure. Furthermore, *CAUSE*, *BECOME* and the result predicate are composed to a lexical unit via head movement on S-structure. Ignoring the latter part as inessential for our discussion, the S-structure for (11) is as in the figure on the next page.

(11) (weil) John das Fenster öffnete

JOHN THE WINDOW OPENED

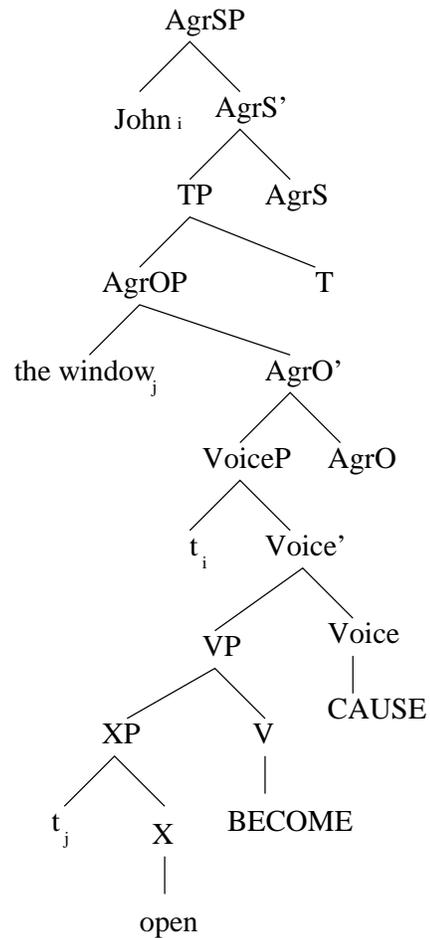
The adverb *wieder* (“again”) may be adjoined to any maximal projection in this structure. So as in the structures assumed by generative semanticists, we expect a scope ambiguity depending on whether the adverb is attached higher or lower than *BECOME*. If

*wieder* (“again”) is attached to AgrSP, TP, AgrOP or VoiceP, we expect the repetitive reading, while adjunction to XP leads to the restitutive interpretation.

Since the object moves obligatorily to SpecAgrO, the scope of *wieder* may partially read off from the surface word order. If the adverb occurs between subject and object, it must be adjoined either to TP or to AgrOP. Both structures lead to the repetitive reading. A surface position of the adverb between object and verb, on the other hand, corresponds either to adjunction to VoiceP (repetitive reading) or to XP (restitutive reading). So the latter word order is predicted to be ambiguous. In other words, von Stechow’s analysis is able to derive the second generalization given above concerning disambiguation by word order in German.

To summarize so far, lexical decomposition in the style of Generative Semantics has three advantages for the analysis of the behavior of *again*: It gives a principled explanation for the repetitive/restitutive ambiguity which is easily incorporated into a general framework of compositional interpretation, it can do so without stipulating a lexical ambiguity of *again*, and it is able to account for disambiguating word order effects. These merits have to be contrasted with some shortcomings, however, that will ultimately lead us to reject it *in toto*.

To start with, an analysis of *again* in terms of scope leads to over-generation. As the careful reader probably already noticed, both the classical Generative Semantics analysis and von Stechow’s modified version do not predict a twofold but a threefold ambiguity of sentences like (1): the adverb may take scope both *CAUSE* and *BECOME* (repetitive reading), it may be scoped out by both operators (restitutive reading), but it should also be able to take scope between *CAUSE* and *BECOME*. The GS-style structure is given below:



(12) [<sub>S</sub> John CAUSE [<sub>S</sub> again [<sub>S</sub> BECOME [<sub>S</sub> the window open]]]]

So (1) should have a reading where it is presupposed that the window opened before, but not necessarily due to an action by John. This interpretation does not exist though.

This over-generation can possibly be dealt with by means of additional restrictions. By taking the interaction *again* with indefinites under consideration, we will find a case of under-generation that is less easily accommodated.

Let us start to look at indefinite objects. Here the prediction of the decomposition analysis are borne out. Consider the sentence

(13) John opened a window again

If we grant that the position between *CAUSE* and *BECOME* is not a possible attachment site, we expect six readings since the sentence contains three scope inducing elements, *CAUSE/BECOME*, *again* and *a window*. The ambiguity arising from different relative scopes of *CAUSE/BECOME* and *a window* is hard to detect though, so we are left with four readings:

- (14) a. [<sub>S</sub> John CAUSE [<sub>S</sub> BECOME [<sub>S</sub> again [<sub>S</sub> a window open]]]]  
b. [<sub>S</sub> [a window]<sub>x</sub> [<sub>S</sub> John CAUSE [<sub>S</sub> BECOME [<sub>S</sub> again [<sub>S</sub> x open]]]]]]  
c. [<sub>S</sub> again [<sub>S</sub> John CAUSE [<sub>S</sub> BECOME [<sub>S</sub> a window open]]]]  
d. [<sub>S</sub> [a window]<sub>x</sub> [<sub>S</sub> again [<sub>S</sub> John CAUSE [<sub>S</sub> BECOME [<sub>S</sub> x open]]]]]]

These four readings do in fact exist. The object *a window* may be either specific (as in (14b,d)) or unspecific (14a,c), and *again* may be repetitive (c,d) or restitutive (a,b). Note that in those readings where *again* takes scope over the indefinite ((14a) and (c)), the presupposition of the sentence is “about” another window than the assertion. In (14a) it is presupposed that some window was open in the past, and (14c) requires that John opened some window before. In either case, it need not be the window of which it is asserted that John opened it.

Now let us turn attention to indefinite subjects. In this connection, those causative verbs where the agent is a component of the result state deserve special attention. Examples of this verb class are *to settle* or *to enter*. Under the decomposition analysis, constructions headed by these verbs have a subject control structure, i.e. the subjects of the main clause and of the most embedded clause are coreferent.

