# Proceedings of the Fourteenth Amsterdam Colloquium

December 19 — 21, 2003

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## Preface

The 2003 edition of the Amsterdam Colloquium is the Fourteenth in a series which started in 1976. Originally, the Amsterdam Colloquium was an initiative of the Department of Philosophy of the University of Amsterdam. Since 1984 the Colloquium is organized by the Institute for Logic, Language and Computation (ILLC) of the University of Amsterdam.

These proceedings contain the abstracts of the papers presented at the colloquium. In the first section one can find abstracts of the talks given by one of the invited speakers (Pauline Jacobson) and that of the 2003 Vienna Circle evening lecture (Elliott Sober). The next two sections contain the contributions to the two workshops:

≫ Evolution and Change of Semantic Conventions
≫ Mood and Modality

The fourth section contains the contributions to the general program. In all cases the copyright resides with the individual authors.

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≫ (local committee) Johan van Benthem, Reinhard Blutner, and Jeroen Groenendijk (chair)
≫ (the invited speakers) Nicholas Asher, Pauline Jacobson, Manfred Krifka and Alessandro Zucchi
≫ (external committee) David Beaver, Michael Moortgat, Barbara Partee, Susan Rothstein, Rob van der Sandt, Arnim von Stechow, Henriëtte de Swart, and Ede Zimmermann

*The Editors*
*Amsterdam, November 2003*

# Contents

# Invited Speakers

# Direct Compositionality:Consequences for Ellipsis

**Pauline Jacobson**

This paper will explore the implications that the hypothesis of direct compositionality has for the analysis of (some) ellipsis phenomena (in particular, VP Ellipsis and short answers to questions). I will then argue that the analysis which follows naturally under direct compositionality is, in fact, the correct one. In a nutshell, it would be surprising under direct compositionality to find that there is actual "silent" or deleted syntactic material in the presence of an ellipsis site which is allowed to be deleted (or silent) on the basis of some kind of identity without some other linguistic material. The reason is that no such identity condition could be stated as a local property of the "silent" (or, deleted) material: it is a property of the entire discourse context.

As a case study, I will focus on one of two domains. The first is a group of related constraints on (T)VP Ellipsis, constraints which have been studied in Wasow (1972), Kennedy (1994), Heim (1997) and others. These are especially interesting in that they have been argued not only to provide evidence that there is actual linguistic material in the position of the ellipsis site, but some proposals also make crucial use of variable names to state this identity condition (Heim, 1997, Kennedy, 2002). This of course also provides an interesting challenge to variable-free semantics. I will argue here that these challenges can be met - and that actually the relevant conditions in any case can be stated only in terms of meanings, not linguistic identity (and not meanings that make crucial use of variable names). A somewhat different approach to the problem is developed in Sauerland (to appear) in which variable names are not crucial but linguistic identity nonetheless is; I will along the way bring up various problems with this alternative, too. To show the main points, I will first situate the general phenomena of ACD within the view of "TVP" ellipsis developed in Jacobson (1992) and more thoroughly in Jacobson (to appear). The cases at hand are all cases involving TVP Ellipsis (which, both in my account and in the standard account turn out to be special cases of the more general phenomena of VP Ellipsis). It will be shown both Heim's and Kennedy's proposals fail to account for the availability of ellipsis in something like (1):

(1) The man that Sue spoke to knows the man that SALLY did (speak to).

I will, however, be suggesting that the essential insight in Heim's proposal is correct: the idea here is that the original facts noted by Kennedy (1994) are a consequence of Rooth's (1991) focus condition on ellipsis, and have to do with finding appropriate contrasts. I believe that this is correct - but that the basic proposals need to be translated into purely semantic (and variable-free) terms. Once this is done the account will (hopefully) generalize to a broad range of cases of TVP ellipsis across sentences which show certain surprising restrictions. For example, cases like (2) are good and were noted in Jacobson (1992) (see also Hardt (1992)):

(2) John kissed every girl. But only MARY wanted him to (kiss her).

But Merchant (1999) points out that these are good only when the "binder" of the second pronouns is a member or a subset of the object in the first clause. Thus note that (3) is not terribly happy (imagine (3) in a context where we know that John will kiss only one girl)

(3) ?*John kissed Sue. Which is too bad, because MARY had wanted him to.

(Note that the impossibility of the ellipsis here cannot be blamed on the fact that the non-elided counterpart must contain a stressed pronoun: it can, but it need not:

(4) John kissed Sue. Which is too bad, because $\text{MARY}_i$ had wanted him to kiss $\text{HER}_i$/ to kiss $\text{her}_i$

The "identity of form" accounts (using either variable names or using linguistic material) has nothing to say about these contrasts. But once we fully "semanticize" Heim's (and Rooth's) accounts, this contrast will follow.

A second possible domain of exploration will be the treatment of "short" answers to questions. In early work in generative grammar it was commonplace to assume that all answers were elliptical for full sentences (see, e.g., Morgan, 1974, Hankamer, 1974) and this position has been explicitly revived in recent work (e.g., Merchant, to appear). Groenendijk and Stokhof (1983) - among others - present an alternative analysis in which short answers are not syntactically full Ss. I will present some arguments for this approach: there are cases where the presuppositions of full answers and of "short" answers are not the same. I will explore the implications of this for a long debate in the literature on the treatment of "connectivity" effects both in question/answer pairs and in copular sentences - a debate which, in turn, is intimately tied up with the feasibility of direct compositionality.



# Likelihood, Model Selection, and the Duhem-Quine Problem

Elliot Sober

When the conjunction of a hypothesis (H1) and a set of auxiliary assumptions (A1) generates an observational prediction that fails to come true, how does the disconfirmation of the conjunction affect the status of the separate conjuncts? Most previous attempts to address this problem probabilistically have been Bayesian, in that they compare the observation's impact on the probability of H1 with its impact on the probability of A1. The present paper describes two other approaches. The first draws on a resource that Bayesians have available. If the hypothesis and the auxiliary assumptions each have alternatives (H2 and A2, respectively) such that the four conjunctions of the form ($Hi$ & $Aj$) ($i, j = 1, 2$) are simple (in the technical statistical sense of that term), then a likelihood analysis can identify asymmetries between the observation's impact on the hypotheses and its impact on the auxiliary assumptions; this analysis does not invoke prior or posterior probabilities. A similar pattern can arise when some or all of the four conjunctions are models that contain adjustable parameters (and so are statistically composite, not simple); here a nonBayesian model selection criterion such as AIC can indicate that the observations have an impact on the hypotheses that differs fundamentally from the impact they have on the auxiliary assumptions. The likelihood approach is developed in terms of a simple example concerning medical diagnosis; the model selection approach is described in the context of the problem of phylogenetic inference.

# Evolution and Change of Semantic Conventions

# Virtual Signs. The emergence of new meanings by reanalysis

**Regine Eckardt***

**Abstract**
I argue that semantic reanalysis is a process of algebraic equation solving that can best be understood in terms of truth conditional semantics. The change itself occurs in a single step, and rests on concise lexical entries for items before and after change. The phases of gradual meaning shifts that were diagnosed in historical texts are the result of pragmatic inferencing on the basis of the older meanings, a commonly accepted preparatory stage for reanalysis.
I will demonstrate that the resulting view can capture the historical data in a more satisfying manner than earlier accounts, specifically those that operate, implicitely or explicitely, on basis of a componential analysis of meaning. Finally, I will suggest applications of pragmatic OT to explain the onset of meaning change by reanalysis.

## 1 Semantic reanalysis in a truth conditional setting

My talk addresses meaning change as it accompanies language change by structural reanalysis; as for instance the emergence of complementizer *that* (*He said that: You must leave!* > *He said that you must leave*), the emergence of *have*-based perfect tense (*I have (a) used car* > *I have used (a) car*) etc. The semantic side of the change has received ample attention in recent literature in historical linguistics and has been characterized as metaphor-like, metonymy-like, bleaching, pragmatic weakening *cum* strengthening and generalized invited inferencing by different authors (see overview in [3]). I will refer to the process as *semantic reanalysis*, thereby indicating my core assumption that it be an autonomous mode of semantic change which essentially rests on the compositionality of natural language.
Following earlier work in [3], I defend the claim that the nature of semantic reanalysis can best be understood if we analyse it in terms of truth conditional compositional semantics. I assume that semantic reanalysis is essentially an algebraic process of solving a semantic equation with one unknown and will explore some consequences of this view. Most importantly, we'd expect that this

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type of meaning change proceeds in descrete steps (before / after reanalysis) and rests on concise and specific lexical entries for the entities-under-change. In particular, each speaker possesses the compositional competence to derive a new meaning from a given type of onset contruction by reanalysis. Social processes of speech imitation hence do not play a role for the individual speaker to interpolate the new meaning of an item-under-change. (They may play a role, of course, in suggesting the speaker that everybody else has already adopted a certain change in their lexicon.) While variations between speakers can occur, each single speaker is assumed to communicate on the basis of clearly identifyable old and new meanings.