- (15) a. John settled in New Jersey  
 b. John entered the stage  
 c. [<sub>S</sub> John CAUSE [<sub>S</sub> BECOME [<sub>S</sub> John [<sub>VP</sub> live in New Jersey]]]]  
 d. [<sub>S</sub> John CAUSE [<sub>S</sub> BECOME [<sub>S</sub> John [<sub>VP</sub> be on the stage]]]]

Now let us add *again* and replace the subject by an indefinite:

- (16) a. A Delaware settled in New Jersey again  
 b. [<sub>S</sub> again [<sub>S</sub> [<sub>NP</sub> a Delaware]<sub>x</sub> [<sub>S</sub> *x* CAUSE BECOME [<sub>S</sub> *x* live in New Jersey]]]]  
 c. [<sub>S</sub> [<sub>NP</sub> a Delaware]<sub>x</sub> [<sub>S</sub> again [<sub>S</sub> *x* CAUSE BECOME [<sub>S</sub> *x* live in New Jersey]]]]  
 d. [<sub>S</sub> [<sub>NP</sub> a Delaware]<sub>x</sub> [<sub>S</sub> *x* CAUSE BECOME [<sub>S</sub> again [<sub>S</sub> *x* live in New Jersey]]]]

Since the indefinite *a Delaware* binds the subject argument place of *CAUSE*, it must take scope over *CAUSE*, and thus also over *BECOME*. So while lexical decomposition correctly predicts four readings for (13), it only admits the three readings for (16a) that are given in (b), (c) and (d). There should be no reading corresponding to (14a) for (16a), i.e. a restitutive reading where the presupposition is about another Delaware than the assertion. Its meaning representation is given in (17).

$$(17) \lambda i. \exists x (\text{DELAWARE}(x) \wedge \text{SETTLE\_IN}(i, x, \text{NJ})) : \\ \exists j < i \exists y (\text{DELAWARE}(y) \wedge \text{LIVE\_IN}(j, y, \text{NJ}))$$

All our informants agree that this reading does in fact exist though. Imagine the following scenario: The Delaware tribe was created in the area of New Jersey at the beginning of time. They never left the area until 200 years ago when they were forced into a reservation in Oklahoma. Recently, a member of the tribe moved to the home of his ancestors. In this setup, (16a) would be true and its presupposition fulfilled even though no Delaware settled in New Jersey before, and no Delaware lived there twice.

Under the decomposition approach, this reading poses a scope paradox since 1. the indefinite must take scope over *CAUSE/BECOME* because it binds an argument place of *CAUSE*, 2. *BECOME* must take scope over *again* since we are dealing with a restitutive reading, and 3. *again*

must take scope over the indefinite since presupposition and assertion are about different individuals.

There are two possible strategies how this reading can be accommodated in a decompositional framework. First, one might wonder whether *to settle* is in fact causative. If it is only to be decomposed into *BECOME* and *live in*, the scope paradox does not arise. If this were the case, however, the forced deportation of the Delawares to Oklahoma 200 years ago could be truthfully described by *The Delawares settled in Oklahoma*. According to our intuitions, this is not the case.

Alternatively, one might argue that the source of the existential quantifier(s) is not the indefinite article but some operation of existential closure that binds all free variables in its scope. This is how existential indefinites are treated in DRT. Under this perspective, the reading in (17) might be taken as an indication that existential closure applies to presupposition and assertion separately. However, the latter hypothesis is falsified by readings like (14b) or (d) where a single existential quantifier binds variables occurrences both in the assertion and in the presupposition. These considerations lead us to the conclusion that the scope paradox problem is in fact inherent to the decomposition approach as such and does not depend on further particular assumptions about the syntax-semantics interface. An alternative analysis has to be found.

## 4 A Davidsonian analysis

Two of the three steps that led to the scope paradox above seem impeccable:

1. In the reading (17) the indefinite subject takes scope over the whole verb—no matter whether it is decomposed or not. Otherwise it could not fill the subject argument place.
2. The adverb *again* takes scope over the subject. This is the only conceivable way how the separate existential quantification in assertion and presupposition can be derived compositionally.

This in mind, there is no choice but to give up the third step, namely the assumption that a restitutive reading arise iff *again* is in the scope of *BECOME*. Rather, the scope relations in the reading in question are like

(18) AGAIN( $\exists x(\text{DELAWARE}(x) \wedge \text{SETTLE\_IN}(x, \text{NJ}))$ ))

This is exactly as in the repetitive reading (16b). So we are forced to assume that *again* is in fact lexically ambiguous between a repetitive and a restitutive reading which are not distinguished scopally.

So next to the repetitive reading of *again* that was given in (9) and is repeated in (19a), we have to assume a lexically restitutive reading that is sketched in (b).

- (19) a.  $\lambda p \lambda i. p(i) : \exists j < i(p(j))$   
b.  $\lambda p \lambda i. p(i) : \exists j < i(\text{RESULT}(p)(j))$

The function constant RESULT is assumed to be interpreted as a function *result*. What are the properties of this function? The first idea that comes to mind is roughly the following: *result* is a function from propositions (i.e. sets of world/time-interval pairs) to propositions, and *result*(*p*) is the most specific proposition that is always true after in an interval immediately following an interval where *p* was true. This first attempt will not do, however. To derive the restitutive reading of (1) correctly, we have to demand that the result of “John opening the window” is “the window being open”. After an event of John opening the window, it is certainly true that the window is open, but it is also true that the window has been opened by John. So in the restitutive reading, (1) would presuppose that the window is open as a result of John opening it before, and thus the restitutive reading would coincide with the repetitive one.<sup>4</sup> We take this problem as an indication that an analysis of actions, states etc. in terms of world/time pairs is too extensional in a sense: even if two event types are extensionally equivalent at all indices, their result states might still differ.

A Davidsonian semantics seems more promising since there intensionally equivalent event types might still be distinct. Following Davidson 1967, we assume that all eventive predicates have an event argument, and we extend this strategy to stative predicates. Furthermore we postulate a relation *R* between event and states that holds between an event *e* and a state *s* iff *s* is a potential result state of *e*. Another paraphrase might be “the postconditions of *e* hold in *s*”. Note that

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<sup>4</sup>This objection can be raised against the model theoretic approaches of Dowty 1979 and Fabricius-Hansen 1983 too.

we do not demand that  $s$  is in fact a result of  $e$  or that  $s$  follows  $e$  temporally. To return to the example, we postulate that  $R$  relates *any* event of the type “John opening the window” to one state of the type “the window being open”, and any state of the latter type is related to one event of the former type by  $R$ . The interpretation of RESULT may now be construed as<sup>5</sup>

$$(20) s \in \|\text{RESULT}(\phi)\| \text{ iff } \exists e R s : e \in \|\phi\|$$

The two lexical entries for *again* in (17) remain unchanged except that  $i, j$  have to be replaced by variables over eventualities.

If we adopt Davidson’s conception of events whereas “ $\exists e.Pe$ ” is to be interpreted as “An event of type  $P$  **occurs**”, this definition of the result function is still inappropriate, for the following reason. Take example (13) in its restitutive reading (the indefinite having narrow scope). Its logical form is

$$(21) \lambda e. \exists x (\text{WINDOW}(x) \wedge \text{OPEN}(e, J, x)) : \\ \exists s < e (\text{RESULT}(\lambda e. \exists x (\text{WINDOW}(x) \wedge \text{OPEN}(e, J, x)))(s))$$

According to Theorem 1 (given in the appendix), the RESULT function commutes with restricted existential quantifiers, so the presupposition part is equivalent to

$$(22) \exists s < e \exists x (\text{WINDOW}(x) \wedge \text{RESULT}(\text{OPEN}(J, x))(s))$$

The relation between “John opening the window” and “the window being open” is formalized as a meaning postulate

$$(MP1) \quad \forall x \forall y \forall s (\text{IS\_OPEN}(s, y) \leftrightarrow \text{RESULT}(\text{OPEN}(x, y))(s))$$

Applying this to (22) yields the desired

$$(23) \exists s < e \exists x (\text{WINDOW}(x) \wedge \text{IS\_OPEN}(s, x))$$

This far everything works out properly. But now consider the presupposition part of (21) again. By simple first order reasoning, it is equivalent to

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<sup>5</sup>The technical details of the model theory and the syntax of the representation language are deferred to the appendix A.

$$(24) \exists s < e(\text{RESULT}(\lambda e.\exists x(\exists e'(\text{WINDOW}(x) \wedge \text{OPEN}(e', J, x)) \wedge \text{OPEN}(e, J, x)))(s))$$

Applying Theorem 1 and MP1 here yields

$$(25) \exists s < e(\exists x(\exists e'(\text{WINDOW}(x) \wedge \text{OPEN}(e', J, x)) \wedge \text{IS\_OPEN}(s, J, x)))$$

Under the Davidsonian interpretation, this says that a window that was opened, is opened or will be opened is open—a much stronger proposition than the one we are looking for. Even worse, by the same kind of reasoning it can be shown that a window is open iff there is an event of it being opened.

This problem can be overcome if we adopt a more abstract notion of “event”. According to Davidson, events are entities that occur in the world. Instead we propose to view events as pieces of pure information like states of affairs in Situation Semantics. They have participants, possibly temporal and local parameters and so on, but they may or may not obtain in reality. (A better term than just “event” might be “conceivable event”). Under this abstraction notion of event, nothing is wrong with the claim that for every open window there is an event of this window being opened. Events that do take place in the real world form a proper subset of the set of abstract events. They are the extension of a predicate constant OBTAINS. (The same holds *ceteris paribus* for states). This in mind, the two lexical entries for *again* have to be modified to

$$(26) \quad \text{a. } \lambda p \lambda e.p(e) : \exists e' < e(\text{OBTAINS}(e) \wedge p(e')) \text{ (repetitive)}$$

$$\quad \text{b. } \lambda p \lambda e.p(e) : \exists s < e(\text{OBTAINS}(s) \wedge \text{RESULT}(p)(s)) \text{ (restitutive)}$$

Now (skipping over inessential features like tense) the logical form of the two readings of (1) will come out as

$$(27) \quad \text{a. John opened the window again}$$

$$\text{b. } \exists e(\text{OBTAINS}(e) \wedge \text{OPEN}(e, J, \text{THE\_WINDOW}) : \left. \begin{array}{l} \left\{ \begin{array}{l} \exists e' < e(\text{OBTAINS}(e') \wedge \text{OPEN}(e', J, \text{THE\_WINDOW})) \\ \exists s < e(\text{OBTAINS}(s) \wedge \text{RESULT}(\text{OPEN}(J, \text{THE\_WINDOW}))(s)) \end{array} \right\} \end{array} \right\}$$

(We leave the issue open where exactly the conjunct “OBTAINS(*e*)” comes in and where the event argument is bound. In a GB-style setup,  $C^0$  would be a plausible candidate for this

function.) By the reasoning given above, the presupposition of the second, restitutive reading can be simplified by using MP1 to

$$(28) \exists s < e(\text{OBTAINS}(s) \wedge \text{IS\_OPEN}(s, \text{THE\_WINDOW}))$$

Next we consider example (13). The two readings where the indefinite object has scope over *again* are analogous to the previous example, so we restrict ourselves to the two readings where *a window* has narrow scope:

(29) a. John opened a window again

$$\text{b. } \exists e(\text{OBTAINS}(e) \wedge \exists x(\text{WINDOW}(x) \wedge \text{OPEN}(e, \text{J}, x)) : \left. \begin{array}{l} \left\{ \begin{array}{l} \exists e' < e(\text{OBTAINS}(e') \wedge \exists x(\text{WINDOW}(x) \wedge \text{OPEN}(e', \text{J}, x)) : \\ \exists s < e(\text{OBTAINS}(s) \wedge \text{RESULT}(\lambda e. \exists x(\text{WINDOW}(x) \wedge \text{OPEN}(e, \text{J}, x)))(s)) \end{array} \right\} \end{array} \right\}$$

As in the previous example, the presupposition of the restitutive reading can be simplified further (using MP1 and Theorem 1). It turns out to be equivalent with

$$(30) \exists s < e(\text{OBTAINS}(s) \wedge \exists x(\text{WINDOW}(x) \wedge \text{IS\_OPEN}(s, x)))$$

So we correctly predict the restitutive non-specific reading to presuppose that some window was open in the past.