It is also important to point out that semantic reanalysis is essentialy more than "loss of meaning" at one end, accompanied by "gain of meaning" at the other end. The complete restructuring of semantic composition typical for reanalysis can, on the contrary, result in a new denotation for the item-under-change that has little in common with its older content, a fact not endorsed in competing accounts for meaning change under reanalysis. Case studies from [3] will be used to illustrate the general mechanism.

## 2 Meanings arent atomic

The resulting picture contrasts with previous accounts of meaning change under reanalysis (mostly discussed under the key word of "grammaticalization"). The overwhelming majority of authors, implicitly or explicitly, operates in terms of semantic representations that rest on conceptual primitives which in conjunction define the meaning of the word. If this view is adopted in the strict binary sense of a feature system (e.g. [4]), semantic reanalysis can only be understood (i) as the loss of a concept or (ii) as reassigning a concept from one word to another. Later authors pointed out the necessity of a third move, namely (iii) the adoption of new concepts by pragmatic strengthening or enrichment (first defended in [5]). Even in this sense, the resulting view proved to be too restrictive. The strict binary view can not reflect the apparently gradual shifts from older to newer meanings witnessed in historical texts. Hence, the prevalent view is that meaning changes result from the slow downtuning and upgrading of conceptual components, perhaps similar to mixing sounds with an equalizer (the paper [2] offers a nice illustration).

Truth conditional semantics traditionally is very parsimonious in positing conceptual primitives. The advantage of capturing meanings in terms of extensions, intensions and functional type is that meanings can be represented without the use of meaning components. This not only frees the semanticist from circular questions like whether CANINE should be a conceptual primitive in the word *dog*. Once we investigate meaning change under reanalysis on that basis, we also are free to cut the "pie of information" (conveyed by a sentence) in any way that matches the lexical and morphological material after structural reanalysis.



In particular, we need not assume that, happily, the meanings of parts of a sentence in its old structural analysis already contain the isolated conceptual atoms to float around, or to fade away under the new structural analysis, while pragmatic inferences slowly tune in new conceptual atoms. Likewise, meaning representation in terms of type logic allows one to express how an items odd bit of propositional content combines with other parts of the sentence.

I argue that an account of semantic reanalysis in terms of truth value based semantics can reflect the gradual, vague aspects and the discrete, compulsory steps of this type of language change in a more balanced manner than accounts that rest on conceptual components. In a preparatory phase of an instance of change, pragmatic inferences of an utterance type *gradually* gain salience but leave the lexical content of words unaffected. However, once the point of imminent reanalysis has been reached, the restructuring and the adoption of consequent meaning change occurs in a discrete step.

Facts about language change corrobate this view. I will offer several examples that show how speakers make use of newly emerged items and constructions in a way that is incompatible with the gradual downtuning and upgrading view as well as, more generally, a view of meaning change by innovation and imitation. While earlier accounts had to operate with the notion of historical accident in such cases, a truth conditional analysis will often reveal the semantic rationale underlying the data.

## 3 Optimal Interpretations and Reanalysis

Case studies in semantic reanalysis suggest interesting links to recent formal theories of pragmatics. Optimalization processes in the sense of [1] appear to be one of the driving forces in language change under reanalysis. I do not want to suggest that language change is always a change for the better ("Heilsgeschichte"). However at a more local level, optimal interpretation strategies can lead the hearer to conclude that an utterances optimal interpretation is one that rests on language change. In particular, we can wittness how over-expensive or implausible presuppositions trigger reanalysis if the new interpretation of a given sentence allows the hearer/reader to derive a similar piece of information without "costly" presupposition accommodation. This can nicely explain why meaning change by reanalysis rarely bear an innovative or creative element and yet take place. According to common assumptions, language changes arise either by creativity (= the speaker) or crude misunderstanding (= the hearer). Optimality principles open up the way for a third, and very plausible seed of change, namely that the speaker simply "overcharges his pragmatic account" and the hearer takes it "in a cheaper manner".

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# Origins of Meaning in Human Language

**James R. Hurford**

This lecture concerns prelinguistic semantics, which deals with conceptual representations of the world independently of any system of communication, and with the subsequent symbolic mapping of these representations to words, phrases and sentences. The lecture weaves together (a) a summary of recent work relating meaning to discoveries in neuroscience, (b) a general survey of animal concepts, and (c) some new speculations on a unification of semantic representations in an attempt to accommodate to neural processes.

Animals and babies have quite complex conceptual representations. Truth and reference originate in relations between mental representations and the world. In the mind, truth and reference are not significantly different. Communication may conceivably lag far behind internal mental representation. The discovery of mirror neurons gives us some clue about how the brain represents concepts, but it does not immediately illuminate our impressive human ability to associate concepts with symbols. Learning a symbol involves assigning a public signal to a pre-existing internal representation. Captive, trained animals (chimpanzees, gorillas, orang-utans, parrots) have shown ability to learn symbols, up to several hundred. But no animal is known to learn symbolic behaviour in the wild.

We can ask: What conceptual representations do animals have? Concepts are grounded in experience of external objects and situations, via the senses, and of internal sensations (hunger, pain, pleasure, effort, ...). It can be shown that animals have some quite complex concepts. The most elementary logical structure, namely PREDICATE(x), can be related to very basic neural processes, shared by humans and many animals. Even a parrot can be shown to have concepts well beyond First Order Predicate Logic. It can also be argued that animals have simple concepts corresponding to human PAST and FUTURE. The issue of the categoriality of animal concepts will be addressed

But for humans, language adds a massive final twist to our possible concepts. Given symbols for concepts grounded in experience, and some syntax, new kinds of abstract concepts can be defined, in words. We can talk, and think, about enormously high numbers, about virtue, love, and ambition, about unicorns, black swans and about even square circles. Cultural evolution provides us with a whole cascade of concepts that only we humans can possibly have. Conveivably, too, the very fact of being tied symbolically to external signals adds a degree of categoriality to original prelinguistic conceptual representations.

'The more speculative portion of the lecture will briefly advance arguments aimed at (a) reducing all predications to one-place predications; (b) conflating representations of eventualities and objects ("Objects are events"); (c) conflating the part-whole relationship with participation in an event; and (d) removing the origins of the syntactic categories Noun and Verb from prelinguistic semantics, and locating them rather in (postlinguistic) discourse patterns.



# On the Emergence of Purely Collective Predication

**Ileana Comorovski** [1]

This paper analyzes the semantic change undergone by the French adjective *divers*, from the interpretation it had in (pre)-Classical French, when it denoted a symmetric relation expressing non-similarity, to its interpretation in contemporary French, where it is a purely collective predicate. A difference is noted between purely collective predicates like *(be) a large group* or *(be) numerous* and purely collective predicates like *(be) a (good) team* or *(be) diverse*. The former characterize the collection they apply to as a whole, that is independently of the relations that obtain among its elements, whereas the latter characterize a collection precisely in terms of the relations that obtain among its elements. The diachrony of *divers* gives us some insight into how purely collective predicates of the latter kind come into being.

In contemporary French, *divers* can occur noun phrase-internally (prenominally or postnominally) or in predicative positions (e.g. after the copula). Prenominal *divers* is arguably a determiner and will be outside the scope of our investigation. For the contemporary French data, we will be concerned with *divers* as it occurs in postnominal and predicative positions, where it is an uncontroversial adjective. In (pre)-classical French, *divers* was an adjective irrespective of the position in occupied.

## 1 Relational *divers*

We will start by examining the semantics of (pre)-classical *divers* ($16^{th}$-$18^{th}$ centuries) (Pre)-classical *divers* denoted a binary relation: until the end of the $18^{th}$ century, the second argument of *divers*, if expressed overtly, was introduced by the preposition *de* or by the preposition *à*; we illustrate below the latter case:

(1) '… la route de ceux qui visent à l'honneur est bien *diverse à* celle que tiennent ceux qui se propose l'ordre et la raison.' (Michel de Montaigne : *Essais*, 1592)
'… the path of those who aim at honour is quite different form that taken by those whose purpose is order and reason.'

Unlike (pre)-classical *divers*, contemporary *divers* cannot be used to relate two arguments. It differs in this respect from the adjective *différent*:

(2) Vénus est (très) différente / * diverse de Saturn.
Venus is (very) different / diverse of Saturn
'Venus is (very) different / * diverse from Saturn.'

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*Différent* denotes a symmetric relation of non-similarity; one of its arguments can be syntactically realized as a noun phrase introduced by *de* ('of'), as in (2) above. In contrast, contemporary *divers* cannot take a complement; the intransitivity of *divers* is a syntactic reflex of its being semantically a one-place predicate.

From (1)-(2) we see that *divers* and *différent* used to be much more similar than they are in contemporary French. *Divers* lost its second argument and this change in valence had consequences on its interpretive possibilities: *divers* lost three readings, listed in (i)-(iii) below, which, interestingly, are displayed by contemporary *différent*:

i) a dependent plural reading;
ii) a quantifier-dependent reading;
iii) a sentence-external (or discourse-anaphoric) reading.

In the examplesbelow, the interpretation of the *divers*-DPs depends on the denotation of some other DP in the sentence; the latter is written in bold characters; I will refer to it as 'the licensor DP'. In the following three subsections, we will illustrate the three readings which relational *divers* had in (pre)-classical French (attested sporadically as late as the end of the 19th century).

**1.1. The dependent plural reading.** On this reading, the licensor is a semantically plural DP:

(3) **'Tes vieus aieus maternels**
**Et tes oncles paternels**
*Divers* champs ont habité :
Mais toi seul qui leur succedes
Des deus tu tiens et possedes
Les biens qu'ils ont herité.' (P. de Ronsard: *Le Premier livre des Odes*, 1550)
'Your old maternal ancestors / And your paternal uncles / Have lived in different fields: / But only you who succeeds to them / You get and own from both of them/ The goods which they have inherited.'

We find this type of reading with contemporary *différent*:

(4) **Jean et Marie /Ils** ont reçu des cadeaux différents. (Laca and Tasmowski 2003)
'John and Mary / They have received different gifts.'

Following Beck 's (2000) analysis of the English adjective *different*,[2] we will consider that (pre)-classical *divers* too contained a hidden reciprocal and will represent the

2 But not her definition, which is redundant: according to Beck, two entities *a* and *b* are different iff (i) a≠b or (ii) *a* and *b* belong to two kinds *a'* and *b'*, a'≠b'. I take it that belonging to non-identical kinds implies not sharing at least one property, a fact from which the non-identity in clause (i) follows; on the other hand, if a≠b, *a* and *b* do not share at least one property, hence they presumably belong to non-identical kinds. Following Laca and Tasmowski (2003), I will take *different* to express non-similarity. By the non-similarity of two entities, I understand either their non-sharing of at least one property or, if all properties are shared, at least one must hold of the entities in question to different degrees.



dependent plural reading of *divers* by resorting to Schwarzchild's (1996) notion of a *cover*, defined below:

(5) C is a *cover* of a plurality P iff:
(i) C is a set of subsets of P; (ii) Every member of P belongs to some set in C, and (iii) ∅ is not in C.

The wording of the poem in example (4) above makes salient the following cover of the set denoted by the DP hosting *divers*:

(6) g(Cov) = { [[the fields that your old maternal ancestors lived in]] ,
[[thefields that your paternal uncles lived in]] }

Equipped with a contextually salient cover, and following Beck's analysis of the dependent plural reading, the interpretation of (3) can be represented as in (7); (7) uses Krifka's (1986) **-operator, meant to obtain a· cumulative reading for sentences containing a relation-denoting expression that takes two plural arguments:

(7) ∃X[fields(X) & **lived-in(your maternal ancestors & your paternal uncles, X)
& ∀x[x≤X & x ∈ Cov → ∀y[y ≤ X & y ∈ Cov → different(x,y)]]]

According to (7), there is a set of fields that have been lived in by your maternal ancestors or by your paternal uncles; the *divers*-DP will distribute down to the two subparts provided by the cells of the cover given in (6). Relational *divers* asserts the non-similarity of these two subparts of the fields.

**1.2. The quantifier-dependent reading.** On this reading, the licensor is a quantifying DP, as illustrated below:

(8) '... à la sixième journée de marche, ils se querellent : divisés en trois bandes, **chaque bande** prend *une route diverse* ;' (François de Chateaubriand : *Mémoires d'outre-tombe*, 1848)
'... on the sixth day of walking, they fight : divided into three bands, each band takes a different route;'

Again, we find this type of reading with contemporary *différent*:

(9) **Chaque enfant** a reçu un cadeau différent. (Laca and Tasmowski (2003))
'Every child received a different gift.'

Laca and Tasmowski (2003), and Tovena and van Peteghem (2003) show that the quantifier-dependent reading of French *différent*, as well as its discourse-anaphoric reading (see (iii) below), cannot be based on an analysis of *différent* as a comparison operator, such as the analysis proposed for the quantifier-dependent reading of English 'different' by Beck (2000). French *différent* is shown by these authors to behave uniformly as a relational adjective. Their remarks hold also of (pre)-classical *divers*; as indicated by the fact that, unlike comparison operators (e.g. *autre* ('other')), *divers* could not be followed by a complementizer (*autre*, for instance, can be followed by the complementizer *que*). The clause '**chaque bande** prend *une route diverse*' in (8) above allows the following analysis:

(10) $\forall x, y$ ((band(x) & band(y) & $x \neq y$) $\rightarrow$ x took a different route from y)

**1.3. The sentence-external (or discourse-anaphoric) reading.** On this reading, one of the terms of the relation denoted by *divers* is provided by the (extra-sentential) context:

(11) 'Je veux donner aux miens *une route diverse*,' (P. Corneille : *Sophonisbe*, 1682)
'I wish to give to mine [my suspicions] a different path.'

Here too we find parallel examples with *différent* in contemporary French:

(12) Jean a proposé une solution différente. (Laca and Tasmowski (2003))
'John suggested a different solution.'

**1.4. Conclusion.** The three readings of *divers* illustrated above could arise because *divers* denoted a binary relation. Once *divers* changed its valence and became a one-place predicate, the readings which were based on the relational nature of *divers* were lost.

## 2 The passage from relational *divers* to the one-place predicate *divers*

**2.1. Covert reciprocity.** We hypothesize that the emergence of the interpretation of contemporary *divers* had as a crucial stage the use of sentences in which *divers* occurred as a covert reciprocal. These are sentences with a semantically plural subject (e.g. a coordination of terms or a plural definite DP) and reciprocal interpretation, but which do not contain any reciprocal pronoun, e.g. the sentence *John and Tom met.* As noted by Hackl (2003), covert reciprocity appears only with symmetric predicates; 'meet', '(be) different', and (pre)-classical *divers* are all symmetric predicates.

Below are some sentences in which *divers* is used as a covert reciprocal predicate. These sentences span three centuries:

(13) a. '...les moiens de plaindre sont divers ...' (J. du Bellay: *Les Regrets*, 1558)
'.... the means of complaining are different... '
b. 'Les avis sont divers ; ' (François de Malherbe: *Les Poésies*, 1627)
'The opinions are different;'
c. 'tous sont divers, et tous furent vrais un moment. (A. Chénier: *Élégies*, 1794)
'they are all different, and they were all true at some point.'

A few words are in order about the way in which the argument structure of symmetric predicates is syntactically projected. A lexical characteristic of the class of symmetric predicates (e.g. a verb such as *meet* or an adjective such as *different*) is that



one of its arguments can be projected syntactically in one of two ways: either as a complement of the respective verb or adjective, or as a subject, provided the subject is semantically plural. Crucially, if the predicate is symmetric and the subject is semantically plural, both arguments of the symmetric predicate can be linked to the same constituent, namely the subject.

To capture the correspondence between relational predicates and covert reciprocals, Krifka (1991) suggests the use of an operator **REC**(iprocal), which takes a two-place relation *R* and yields a one-place relation which is true of sum individuals. Krifka defines the operator **REC** as below (in the definition (14), $\leq_a$ is the atomic subpart relation: $x \leq_a y$ is true iff $x \leq y$ and x is an atom):

(14) $\mathbf{REC}(R)(x) \leftrightarrow \forall y,z[\, y\leq_a x \,\&\, z\leq_a x \,\&\, y\neq z \rightarrow R(y,z)] \,\&\, \exists y,z[\, y\leq_a x \,\&\, z\leq_a x \,\&\, y\neq z]$

According to the definition above, ***REC(R)*** is true of *x* iff every two distinct atomic parts of *x* stand in the *R* relation to each other and there are such parts. As a consequence of the way Krifka defines the **REC**-operator, the range of the relation variable *R* is restricted to symmetric relations. Thus Krifka's definition takes care of the generalization made by Hackl (2003), who observes that predicates expressing symmetric relations have inherently reciprocal plural counterparts.[3]

In sentences with a plural subject and a symmetric predicate, one of the arguments of the predicate can optionally (and redundantly) be projected as a reciprocal pronoun (e.g. 'John and Tom are quite different (from *each other*)'). Such was the case in (pre)-Classical French of sentences containing *divers*: the reciprocal pronoun *les uns les autres* could optionally appear after the symmetric predicate *divers* if the subject of the sentence was semantically plural:

(15) '... les Philosophes [...] confondent inconsidérément deux estats de l'homme qui sont fort *divers l'un de l'autre.*' (Jean Calvin : *Institution de la religion chrestienne*, 1560)
'... Philosophers [...] inconsiderately confound two states of man which are quite different from each other.'