We conclude this discussion with example (16a), the construction that proved difficult for the decomposition approach. Again we only consider the readings where *again* takes scope over the indefinite. Quite similar to the previous example, the two logical forms for the repetitive and the restitutive readings are

(31) a. A Delaware settled in New Jersey again

$$\text{b. } \exists e(\text{OBTAINS}(e) \wedge \exists x(\text{DELAWARE}(x) \wedge \text{SETTLE\_IN}(e, x, \text{NJ}))) : \left. \begin{array}{l} \left\{ \begin{array}{l} \exists e' < e(\text{OBTAINS}(e') \wedge \exists x(\text{DELAWARE}(x) \wedge \text{SETTLE\_IN}(e', x, \text{NJ}))) \\ \exists s < e(\text{OBTAINS}(s) \wedge \text{RESULT}(\lambda e. \exists x(\text{DELAWARE}(x) \wedge \text{SETTLE\_IN}(e, x, \text{NJ}))))(s)) \end{array} \right\} \end{array} \right\}$$

Analogously to MP1, we assume a meaning postulate that guarantees that the result of settling somewhere is living there.

(MP2)  $\forall x \forall x' \forall s (\text{LIVE\_IN}(s, x, y) \leftrightarrow \text{RESULT}(\text{SETTLE\_IN}(x, y))(s))$

Using MP2 and Theorem 1, the presupposition of the restitutive reading may equivalently be written as

(32)  $\exists s < e (\text{OBTAINS}(s) \wedge \exists x (\text{DELAWARE}(x) \wedge \text{LIVE\_IN}(s, x, \text{NJ})))$

i.e. in the critical reading, the sentence presupposes that some Delaware used to live in New Jersey before.

To conclude this discussion, our main conclusions up to this point can be summarized as follows: 1. The ambiguity of *again* can not be reduced to a structural ambiguity, since this assumption leads to a scope paradox. In both readings, *again* takes scope over the entire matrix verb and its arguments. 2. Since the two readings of *again* occupy the same structural positions, the assumption of a lexical ambiguity (or underspecification) is inevitable. While this is compatible with a decompositional view, it undermines one of the prime motivations for this strategy. 3. Neither Montagovian/Dowtyan possible-world semantics nor Davidsonian event semantics employs a notion of meaning that is fine-grained enough to derive the restitutive reading in all cases in a compositional way. This goal can be achieved though if Davidsonian events are interpreted in an information based manner, as pieces of information that may or may not be realized by actual events.

## 5 German word order effects

A major advantage of a structural/decompositional analysis of the behavior of *again* is the fact that it offers a principled explanation of the German word order effects illustrated in (6). If the ambiguity in question is a lexical one—as we assume here—this disambiguating effect of syntactic patterns seems mysterious.

A closer inspection of the data reveals, however, that the connection between word order and intonation on the one hand and interpretation on the other hand is less tied than one would expect if it were a consequence of the mechanics of the syntax/semantics interface in the narrow sense. Recall that von Stechow’s framework predicts that a word order “subject > again > object > verb” in German invariably results in the repetitive reading of *again*. But this is true only if the

object is definite. With an indefinite object, both readings are possible. Disambiguation is done only by intonation.

- (33) a. (weil) Hans wieder ein **Fenster** öffnete  
HANS AGAIN A **WINDOW** OPENED (restitutive, AGAIN > ∃)
- b. (weil) Hans **wieder** ein Fenster öffnete  
HANS **AGAIN** A WINDOW OPENED (repetitive, AGAIN > ∃)  
'Hans opened a window again'

Both readings of *again* are possible in this word order, but in either case, *again* takes scope over the indefinite object. To express the readings where the object takes scope over *again*, the order of object and adverb have to be reversed.

- (34) a. (weil) Hans ein Fenster wieder **öffnete**  
HANS A WINDOW AGAIN **OPENED** (restitutive, ∃ > AGAIN)
- b. (weil) Hans ein Fenster **wieder** öffnete  
HANS A WINDOW **AGAIN** OPENED (repetitive, ∃ > AGAIN)  
'Hans opened a window again'

So it seems that the relative scope of adverb and object is always made transparent by overt word order. Word order can be utilized to disambiguate *again* only if no scope ambiguity is pending.

So the picture that arises is this: Anything else being equal, the word order "again > object" has a preference for the repetitive reading. This preference can be ignored if other factors are not equal; if word order can be used to make scope transparent, it has to.

## 6 Bi-directional optimality

In the previous section we have shown that word order in German is subject to different constraints that may be in conflict with each other. In this case, one of the constraints can be violated. Since this conception of competing and violable constraints is the brand mark of Optimality Theory, this framework seems promising to account for the disambiguating effects of

formal grammatical parameters in German. Before we attempt an analysis in this way, some general remarks about the application of Optimality Theory (“OT” henceforth) are in order.

Generally speaking, OT provides a mechanism to select a set of optimal candidates from a larger set of candidates. In phonological theory, where OT was initially applied to, this set of candidates are potential surface realizations of a single underlying form. In other words, in phonological applications OT is considered to be part of the generation function. Applying this perspective to syntax/semantics, this means that the OT mechanism selects among the possible verbalizations of a given meaning. A certain form/meaning pair  $\langle \pi, \lambda \rangle$  is blocked iff there is a form  $\pi'$  such that the pairing  $\langle \pi', \lambda \rangle$  is more economical than  $\langle \pi, \lambda \rangle$  (provided both pairings obey the hard constraints posed by the grammar). The ranking of candidates is calculated from the number and rank of constraints that are violated. This kind of blocking is arguably pervasive in natural language. A typical example is given below.