Not surprisingly, we find such sentences with contemporary *différent*, but not with contemporary *divers*, which is a one-place predicate:

(16) Ces propositions sont très différentes (les unes des autres).
'These proposals are very different (from each other).'

(17) Leurs propositions ont été très diverses (* les unes des autres).
'Their proposals were very diverse (* from each other).'

We suggest that the one-place predicate *divers* characterizes the relations which obtain between pairs of elements in the collection that *divers* is predicated of: a majority of these elements must be related by a symmetric relation, namely one of non

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[3] The reader is referred to Hackl (2003) for an alternative approach to covert reciprocity.

similarity. Thus contemporary *divers* induces a weak form of reciprocity, in that the non-similarity relation need not hold among all the pairs of elements in the collection that *divers* is predicated of.

In case the subject of the sentence is a semantically singular DP, the interpretation of postnominal *divers* in contemporary French imposes truth conditions identical to those induced by what Laca and Tasmowski (2003) call the 'NP-internal reading of *différent*'. Thus the truth conditions of (18a) and (18b) below are identical:

(18) a. Marie a reçu des cadeaux très différents (les uns des autres).
'Mary has received different gifts.'
b. Marie a reçu des cadeaux très divers (*les uns des autres).
'Mary has received various gifts.'

In (18a), the arguments of the symmetric relation denoted by *différent* are obtained inside the denotation of the host noun *cadeaux*. The non-similarity relation induced by the one-place predicate *divers* equally applies to pairs of elements in the denotation of the host noun *cadeaux*. Despite the identity in truth conditions, the two sentences in (18) are constructed with predicates whose valences are different; the challenge is to characterize the distinction between *divers* and *différent* as they occur in (18).

**2.2. Two types of purely collective predicates**Comorovski and Nicaise (to appear) have demonstrated that contemporary *divers* is a purely collective predicate (in most dialects of French), as shown, among other evidence, by: (i) the impossibility of applying it to a quantifying subject (* *La plupart de ses outils sont très divers* = 'Most of his tools are very diverse') and (ii) its non-co-occurrence with (floated) *tous* ('all') (**Ses outils sont tous très divers* = 'His tools are all very diverse'); it is of interest to contrast the unacceptable sentence in (ii) with the acceptable (13c) above, a Classical French sentence in which *tous* and relational *divers* co-occur. The properties given in (i)-(ii) have been identified by Dowty (1987) as being characteristic of purely collective predicates, i.e. predicates which denote sets of collections of individuals.

Note now that there is a difference between purely collective predicates such as *(be) a large group* or *(be) numerous* and purely collective predicates such as *(be) a cohesive group*, *(be) a (good) team*, or *(be) diverse*. The former characterize the collection they apply to as a whole, that is independently of the relations that obtain among the elements of the collection, whereas the latter characterize a collection precisely in terms of these relations.

The diachrony of *divers* gives us some insight into how purely collective predicates of the latter kind can come into being. In the particular case of *divers*, a predicate which denoted a symmetric relation was sometimes used in covert reciprocal constructions. Covert reciprocity trickled from the level of argument structure down into a sub-lexical level: the predicate *divers* continues to express a symmetric relation, but this relation no longer holds between arguments that can be syntactically projected as constituents of a sentence, but obtains between the elements of the collection that *divers* takes as its sole argument.



# Evolutionary Game Theory and Linguistic Typology: a Case Study

Gerhard Jäger*

**Abstract**
The paper deals with the typology of the case marking of semantic core roles. The competing economy considerations of hearer (disambiguation) and speaker (minimal effort) are formalized in terms of evolutionary game theory. It will be shown that the case marking patterns that are attested in the languages of the world are those that are evolutionary stable for different relative weightings of speaker economy and hearer economy, given the statistical patterns of language use that were extracted from corpora of naturally occurring conversations.

## 1 The frequencies of clause types

Consider all (logically) possible case marking types that only use case splits induced by the contrast between pronouns and full NPs. I will restrict attention to possible grammars where the morphological form of the intransitive subject (nominative/absolutive) is less complex than ergative and accusative (if present). Which language types are functional and which aren't? The main function of case marking is of course to disambiguate, i.e. to enable the hearer to identify the semantic role of the denotation of an NP. More particular, case should uniquely identify the argument roles "A" (agent, i.e. the transitive subject) and "O" (the direct object). We can assume without loss of generality that the hearer always interprets an ergative morpheme as A if there is one, and likewise an accusative morpheme as O, so ambiguity can safely be avoided if at least one NP per clause is case marked. For the sake of brevity, I will denote case marking patterns from now on as a quadruple of case forms, in the order: case of 1. pronominal agents, 2. non-pronominal agents, 3. pronominal objects, and 4. non-pronominal objects. Ergative marking is abbreviated as "*e*", accusative as "*a*", and zero marking (i.e. nominative/absolutive) as "*z*". For instance, a language like English where only pronominal objects are case marked would thus follow the pattern *zzaz*, while a language like Basque with obligatory ergative marking of all agents is *eezz*.

Ambiguity will only arise if a grammar admits clause types without any case marking. However, this need not lead to ambiguity if one of the two unmarked arguments is prominent and the other isn't. Then the hearer may em-

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ploy a default rule to the effect that in such a case the more prominent NP is A (or vice versa). This taken into account, the speaker strategies *zeaz* and *ezza* also avoid ambiguity in the sense that there is a corresponding hearer strategy that always correctly identifies semantic roles. One might assume that word order is a good predictor of syntactic roles too, but even in languages with fixed word order there may occur elliptical expressions which are, without the aid of case morphology, ambiguous. Let us assume that disambiguation is the main priority of the speaker, but he has the secondary priority to use as few case morphemes as possible. It depends on the relative frequencies of clause types which patterns minimize the average number of case morphemes per clause. We only have to consider four clause types – both A and O may be $p$ (pronominal) or $n$ (non-pronominal). The percentages in figure 1 are extracted from Geoffrey Sampson's CHRISTINE corpus of spoken English, and I took pronouns to be prominent and full NPs to be non-prominent. The set of all clauses comprising a subject and a direct object amount to 100%.

I will refer to the four cells of this table with pairs *pp*, *pn*, *np*, and *nn*, where the first element gives the specification of $A$ and the second of $O$. The concrete figures of course depend on the corpus under investigation and the choice of the prominence split. However, for the results reported below, the only thing that matters is that $pn > np$, and this inequality robustly holds for all corpora (including both spoken and written corpora in English, German and Swedish) I investigated and for all split points along the definiteness hierarchy or the animacy (to the degree that the corpora investigated were annotated for animacy) hierarchy.

| | $O/p$ | $O/n$ |
|---|---|---|
| $A/p$ | 19.70% | 71.24% |
| $A/n$ | 1.59% | 7.46% |

Figure 1: clause type frequencies

## 2 Game Theory

Game Theory is well-suited to make the possibly conflicting priorities of speakers and hearers more precise. Let us assume that a fixed set of meanings $M$ and forms $F$ is given. A speaker strategy is any function $S$ from $M$ to $F$, i.e. a production grammar. Likewise, a hearer strategy is a comprehension grammar, i.e. a function from $F$ to $M$. In an utterance situation, the speaker has to decide what to say and how to say it. Only the latter decision is a matter of grammar; the decision about what meaning the speaker tries to communicate is related to other cognitive domains. Let us thus assume that in each game, nature presents the speaker with a meaning $m$, and the speaker only has to choose how to express $m$. Communication is successful if the hearer recovers the intended meaning from the observed form. It is measured by the $\delta$-function:

$$\delta_m(S,H) = \begin{cases} 1 & \text{iff } H(S(m)) = m \\ 0 & \text{else} \end{cases}$$



Forms differ with respect to their complexity. I take it that the complexity can be measured numerically, i.e. *cost* is a function from $F$ to the non-negative real numbers. The speaker has two possibly conflicting interests: he wants to communicate the meaning as accurately as possible while simultaneously minimizing the complexity of the form used. This is captured by the following definition of speaker utility:

$$u_s(m,S,H) = \delta_m(S,H) - k \times cost(S(m))$$

Here $k$ is some positive coefficient that formalizes the priorities of the speaker. A low value for $k$ means that communicative success is more important than minimal effort and vice versa. The hearer tries to recover the intended meaning as accurately as possible. So the hearer utility can be identified with the $\delta$-function:

$$u_h(m,S,H) = \delta_m(S,H)$$

Nature presents meanings to the speaker according to a certain probability distribution $x$. The average utilities of speaker and hearer in a game can thus be given as

$$u_s(S,H) = \sum_m x_m \times (\delta_m(S,H) - k \times cost(S(m)))$$

$$u_h(S,H) = \sum_m x_m \times \delta_m(S,H)$$

We are only concerned with elementary transitive clauses. So we are dealing with two NPs. One is $A$ and the other $O$, and both may be either $p$ or $n$. I am not concerned with the effect of word order or head marking on argument linking in this paper. Therefore I take it that nature chooses the word orders $A-O$ and $O-A$ with a 50% probability each, and that this choice is stochastically independent from the specifications of the NPs as $p$ or $n$. Furthermore nature specifies which of the two NPs is $A$ and which is $O$, and whether they are $n$ or $p$. This gives a total of eight meanings. $x$ is a probability distribution over these eight meanings. It is plausible to assume that the prominence of an NP is always unambiguously encoded in its form. This leaves us with 36 possible forms — each of the two NPs may be $p$ or $n$, and either one may be marked with ergative, accusative, or zero case. The cost function simply counts the number of case morphemes per clause.