- (35) a. John ate chicken  
b. ?John ate pig  
c. John ate pork

As (35a) illustrates, there is a general lexical rule operative in English shifting the meaning of names of animals to meat from such animals. This rule must not be applied though if there is a lexicalized expression for the meat of an animal (like *pork* for the meat of pigs). This falls out in an OT like treatment if we assume that the application of the meaning shift comes with a cost, i.e. violates a constraint. Both (35a) and (b) violate this constraint, but only for (b) there is a form alternative that avoids this violation. So (a) is optimal, but (b) isn't.

With equal right one can argue that such an optimization strategy is used in the parsing direction. If an expression is potentially ambiguous but one reading is more economical/coherent/informative than the other, then the more expensive interpretation is blocked. A typical example is the interpretation of local presupposition. Consider the following example:

- (36) If Peter has a cat, then his cat is grey

Structurally, this sentence is ambiguous, depending on whether the existential presupposition triggered by *his cat* is bound by the protasis of the conditional or accommodated globally. In

the latter reading, the sentence would mean *Peter has a cat x, and if Peter has a cat, then x is gray*. Since binding of presuppositions is arguably preferable to accommodation (cf. van der Sandt 1992; Blutner 1999), the latter reading is blocked and the sentence is perceived as non-ambiguous.

So to apply OT to the syntax/semantics interface, both speaker direction and hearer direction should be taken into account. A grammatically licit form/meaning pair  $\langle \pi, \lambda \rangle$  may be blocked both by a more economical form alternative and a more economical meaning alternative. It should be added that a blocking expression should itself be optimal. So we arrive at the following definition of bi-directional optimality (where **GEN** is the set of grammatically licit form/meaning pairs):

**Definition 1 (Optimality)**

$\langle \pi, \lambda \rangle$  is optimal iff

1.  $\langle \pi, \lambda \rangle \in \mathbf{GEN}$ ,
2. there is no optimal  $\langle \pi', \lambda \rangle \in \mathbf{GEN}$  such that  $\langle \pi', \lambda \rangle < \langle \pi, \lambda \rangle$ , and
3. there is no optimal  $\langle \pi, \lambda' \rangle \in \mathbf{GEN}$  such that  $\langle \pi, \lambda' \rangle < \langle \pi, \lambda \rangle$ .

For a more detailed discussion of the formal properties and further applications of this notion of optimality, the reader is referred to Blutner 1998, 1999. The definition given there is conceptually somewhat different but provably equivalent to the one used here (cf. Appendix B).

## 7 Application to *wieder*

In this section we will propose an optimality-based account for the syntax/semantics map in the German examples with *wieder* (“again”) and either a definite or an indefinite object, i.e. (6a-d), (33a,b), and (34a,b).

We follow standard assumptions about German syntax in assuming that there are two s-structural positions for objects: a base position inside VP, and a target position for scrambling. Sentence adverbials are placed between these two positions and may thus be used as indicator for scrambling (cf. Diesing 1992 and much subsequent work). We take it that *wieder* behaves like other

adverbials in this respect. So the effects under considerations should fall out from general constraints on scrambling in German.

To start with, definiteness plays a prominent role as a trigger for scrambling (cf. Lenerz 1977; Reis 1987; Müller 1998 and many others). This may be formulated as the following constraint:<sup>6</sup>

**DS: Definites scramble!**

This constraint is violated by (6a,b) in both readings.

Furthermore, scrambling is exploited to make scope relations transparent. We assume a corresponding constraint

**SC: Surface word order mirrors scope relations!**

Again, this is likely to be a corollary of more fundamental constraints, but it will do for the purposes of this discussion. It is violated by the object-wide-scope readings of (33a,b) and the object-narrow-scope readings of (34a,b).

Finally, we assume that the interaction of intonation and interpretation is due to anaphoric de-accenting. Roughly, a constituent is to be de-accented if and only if it is given in the context (for a precise definition of “givenness” see Schwarzschild 1999). We restrict attention here to empty contexts, so one might expect that every stressed constituent violates this requirement. However, an empty context requires accommodation of the presupposition induced by *again*, and the accommodated material is to be considered as given.

Strictly speaking, there are two constraints at work here. First, it is required that given constituents are de-accented. This is an instance of a more general constraint—proposed by Williams 1997—to the effect that anaphoric possibilities must be seized.

**DOAP: Don’t overlook anaphoric possibilities!**

To figure out which form/meaning pairs violate it, we have to look at each constituent separately. First of all, in all examples under consideration, the object (*the window* or *a window*) is given by the presupposition, no matter whether we take the repetitive or the restitutive reading.

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<sup>6</sup>This does not exclude the possibility that it can be reduced to more fundamental constraints, cf. Reinhart 1995.

Thus DOAP is violated wherever the object is accented, i.e. (6a) and (33a) in all their possible readings. Further, the verb *opened* is always given in the repetitive reading, but never in the restitutive reading. So DOAP is violated by all candidates with a repetitive reading and an accent on the verb ((6c), (34a), the latter in both scope readings). Finally, the constituent “object+verb” too is given in all repetitive but in no restitutive reading. There are two way how this may lead to a violation of DOAP; either the object carries an accent (as in all repetitive readings of (6a) and (33a)), or the complex “object+verb” does not form a constituent at all since the object is scrambled (as in (6c,d) and in (34a,b)).

Last but not least, anaphoric de-accenting of new material is prohibited as well. Modifying Schwarzschild’s 1999 formulation somewhat, the corresponding constraint is

**GIVEN: De-accented constituents are given!**

It is violated whenever de-accenting is not licensed by the presupposition. In our sample, this is the case in all restitutive readings of examples where 1. the verb is de-accented ((6b,d),<sup>7</sup> (33b) and (34b)) or where 2. “object+verb” form a de-accented constituent ((6b) and (33b)).

These four constraints are ranked as

**SC >> DOAP ≡ DS >> GIVEN**

The sign ≡ indicates that violations of DOAP and of DS have equal weight. The pattern of constraint violations is summarized in the tableaux below.