I will restrict attention to just a small subset of simple strategies. First, word order effects are kept out of considerations. Furthermore, I take it that the case morphology of a given NP only depends on its own prominence value and syntactic function, not on the prominence value of the other NP. Among these strategies, I will restrict attention to those where the two marked forms are reserved for one syntactic role each while the unmarked form is in principle ambiguous between $A$ and $O$. This leaves us, modulo renaming of $e$ and $a$, with 16 case marking patterns, *eeee, eeaz, eeza,* $\cdots$, *zzza, zzzz*. Of these 16 strategies, 6 are strictly dominated (i.e. they are never optimal, no matter what the hearer does), namely those that sometimes use two case morphemes per clause, and the inverse split ergative pattern *ezza*.

A hearer strategy is a mapping from forms to meanings. If ergative is only used to mark $A$ by the speaker and accusative only for $O$, it would obviously be unreasonable by the hearer to interpret the case morphemes otherwise. I will call the hearer strategies that interpret ergative as $A$ and accusative as $O$ "faithful." There are only 16 faithful strategies. Thus only the interpretation of clauses without case morphology is undetermined. There are four such clause types (depending on the prominence features of the two NPs), each of which may receive two possible interpretations. If both NPs in a form $f$ have the same prominence value, both interpretation strategy classes have actually the same expected payoff because by assumption, the speaker strategies exclude correlations between word order and meaning, and the prominence values give no clue. So we may safely identify any pair of hearer strategies which only differ in their interpretation of $p/z - p/z$ or $n/z - n/z$. Now we are down to four hearer strategies — they differ with respect to the meaning they assign to $p/z - n/z$ and $n/z - p/z$. I will denote these strategies as $AA$, $AO$, $OA$ and $OO$, where the first component is the interpretation of the first NP in $p/z - n/z$, and the second component the interpretation of the first component of $n/z - p/z$.

The configuration of Nash Equilibria (NEs henceforth) depends on the value of $k$. For small values of $k$, the split ergative pattern $zeaz/AO$ is a strict NE (i.e. each component strategy is the **unique** best response to the opponent's strategy). Besides, each combination of a pure ergative (*eezz*) or pure accusative (*zzaa*) speaker strategy with any hearer strategy $\neq AO$ is a non-strict NE. For larger values of $k$, two strict NEs coexist, either differential object marking ($zzaz/AO$) and inverse differential subject marking ($ezzz/OA$), or differential subject marking ($zezz/AO$) and inverse differential object marking ($zzza/OA$). Finally, for very large values of $k$, the system without case marking $zzzz/AO$ is the unique (and hence also strict) NE.

Let us take stock. Of the sixteen case marking strategies that we considered, only eight give rise to an NE in some configuration. The eight strategies that were excluded are in fact typologically unattested or at least very rare. There is apparently only one language with a full-blown tripartite system, i.e. with the strategy *eeaa*, namely the Australian language Wangkumara. Inverse split ergative systems — *ezza* in my notation — are also very rare. It is a bit tricky to decide whether languages of the type *zeaa* or the like exist. There are several split ergative languages where the split points for ergative and accusative differ, and where there is an overlap in the middle of the hierarchy with a tripartite paradigm. Since the system I use here implicitly assumes that the two split points always coincide, such languages cannot really be accommodated; they are a mixture of *eeaz*, *zeaa* and *zeaz*. To my knowledge, clearcut instances of *eeaz* or *zeaa* do not exist, and the combinations *ezaa* and *eeza* are unattested as well. There are no languages which would have a tripartite paradigm for all and only the prominent or all and only the non-prominent NPs.



Hence *zeza* and *ezaz* are correctly excluded. So the concept of a Nash Equilibrium proves fairly successful in identifying possible case marking systems. Conversely, we expect to find instances of languages with an NE pattern. This is certainly the case for *zzaz* (like English), *zezz* (for instance the Circassian languages Adyghe and Kabardian), *zeaz* (like Dyirbal), and *zzzz* (as in several Bantu languages). However, the concept is still too inclusive. I know of only one language of the types *zzza* and *ezzz* each, namely Nganasan (see [3], p. 90) as instance of the former and (according to [1]) Wakhi of the latter. The pure accusative systems — *eezz* — do exists (Hungarian is an example), but they are also very rare. Most accusative languages have DOM, and most ergative languages DSM. Besides, the rationalistic approach has the same conceptual problem as any functional explanation of grammatical patterns: natural languages are not consciously designed, and it is *a priori* not clear at all why we should expect to find functionally plausible patterns.

## 3 Evolutionary Game Theory

In Evolutionary Game Theory (EGT), we are dealing with populations of players that are programmed for a certain strategy. Players replicate and pass on their strategy to their offsprings. The number of offsprings is directly related to the average payoff of the parent strategy.

How can this model be applied to linguistics? If the strategies in the EGT sense are identified with grammars (as done in the previous section), games should be identified with utterances. However, grammars are not transmitted via genetic but via cultural inheritance. Therefore, **imitation dynamics** is more appropriate here than the replicator dynamics that is used in applications of EGT to theoretical biology. According to the imitation dynamics, players are not mortal and have no offsprings. However, every so often, a player is offered the opportunity to pick out some other player and to change his own strategy against the strategy of the other player. The probability that a certain strategy is adopted for imitation is positively correlated to the gain in average utility that is to be expected by this strategy change. So here as well as in the standard model, successful strategies will tend to spread while unsuccessful strategies die out. Moreover, exactly the same strategies are evolutionary stable under the replicator dynamics and under the imitation dynamics. Several sources of mutations are conceivable here, ranging from plain speech errors to socio-linguistic factors like language contact. We expect that most natural language grammars are evolutionary stable because unstable grammars do not persist. The Game of Case that was introduced in the last section is an **asymmetric game**. In a population dynamic setting, this means that we are dealing with two separate populations. So rather than with evolutionary stable strategies, we have to deal with evolutionary stable strategy pairs here. In multi-population dynamics, evolutionary stability can be characterized quite easily in rationalistic terms. Briefly put, a strategy pair is evolutionary stable iff it is a **Strict Nash Equilibrium** (SNE henceforth).

Let us apply the analytical tools of EGT to the different instantiations of the Game of Case. The NEs using a pure case marking strategy (*eezz* or *zzaa*) are never strict and thus not evolutionary stable. The remaining 6 NEs are strict though. Of these 6 strategy pairs, two are very rare among the languages of the world: *zzza/OA* and *ezzz/OA*. Put differently, it is important to note that these two "wrong" SNE each coexist with a well-attested SNE, namely inverse differential subject marking (*ezzz/OA*) with differential object marking (*zzaz/AO*), and inverse differential object marking *zzza/OA* with differential subject marking *zezz/AO*. In both scenarios, the typologically attested SNE is Pareto-optimal, i.e. it has a higher average utility than the competing SNE.

The standard approach to EGT assumes that populations are infinite. If we assume instead that the populations are finite but large, every invasion barrier is occasionally broken, no matter how low the mutation rate is. (With increasing population size, the likelihood of such an incident converges towards 0.) It can be shown that the Pareto-optimal SNE always has a higher invasion barrier than the other SNE. In a finite population, it is thus more probable to switch **to** than **from** the Pareto-optimal SNE. In a *population of finite populations*, the unique attractor state is the one where the majority of population is in the Pareto-optimal SNE, and as the size of the single finite populations increases, the probability of the non-Pareto-optimal SNE converges towards 0. (See [4] for a similar explanation of the asymmetry between multiple evolutionary stable strategies.)