- Definite object

|      | Repetitive reading  |      | Restitutive reading |       |    |       |      |  |    |   |  |      |  |  |   |  |      |  |    |  |  |      |  |   |  |  |  |  |  |    |      |    |       |  |  |   |   |  |  |  |  |   |    |  |  |  |  |  |  |  |  |  |   |
|------|---|------|---------------------|-------|----|-------|------|--|----|---|--|------|--|--|---|--|------|--|----|--|--|------|--|---|--|--|--|--|--|----|------|----|-------|--|--|---|---|--|--|--|--|---|----|--|--|--|--|--|--|--|--|--|---|
|      | <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 5%;"></th> <th style="width: 15%;">SC</th> <th style="width: 15%;">DOAP</th> <th style="width: 15%;">DS</th> <th style="width: 15%;">GIVEN</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">(6a)</td> <td></td> <td style="text-align: center;">**</td> <td style="text-align: center;">*</td> <td></td> </tr> <tr> <td style="text-align: center;">(6b)</td> <td></td> <td></td> <td style="text-align: center;">*</td> <td></td> </tr> <tr> <td style="text-align: center;">(6c)</td> <td></td> <td style="text-align: center;">**</td> <td></td> <td></td> </tr> <tr> <td style="text-align: center;">(6d)</td> <td></td> <td style="text-align: center;">*</td> <td></td> <td></td> </tr> </tbody> </table> |      | SC                  | DOAP  | DS | GIVEN | (6a) |  | ** | * |  | (6b) |  |  | * |  | (6c) |  | ** |  |  | (6d) |  | * |  |  |  | <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 5%;"></th> <th style="width: 15%;">SC</th> <th style="width: 15%;">DOAP</th> <th style="width: 15%;">DS</th> <th style="width: 15%;">GIVEN</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td style="text-align: center;">*</td> <td style="text-align: center;">*</td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td style="text-align: center;">*</td> <td style="text-align: center;">**</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td style="text-align: center;">*</td> </tr> </tbody> </table> |  | SC | DOAP | DS | GIVEN |  |  | * | * |  |  |  |  | * | ** |  |  |  |  |  |  |  |  |  | * |
|      | SC  | DOAP | DS                  | GIVEN |    |       |      |  |    |   |  |      |  |  |   |  |      |  |    |  |  |      |  |   |  |  |  |  |  |    |      |    |       |  |  |   |   |  |  |  |  |   |    |  |  |  |  |  |  |  |  |  |   |
| (6a) |   | **   | *                   |       |    |       |      |  |    |   |  |      |  |  |   |  |      |  |    |  |  |      |  |   |  |  |  |  |  |    |      |    |       |  |  |   |   |  |  |  |  |   |    |  |  |  |  |  |  |  |  |  |   |
| (6b) |   |      | *                   |       |    |       |      |  |    |   |  |      |  |  |   |  |      |  |    |  |  |      |  |   |  |  |  |  |  |    |      |    |       |  |  |   |   |  |  |  |  |   |    |  |  |  |  |  |  |  |  |  |   |
| (6c) |   | **   |                     |       |    |       |      |  |    |   |  |      |  |  |   |  |      |  |    |  |  |      |  |   |  |  |  |  |  |    |      |    |       |  |  |   |   |  |  |  |  |   |    |  |  |  |  |  |  |  |  |  |   |
| (6d) |   | *    |                     |       |    |       |      |  |    |   |  |      |  |  |   |  |      |  |    |  |  |      |  |   |  |  |  |  |  |    |      |    |       |  |  |   |   |  |  |  |  |   |    |  |  |  |  |  |  |  |  |  |   |
|      | SC  | DOAP | DS                  | GIVEN |    |       |      |  |    |   |  |      |  |  |   |  |      |  |    |  |  |      |  |   |  |  |  |  |  |    |      |    |       |  |  |   |   |  |  |  |  |   |    |  |  |  |  |  |  |  |  |  |   |
|      |   | *    | *                   |       |    |       |      |  |    |   |  |      |  |  |   |  |      |  |    |  |  |      |  |   |  |  |  |  |  |    |      |    |       |  |  |   |   |  |  |  |  |   |    |  |  |  |  |  |  |  |  |  |   |
|      |   |      | *                   | **    |    |       |      |  |    |   |  |      |  |  |   |  |      |  |    |  |  |      |  |   |  |  |  |  |  |    |      |    |       |  |  |   |   |  |  |  |  |   |    |  |  |  |  |  |  |  |  |  |   |
|      |   |      |                     |       |    |       |      |  |    |   |  |      |  |  |   |  |      |  |    |  |  |      |  |   |  |  |  |  |  |    |      |    |       |  |  |   |   |  |  |  |  |   |    |  |  |  |  |  |  |  |  |  |   |
|      |   |      |                     | *     |    |       |      |  |    |   |  |      |  |  |   |  |      |  |    |  |  |      |  |   |  |  |  |  |  |    |      |    |       |  |  |   |   |  |  |  |  |   |    |  |  |  |  |  |  |  |  |  |   |

<sup>7</sup>De-accenting of the verb in (6a) is due to the general rules of focus projection. Space does not permit a more in-depth discussion of this point.

- Indefinite object, object has narrow scope

Repetitive reading

|       | SC | DOAP | DS | GIVEN |
|-------|----|------|----|-------|
| (33a) |    | **   |    |       |
| (33b) |    |      |    |       |
| (34a) | *  | **   |    |       |
| (34b) | *  | *    |    |       |

Restitutive reading

|  | SC | DOAP | DS | GIVEN |
|--|----|------|----|-------|
|  |    | *    |    |       |
|  |    |      |    | **    |
|  | *  |      |    |       |
|  | *  |      |    | *     |

- Indefinite object, object has wide scope

Repetitive reading

|       | SC | DOAP | DS | GIVEN |
|-------|----|------|----|-------|
| (33a) | *  | **   |    |       |
| (33b) | *  |      |    |       |
| (34a) |    | **   |    |       |
| (34b) |    | *    |    |       |

Restitutive reading

|  | SC | DOAP | DS | GIVEN |
|--|----|------|----|-------|
|  | *  | *    |    |       |
|  | *  |      |    | **    |
|  |    |      |    |       |
|  |    |      |    | *     |

Due to the bi-directional interpretation of OT, the evaluation procedure is somewhat different from standard OT. To simplify discussion somewhat, we use abbreviations like (33a,rest,ns) for the restitutive object-narrow-scope reading of (33) etc.