To sum up, under the assumption of a population of finite but large populations of speakers/hearers, only four strategies are evolutionary stable: split ergativity, differential subject marking, differential object marking, and absence of case marking. This fits the typological findings rather well. While the majority of languages is in an evolutionary stable state, there are some exceptions. Evolutionary Game Theory predicts that such language types should be diachronically unstable. This is an empirically testable claim that should be tackled in future research.

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# A Framework for Modelling Evolutionary Stable Strategies in Discourse Semantics

**Rodger Kibble***


**Abstract**

Collaborative reference resolution involves various trade-offs between and within speakers and hearers: use of "cheap" forms such as pronouns succeeds only if speakers and hearers invest effort in planning and discourse modelling. Evolutionary Game Theory offers a way to characterise resulting conventions of discourse reference.


## 1 Discourse reference

Gärdenfors [3] seeks to explain why humans are the only species so far known to be capable of fully symbolic communication, exchanging information about entities which may be remote in time and/or space. His thesis is that "language makes it possible to cooperate about future goals" and that "humans are the only animals that can plan for future goals". Gärdenfors postulates three stages of abstraction in the evolution of referring expressions (REs): *names*, which identify unique individuals, *nouns*, which identify *clusters* in "conceptual space", and *adjectives*, representing *dimensions* in conceptual space, allowing for a finer level of granularity than nouns on their own. The resulting proto-language appears suited for *direct* reference but not for *anaphora*, lacking mechanisms which give hearers the choice between resolving RE's directly to a particular entity, or indirectly via linkage with a previous direct reference. It seems reasonable to assume that discourse reference arose as a distinct stage in the evolution of language use. However, in this paper I will work up to a more modest question: how can we tell if a convention for reference resolution constitutes an *evolutionary stable strategy*?

## 2 Some ingredients of collaborative reference resolution

A proper treatment of reference resolution must take account of both the speaker's and hearer's perspectives. Consider the following examples:

1. a. The poodle$^i$ and the small chihuahua$^j$ fought over a bone.

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b. The small $\text{chihuahua}_j$ was hurt.
b′. The $\text{chihuahua}_j$ was hurt.
2. a. Alice likes Betty.
b. $\text{She}_A$ often visits $\text{her}_B$ for tea.
c. Yesterday Betty baked a cake for $\text{her}_A$.
c′. #Yesterday $\text{she}_B$ baked a cake for $\text{her}_A$.

Assume the domain of example (1) includes the following objects:

$d_1$: <type: chihuahua>, <size: small>, <colour: black>
$d_2$: <type: chihuahua>, <size: large>, <colour: white>
$d_3$: <type: siamese>, <size: small>, <colour: black>
$d_4$: <type: poodle>, <size: small>, <colour: white>

The continuation (1b) is generated by Dale and Reiter's Incremental Algorithm (IA) [1], assuming no account is taken of the changing discourse context, while (1b′) results from Krahmer and Theune's Modified Incremental Algorithm (MIA) [6]. D & R's algorithm constructs descriptions by systematically adding properties until all "distractors" are eliminated; K & T allow for *definite anaphora* by modifying the algorithm so that it terminates when the target referent is the *most salient* entity satisfying the current list of properties. Some observations:

• In order for a hearer to identify the intended referent in (1b′), they must also maintain a discourse model which makes $d_1$ more salient than $d_2$ at this point. Otherwise, there would only be a 0.5 probability of interpreting the referent correctly.

• Gärdenfors [3] proposes that "when you are faced with a situation where a noun covers several potential referents, you should select an adjective that picks out a *maximally informative* dimension within the cluster that represents the noun." However, D & R (op cit.) already dispute this, as they show that the strategy of formulating the most economical description of a given referent (*Full Brevity (FB)*) is exponentially complex in the worst case. Whereas Gärdenfors is concerned with "cognitive economy" from the *hearer's* perspective, the IA is claimed to be the most efficient for *speakers*.

Turning to example (2): the subscripts in (2b/c) represent the "natural" readings of the pronouns as predicted by Centering Theory [4]. A speaker who utters (2c′) intending to convey the meaning indicated by the subscripts will almost certainly be misunderstood. Centering Theory (CT) claims that every utterance has a designated centre of attention or *center*; that sequences of utterances are preferred where the same center is maintained and where the center appears in Subject position; and that the center is most likely to be pronominalised. Thus *Betty* is necessary in (2c) to pre-empt the expectation that Alice will be mentioned as Subject. CT is motivated in part on processing grounds: preferred types of sequences are claimed to be easier for hearers to understand, and the pronoun rule allows the speaker to expend less effort when referring to more predictable entities. However, the picture is a little more complicated: the correct interpretation of pronouns assumes that S and H maintain a congruent



discourse model, which itself has some processing cost, and the task of *planning* text so as to maximise the number of coherent transitions turns out to be of factorial complexity in the worst case [5].

At this point I wish to offer a conjecture: a semantic convention will be adopted in a speech community only if:

• Following the convention generally results in successful communication (within a tolerable margin of error $\epsilon$);
• No other convention is equally successful (or perhaps almost equally, within a margin $\epsilon$) but requires less cognitive effort.

(Note the *only if*: I claim to be offering some *necessary* conditions which do not exhaust the *sufficient* conditions.) The "success" of a convention depends of course on which convention is being followed by one's interlocutor, which again depends in part on questions of cognitive effort. So what we are assuming is that speakers and hearers tend towards a balance between expressivity and a joint minimisation of processing costs.

## 3 Modelling collaborative reference resolution

To get a clearer picture of where "processing costs" might come from, I list some possible strategies under four headings: the *strategic* and *tactical* options available to S and H respectively.

### 3.1 Speaker perspective

**Planner/Content Determination (P)** is responsible for organising input propositions into a text structure, which may already be partially ordered according to coherence relations and planning sentences by e.g. choosing verb forms to realise a preferred order of arguments. Increased planning effort will increase objective *predictability* of referring events and so aid the hearer's comprehension (reduce H's effort).

1. **Random:** Do nothing, resulting in a random order of propositions and arguments within clauses.
2. **Salience** Promote clausal arguments to Subject position according to some measure of salience.
3. **Continuity:** Plan sequence of clauses to maximise referential continuity (i.e., so that consecutive clauses have at least one referent in common).
4. **"Centering":** Combine **Salience** and **Continuity**, and update salience weighting for repeated referents.

**Realiser (REG)** generates appropriate referring expression to denote arguments of predicates.

1. **Null:** Do (almost) nothing: generate $\epsilon$ or a personal pronoun.
2. **Name:** Use a distinct RE for each entity in the domain.
3. **Short-NP:** Reduced definite using a basic-level predicate, such as *the dog.*

**4. Full-NP:** Uniquely identifying definite *the small white poodle in the kennel*. Various algorithms are available: IA, MIA, FB, etc.

### 3.2 Hearer perspective

**Discourse Modeller (DM)** maintains a record of entities mentioned in the discourse which will be candidates for anaphora resolution:

**1. Null:** no record of discourse referents. Only fully explicit definites will be unambiguously resolvable in the worst case.
**2. Clausal:** Keep a one-clause buffer of focal referents
**3. Weights:** Update salience weights each time a referent is mentioned.
**4. Full-DM:** fully-structured discourse model including salience-ranked history list, segmented to reflect rhetorical structure.

**Reference Resolver (RR)** is responsible for identifying the referent of a RE with an entity in the domain.

**1. Default:** Resolve to most salient entity in **DM** if available.
**2. Search-DM:** Search the discourse model constructed by **DM**
**3. Search-Dom:** Search the domain if no candidate is found in the discourse model

It should be clear that the more effort **P** expends in constructing coherent plans, the more opportunities there will be for **REG** to use reduced REs or pronouns, and that **RR**'s success in interpreting these with least effort will depend on the work done by **DM**.

## 4 Searching the solution space

The above classification of the choices available to language users maps out a four-dimensional solution space, where each point identifies a potential encounter between a speaker S and hearer H. In some of these encounters, reference resolution will fail; in others it will succeed but inefficiently, perhaps with S giving H more information than is required or with H constructing a DM which never needs to be queried. Two questions which arise are:

- how can we identify *optimal* points in the solution space?
- how can we tell whether real language users actually arrive at these theoretical optima?