First note that (6c,rest), (33a,rep,ns) and (34a,rest,ws) do not violate any constraint. Thus these three form/meaning pairs cannot be blocked by any other candidate and are therefore optimal. As a consequence of this, all other readings of the forms involved are blocked, i.e. (6a,rest), (34a,rep,ws), (34a,rep,ns), (34a,rep,ws), (33a,rest,ws), (33a,rep,ns), and (33a,rest, ns).

Now consider the remaining candidates with a definite object. (6b,rest) is blocked by (6c, rest), and neither (6a,rep) nor (6d,rep) violates fewer constraints than (6b,rep)—recall that DOAP and SC have equal weight. Thus (6b,rep) is not blocked and thus optimal. The same holds for (6d,rep). Finally, (6a,rep) is blocked both by (b) and (d).

Now we move on to (33) and (34). Next to the optimal (33b, rep, ns) and (34a, rest, ws), (34b,rest,ws) seems to be optimal since it only violates the lowest ranked constraint GIVEN. It

shares its meaning with (34a,rest,ws) though and is hence blocked. Likewise, (33b,rest,ns) is blocked by (33a,rest,ns). Of the remaining candidates, (34b,rep,ws) is among the best ones since it only violates DOAP once. All its form- or meaning alternatives are either already shown to be blocked or are more expensive. Thus (34b,rep,ws) is optimal. This blocks all other (rep,ws) candidates. The same holds for (33a,rest,ns). Its only better alternative, (33b,rest,ns), is blocked by (33b,rep,ns). So (33a,rest,ns) is optimal too. All other candidates either share the form or the meaning with one optimal candidate and thus blocked, so this list of optimal form/meaning pairs in our sample is exhaustive.

To summarize informally, SC is the strongest constraint, and all optimal candidates obey it. If, as in (6), scope issues do not arise, two competing forces are at work. On the one hand, definite objects are required to scramble. On the other hand, in the repetitive reading scrambling leads to a violation of DOAP. Since both forces are equally strong, both outcomes are optimal ((6b) and (d)). In case of the restitutive reading, there is no reason to avoid scrambling, so it is obligatory ((6a) vs. (c)).

As for intonation, in the repetitive reading virtually everything in the sentence except the adverb is given, so DOAP requires that the sentence accent ends up on the *again*. So this intonation pattern is reserved for the repetitive reading and the restitutive interpretation is restricted to the unmarked intonation.

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## Appendix A

We assume a three-sorted extensional type theory as representation language, the basic types being  $t, e, s, ev$  (for truth values, individuals, states and events respectively). A model contains three domains  $D, S, E$  (individuals, states and events). Time can be constructed from events and thus need not be assumed to be ontologically basic<sup>8</sup>. Possible worlds are omitted for simplicity since intensionality does not play any role for the issues discussed.

Next to these domains, the standard relations between events and states  $<$  (temporal precedence),  $\circ$  (temporal overlap),  $\succ$  (abut),  $\subseteq$  (temporal inclusion) etc. and an interpretation function  $F$ , a model contains a relation  $R \subseteq E \times S$  obeying the restrictions that

$$\forall e \exists s (e \succ s \wedge eRs)$$

Intuitively  $eRs$  may be read as “the post-conditions of the event  $e$  hold in state  $s$ ”. So the postulate says that every event is followed by a state where its post-conditions hold.

The representation language is extended with a logical constant RESULT with the following syntax and semantics:

- If  $\phi$  has type  $\langle ev, t \rangle$ , then  $\text{RESULT}\phi$  has type  $\langle s, t \rangle$ .
- $s \in \|\text{RESULT}(\phi)\|$  iff  $\exists eRs : e \in \|\phi\|$ .

Given this model-theoretic background, the following holds:

### Theorem 1

$$\models \exists x (P_{\langle e, t \rangle}(x) \wedge \text{RESULT}(Q_{\langle e, \langle ev, t \rangle \rangle}(x))(s)) \leftrightarrow \text{RESULT}(\lambda e \exists x (P(x) \wedge Q(x)(e)))(s)$$

*Proof:* Suppose that  $\|\exists x (P(x) \wedge \text{RESULT}(Q(x))(s))\| = 1$  and  $\|s\| = \mathbf{s}$ . Then there is an individual  $\mathbf{d} \in \|P\|$  such that  $\mathbf{s} \in \|\text{RESULT}(Q(x))\|_{\mathbf{x}}^{\mathbf{d}}$ . Thus there is an event  $\mathbf{e}$  with  $\mathbf{e}Rs$  and  $\mathbf{e} \in \|Q(x)\|_{\mathbf{x}}^{\mathbf{d}}$ . From this we infer that  $\|P(x) \wedge Q(x)(e)\|_{\mathbf{x}, \mathbf{e}}^{\mathbf{d}, \mathbf{e}} = 1$ . So  $\|\exists x (P(x) \wedge Q(x)(e))\|_{\mathbf{e}}^{\mathbf{e}} = 1$  too, and thus  $\mathbf{e} \in \|\lambda e. \exists x (P(x) \wedge Q(x)(e))\|$ . Since  $\mathbf{e}Rs$  by assumption,

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<sup>8</sup>See for instance Kamp and Reyle 1993:667pp

$\mathbf{s} \in \|\text{RESULT}(\lambda e.\exists x(P(x) \wedge Q(x)(e)))\|$ , hence  $\|\text{RESULT}(\lambda e.\exists x(P(x) \wedge Q(x)(e)))(\mathbf{s})\| = 1$ .