One way of tackling these questions is offered by orthodox game theory: we assume that speakers and hearers independently compute the outcomes for both parties at every point in the solution space, and (again independently) choose the actions which will result in an optimal outcome. Many researchers in language and information have been turning to Game Theory as a way of modelling the interdependent choices and preferences of language users in dialogue [2, 8], following Lewis's pioneering study [7]. A key notion has been the "Nash Equlibrium", a state where neither discourse partner can better achieve their communicative goals by unilaterally changing strategy. However there are



well known difficulties with this approach. There tend to be too many potential equilibria (i.e., more than one) and the task of calculating optimal states assumes that speaker-hearers operate as Kantian ideal reasoners, with both the willingness and the computational resources to calculate the best outcome for themselves and their interlocutors. Paradoxically, the computational cost of identifying the optimal strategy may well outweigh the savings gained by using this strategy in preference to a more expensive one.

These difficulties are explicitly addressed by Evolutionary Game Theory (EGT) which assumes that strategies evolve over repeated interactions through trial and error. EGT introduces the idea of an Evolutionary Stable Strategy, which is supposed to be "immune" to being ousted by mutant or invading strategies; more formally (with $u(s, s')$ = utility of $s$ when played against $s'$):

> A strategy $s^*$ is an Evolutionary Stable Strategy (ESS) if for any strategy $s$ either $u(s, s^*) < u(s^*, s^*)$ or, $u(s, s^*) = u(s^*, s^*)$ and $u(s, s) < u(s^*, s)$. [8, p. 29]

A *strategy* in this context corresponds to a point in the solution space defined in section 3, with each point now identifying a composite Speaker-Hearer strategy. We assume that individuals in a population have a 0.5 chance of being either S or H in any encounter. For the purposes of ranking strategies, a rough definition of *utility* is $\frac{\textsf{success}}{\textsf{strategic-cost} + \textsf{tactical-cost}}$ where success is the average proportion of successful referring events in an encounter and strategic-cost, tactical-cost are measurable (in principle) in terms of time and memory requirements. Strategic costs are incurred by **P** and **DM**, tactical costs by **REG** and **RR**.

For expository purposes, let us focus on three representative strategies:

**1. Direct Reference (DR):** Planner and Discourse Model do nothing; REG generates names, indexicals or uniquely identifying definites; RR searches entire domain to resolve referent.

**2. Opportunistic Anaphora (OA):** Planner does nothing; Discourse Model keeps a one-clause buffer of entities recently mentioned *by either interlocutor*; REG generates anaphoric pronouns or reduced definites where possible; RR searches DM before domain.

**3. Planned Anaphora (PA):** Planner aims to maximise predictability of referents via ordering of propositions and arguments; DM maintains a salience-weighted history list of all entities mentioned by either interlocutor; REG generates anaphoric pronouns or reduced definites where possible; RR searches DM before domain, taking account of salience weights.

In any symmetrical pairing ($x$, $x$), it seems likely that success will be close to 1.0, i.e. that S will not produce REs which H cannot uniquely resolve. (This should warn us that these strategies are all idealisations: in real life we do encounter ambiguities and misunderstandings, arising from particular compromises between expressivity and complexity.) For asymmetric pairings, the following orderings seem reasonable:

- success(DR, OA|PA)< success($x$, $x$)

- success(OA, PA) < success($x$, $x$)
- strategic-cost(DR) < strategic-cost(OA) < strategic-cost(PA)
- tactical-cost(DR) > tactical-cost(OA) > tactical-cost(PA)

So for example, OA will interpret all REs generated by DR, but will produce some pronouns and reduced definites which DR cannot handle. Calculating *utility* depends on the balance between strategic and tactical costs, which will be inversely correlated. My initial hypotheses are:

• Assuming DR to be the original incumbent strategy, it is vulnerable to invasion by OA, which achieves savings in tactical costs at a modest strategic expense.

• The most likely ESS[1] is somewhere between OA and PA: the latter involves planning of factorial complexity which will severely impact on utility.

Further investigation of these hypotheses will involve empirical research and computational modelling to determine appropriate values for strategic and tactical costs.

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1. Assuming there is a unique ESS; but see [9] for discussion of games with multiple ESS.



# Mood and Modality

# On the combinability of deontic, epistemic and evidential expressions

**Jan Nuyts**

At least in the West Germanic languages — but possibly this is a wider, maybe even a universal phenomenon — there are considerable limitations on the possibilities to combine evidential, epistemic modal and deontic modal qualifications of states of affairs in one clause. Corpus research reveals that combinations of these forms are very rare, and combinations that do occur quite systematically show semantic peculiarities (either only one form is used 'performatively' while the other is used 'descriptively', or one of the forms does not perform its 'normal' function). Moreover, if one attempts to construct additional examples, it turns out that many combinations are simply impossible. In this paper I will attempt to explain these facts by analyzing the status of these qualificational categories (also in relation to/contrast with other qualificational dimensions such as time and aspect) in human conceptualization and in language processing.

# 'Or' in context

**Bart Geurts***

This paper is primarily concerned with the following data:

(1) a. It may be here or (else) it may be there.
b. It must be here or (else) it must be there.
c. It may be here or (else) it must be there.
d. ?It must be here or (else) it may be there.

(So as to forestall referential confusion, let us suppose that 'It' is the name of a runaway chicken.) The most pressing problem presented by these sentences is that, on one of its readings, (1a) seems to imply both that It may be here and that it may be there (though not both, presumably), whilst (1b) does not license the corresponding inferences; that is, it does not imply that It must be here, nor does it imply that it must be there. Another problem, which is less well-known, is the contrast between (1c) and (1d). It may be that (1c) is less than fully acceptable to some speakers, but everyone agrees that (1d) is a lot worse. This asymmetry is entitled to an explanation, too. Non-epistemic modalities raise analogous problems.

This paper can be seen as an attempt to remedy various problems with Zimmermann's (2000) theory. The present proposal is indebted to Zimmermann's in two major respects. First, and most importantly, disjunctions will be analysed as conjunctions of modal propositions. Secondly, I adopt Zimmermann's idea that the essential contribution of 'or' is merely to present a list of alternatives. Any further ingredients in the interpretation of a disjunctive construction (such as exhaustivity) are contributed by extraneous factors; they are not part of the meaning of 'or'.

I depart from Zimmermann's original proposal in three ways. First, I reject his premiss that disjunctions are always lists of *epistemic* modals. Intuitively, the function of 'or' is just to present alternatives, not to determine their modal status; it is not for 'or' to decide whether its arguments are epistemic or deontic or something else, though it may well be that disjunctions are epistemic by default.

The second difference between Zimmermann's theory and mine concerns the logical form of disjunctive sentences. According to Zimmermann, the logical form of (1a) contains four modal operators: $\Diamond\Diamond A \wedge \Diamond\Diamond B$. I maintain that there

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are just two: the overt modals *fuse* with the modals covertly required by 'or'. Hence, to a first approximation at least, the logical form I propose for (1a) is simply $\Diamond A \wedge \Diamond B$; from which it follows straightaway that $\Diamond A$ and that $\Diamond B$. However, this is just the beginning of my story. For if the same analysis is applied to (1b), for example, what we get is $\Box A \wedge \Box B$; and we don't want (1b) to imply that It must be here *and* there. The solution, I believe, lies in the way modals interact with the context. This context dependence is the fulcrum of my analysis, and the third respect in which I deviate from Zimmermann's model. In the following I develop these ideas in more detail, starting with the last.

It is a familiar observation that the meaning of a modal expression is dependent on contextual factors. This context dependence is manifest in examples like the following:

(2) Your teeth might fall out.

In this example it is perfectly clear what kind of contextual information the sentence requires, at least intuitively speaking: (2) means something like 'If the circumstances were to be such and such, your teeth might fall out', and unless the context determines what 'such and such' stands for, the sentence will be unintelligible.

Simple modal sentences like (2) don't impose overt restrictions on their domains. Such restrictions can be communicated, if need be, by means of an if-clause:

(3) If you don't brush your teeth anymore, they might fall out.

Here it is the if-clause that furnishes the constraints on the modal domain that were previously derived from the context. This is not to say, however, that the if-clause replaces the context altogether, for conditional modals like (3) are context dependent just as simple modals are. For example, if (3) is continued as follows:

(4) ... and if your teeth fall out, you'll be sorry you didn't brush them.

the states of affairs under consideration are those in which the addressee's teeth fall out because she didn't brush them, but the sentence doesn't say so explicitly.

What if a conditional doesn't contain an overt modal element, as in (5a)? There is a popular view, which I will adopt too, that in such cases there is a covert operator, which defaults to epistemic necessity. Hence, all things being equal, (5a) will be equivalent to (5b):

(5) a. If Betty isn't in Lagos, she is in Harare.
b. If Betty isn't in Lagos, she must be in Harare.

Note that, even though the interpretation of (5a) involves a covert modal, this does not imply that there two modals in (5b), one overt and one covert. Rather,



(5b) makes explicit an element of meaning that is left implicit by (5a). This is the rule, but there are exceptions:

(6) a. If you're myopic, you shouldn't use contraceptives.
b. If the Pope is right, you shouldn't use contraceptives.