Now suppose that  $\|\text{RESULT}(\lambda e.\exists x(P(x) \wedge Q(x)(e)))(\mathbf{s})\| = 1$ , and that  $\|\mathbf{s}\| = \mathbf{s}$ . This means that  $\mathbf{s} \in \|\text{RESULT}(\lambda e.\exists x(P(x) \wedge Q(x)(e)))\|$ . Then there is an event  $\mathbf{e}$  with  $\mathbf{e}R\mathbf{s}$  and  $\mathbf{e} \in \|\lambda e.\exists x(P(x) \wedge Q(x)(e))\|$ . Therefore  $\|\exists x(P(x) \wedge Q(x)(e))\|_{\mathbf{e}}^{\mathbf{e}} = 1$ . Thus there is an individual  $\mathbf{d} \in \|\mathbf{P}\|$  such that  $\|Q(x)(e)\|_{\mathbf{e},x}^{\mathbf{e},\mathbf{d}} = 1$ . This entails that  $\mathbf{e} \in \|Q(x)\|_{\mathbf{e},x}^{\mathbf{e},\mathbf{d}}$ . Since  $e$  is not free in  $Q(x)$ ,  $\mathbf{e} \in \|Q(x)\|_{\mathbf{x}}^{\mathbf{d}}$ . By assumption  $\mathbf{e}R\mathbf{s}$ , thus  $\mathbf{s} \in \|\text{RESULT}(Q(x))\|_{\mathbf{x}}^{\mathbf{d}}$ . From this we conclude that  $\|\text{RESULT}(Q(x))(\mathbf{s})\|_{\mathbf{x}}^{\mathbf{d}} = 1$ , so  $\|\exists x(P(x) \wedge \text{RESULT}(Q(x)))(\mathbf{s})\| = 1$  as well.

⊢

## Appendix B

Blutner 1999 gives the following definition of an optimal syntax-semantics map (“Super-optimality”), which is inspired by work of Atlas and Levinson 1981 and Horn 1984:

### Definition 2 (Super-optimality)

1.  $\langle \pi, \lambda \rangle$  satisfies the Q-principle iff  $\langle \pi, \lambda \rangle \in \mathbf{GEN}$  and there is no other pair  $\langle \pi', \lambda \rangle < \langle \pi, \lambda \rangle$  satisfying the I-principle.
2.  $\langle \pi, \lambda \rangle$  satisfies the I-principle iff  $\langle \pi, \lambda \rangle \in \mathbf{GEN}$  and there is no other pair  $\langle \pi, \lambda' \rangle < \langle \pi, \lambda \rangle$  satisfying the Q-principle.
3.  $\langle \pi, \lambda \rangle$  is super-optimal iff it satisfies both the Q-principle and the I-principle.

This is to be compared with the definition of optimality given in the text (Definition 1).

### Theorem 2

If “ $<$ ” is irreflexive, transitive and well-founded, then

1. there is a unique optimality relation
2.  $\langle \pi, \lambda \rangle$  is optimal iff it is super-optimal

*Proof:* Part 1 is a straightforward application of the recursion theorem. As for part 2, suppose  $\langle \pi, \lambda \rangle$  is optimal but not super-optimal. This means that it either violates the I-principle or the Q-principle. Suppose it violates the I-principle. Then there is a  $\lambda'$  with  $\langle \pi, \lambda' \rangle < \langle \pi, \lambda \rangle$  such that  $\langle \pi, \lambda' \rangle$  satisfies the Q-principle. Since  $\langle \pi, \lambda \rangle$  is optimal,  $\langle \pi, \lambda' \rangle$  cannot be optimal. Thus there is either an optimal  $\langle \pi, \lambda'' \rangle < \langle \pi, \lambda' \rangle$  or an optimal  $\langle \pi', \lambda' \rangle < \langle \pi, \lambda' \rangle$ . The first option is excluded since if it were the case, by transitivity,  $\langle \pi, \lambda'' \rangle < \langle \pi, \lambda \rangle$ , thus contradicting the assumption that  $\langle \pi, \lambda \rangle$  is optimal. So there is an optimal  $\langle \pi', \lambda' \rangle < \langle \pi, \lambda' \rangle < \langle \pi, \lambda \rangle$ . Since  $\langle \pi, \lambda' \rangle$  satisfies the Q-principle,  $\langle \pi', \lambda' \rangle$  does not satisfy the I-principle. By repeated application of this argument, we can construct an infinite chain  $\dots < \langle \pi''', \lambda''' \rangle < \langle \pi'', \lambda'' \rangle < \langle \pi', \lambda' \rangle < \langle \pi, \lambda \rangle$ , all members being optimal and violating the I-principle. This is excluded by the assumption that “ $<$ ” well-founded, so  $\langle \pi, \lambda \rangle$  cannot violate the I-principle if it is optimal. By a symmetric argument, we conclude that it cannot violate the Q-principle either, so it is super-optimal.

As for the other direction, suppose  $\langle \pi, \lambda \rangle$  is super-optimal but not optimal. Then there is either an optimal  $\langle \pi', \lambda \rangle < \langle \pi, \lambda \rangle$  or an optimal  $\langle \pi, \lambda' \rangle < \langle \pi, \lambda \rangle$ . Suppose the former is the case. From the previous paragraph we know that any optimal candidate satisfies the Q-principle, so  $\langle \pi', \lambda \rangle$  satisfies the Q-principle since it is optimal. This is excluded though since by assumption,  $\langle \pi, \lambda \rangle$  satisfies the I-principle. By the same kind of reasoning, we also derive a contradiction if  $\langle \pi, \lambda \rangle$  is blocked by some  $\langle \pi, \lambda' \rangle$ . ⊥

It is easy to see that the ordering of candidates that is induced by ranked constraints in the sense of Optimality theory is irreflexive, transitive and well-founded. Thus our notion of optimality is well-defined, and it coincides with Blutner’s 1999 notion of Super-optimality.