Suppose that the personal pronouns in these examples are all generic. Then (6a) proclaims a ban of a somewhat peculiar nature, namely, that short-sighted people shouldn't use contraceptives. By contrast, a speaker who utters (6b) doesn't issue a ban of any kind, but rather considers the possibility that a certain norm applies, namely, that contraceptives should not be used (by anyone). So this *is* an instance of double modality, one part of which is overt while the other part is covert.

In order to model the context dependence of modal expressions, I assume that modals are explicitly represented as relations between sets of worlds. For example, the logical form of (2) is $A\Diamond B$, where A represents the domain of the modal and B stands for the sentence's descriptive content. The linguistic surface form of a sentence like this leaves the domain of the modal quantifier virtually unrestricted, although modal expressions always impose some constraints on their domains, as witness the difference between 'can' and 'may', for example. But it is clear that, in general, the domain of a modal is determined chiefly by the context. In the following I will assume, therefore, that a modal proposition is always interpreted against a given 'background' (i.e. a set of worlds), which depending on the occasion is to be thought of as epistemic, deontic, etc. The domain of a modal quantifier can relate to this background in one of two ways: domain and background may be identical or the former may be a subset of latter. Conversational backgrounds may be thought of as a kind of discourse topics: unless a speaker wants to change the topic, he goes on talking about the same topic or at least part of it.

Generalising Zimmermann's analysis, I assume that the logical form of a sentence '$S_1$ or ... or $S_n$' is a conjunction of propositions of the form $A_i\mathcal{Q}_iB_i$, where $\mathcal{Q}_i$ is a modal quantifier. The lexical meaning of 'or' doesn't say which quantifier $\mathcal{Q}_i$ is, though it may specify that, all things being equal, $\mathcal{Q}_i$ is epistemic and existential. However, in the cases we are concerned with all things are not equal, because the arguments of 'or' are modal propositions, which usually means that $\mathcal{Q}_i$ is determined by the modality of $S_i$. That is to say, the logical forms of (1a) and (1b) are (7a) and (7b), respectively:

(7) a. $A\Diamond B \wedge A'\Diamond B'$
b. $A\Box B \wedge A'\Box B'$

As in conditionals with modal consequents (cf. (5b)), the modal verbs in (1a) and (1b) make explicit the modal operators covertly required by 'or'. This is the normal case; there are also cases in which overt and covert modals don't fuse:

(8) You may do this or you may do that.

*Pace* Zimmermann, I maintain that this sentence is ambiguous. On one reading, the speaker grants the addressee permission to do this or that; in which case overt and covert modals fall together, and the logical form of (8) mirrors that of (1a). On the other reading, the speaker doesn't give permission but considers what is permitted. For this reading, I adopt roughly the same logical form as does Zimmermann, according to which each disjunct contains an epistemic modal which has a deontic modal in its scope. The contrast between these two readings is analogous to the contrast between the two sentences in (6).

Again following Zimmermann's lead, I assume that the interpretation of disjunction is usually restricted by constraints other than the meaning of 'or' itself. The two main constraints are the following. Let $A_1 \mathcal{Q}_1 B_1 \wedge \ldots \wedge A_n \mathcal{Q}_n B_n$ be the logical form of a sentence '$S_1$ or ... or $S_n$' which is interpreted against a contextually given background set C:

**Exhaustivity:** $C \subseteq (A_1 \cap B_1) \cup \ldots \cup (A_n \cap B_n)$
**Disjointness:** If $1 \leq i, j \leq n$, then $A_i \cap B_i \cap A_j \cap B_j = \varnothing$

My Exhaustivity constraint is almost identical to Zimmermann's, the main difference being that the background set C is not necessarily epistemic. The Disjointness constraint gives rise to what is generally known as the exclusive interpretation of disjunction. Both constraints can be triggered by a variety of factors: intonation, certain keywords ('either', 'else'), background knowledge, pragmatic inference. It is also plausible to assume, I believe, that these constraints hold by default.

I will now apply this analysis to the examples listed at the outset, starting with (1a). The logical form of (1a) is $A\Diamond B \wedge A'\Diamond B'$, and it is interpreted against an epistemic background C. By default, A and A′ are bound to C, i.e. $A = A' = C$. Thus we get $C \cap B \neq \varnothing$ (from the first disjunct) and $C \cap B' \neq \varnothing$ (from the second disjunct). Hence, it follows more or less directly that It may be here and that It may be there.

Without further constraints, (1a) does not exclude the possibility that It may be neither here nor there. This possibility is ruled out if the Exhaustivity constraint applies, because then it holds that $C \subseteq B \cup B'$. Thus Exhaustivity in effect turns (1a) into the claim that It *must* be here or there—which is perhaps the most natural reading for (1a) to have.

On the account proposed here, (8) is more or less the same as (1a), except of course that (8) is to be interpreted against a deontic background. Furthermore, the tendency to assume that Exhaustivity holds may not be as strong in this case as it is in the previous one, but this is a difference in degree not in kind; for (8) may well be used to convey that the addressee must do either this or that.

The logical form of (1b) is $A\Box B \wedge A'\Box B'$. The main difference between this example and its existential counterpart in (1a) consists in the connections



between A and A′ on the one hand and the background set C on the other. For if $A = A' = C$, the sentence means that It must be here and there, which is inconsistent with the fact that, as a rule, a chicken cannot be in more than one place at a time. More generally, the Disjointness constraint is violated if either $A = C$ and $A' \subseteq C$ or $A' = C$ and $A \subseteq C$. Therefore, we assume that A and A′ need not cover all of C, i.e. $A \subseteq C$ and $A' \subseteq C$. Assuming Exhaustivity, (1b) states that all C-worlds are either B-worlds or B′-worlds, so It must be here or there. And if Disjointness holds, as well, C is partitioned into A and A′. This seems to capture the intended reading of (1b) quite well. In particular, on the present analysis, it does not follow from (1b) that It must be here, nor does it follow that It must be there.

The logical form of (1c) is $A\Diamond B \wedge A'\Box B'$, and in this case it is possible to identify A, though not A′, with the epistemic background C; hence $A = C$ and $A' \subseteq C$. Now we get the following:

| | | | |
|---|---|---|---|
| First disjunct: | $C \cap B \neq \varnothing$ | Exhaustivity: | $C \subseteq B \cup A'$ |
| Second disjunct: | $A' \subseteq B'$ | Disjointness: | $B \cap A' = \varnothing$ |

An important difference between this example and the preceding ones lies in the relationship between the modal domains and the background set. In the foregoing, the domain sets A and A′ either coincided with C or they determined each other: in (1b) C was partioned by A and A′. In this example, by contrast, the only way to characterise A′ in terms of the other sets is as follows: $A' = C-B$; i.e. A′ contains all and only the non-B worlds in C. That is, in order to identify the domain of the second disjunct we require the descriptive content of the first. My suggestion is that this explains why (1c) is so much better than (1d). In (1d) the domain of the first modal is dependent on the descriptive content of the second, which is awkward for the same reason that kataphora is, in general, awkward.

The proposed analysis extends in a natural way to other constructions with 'or'. One straightforward extension is to disjunctions of conditionals like the following example, which is due to Woods (1997):

(9) Either he is in Rome, if he is in Italy, or he is in Bordeaux, if he is in France.

Woods observes that this sentence seems to entail that 'he' is in Rome or Bordeaux; which is precisely what we predict if we adopt the modal analysis of conditionals outlined above.

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## The Modality of the Future: A Default-Semantics Account

K.M. Jaszczolt*

**Abstract**
I discuss three types of use of English *will*: regular future, dispositional necessity, and epistemic necessity, and demonstrate that they can be accounted for by one semantic representation which I call a *compositionality-intentionality merger*. For this purpose, I propose to introduce into DRT an acceptability operator $ACC_{\Delta n}$ p ('it is acceptable to a degree *n* of the mode of presentation Δ that p') where the scalar value *n* determines the type of use of *will*. I demonstrate that an analogous scalar analysis applies to various ways of expressing futurity such as regular future, futurative progressive and tenseless future. The principles of Default Semantics correctly predict the existence of a default interpretation among the possible uses of *will* on the one hand, and possible expressions of futurity on the other.

### 1 The modality of *will* and the modality of the 'future': An overview

This paper contributes to the ongoing debate concerning the status of the English *will* as a marker of (i) tense, (ii) modality, or (iii) ambiguous between the two (see e.g. Fleischman [2]; Enç [1]; Werth [20]; Hornstein [5]; Ludlow [11]). In particular, I concentrate on clearly modal uses of *will* as in (1) and (2) (epistemic and dispositional necessity respectively), as opposed to (3) where *will* is primarily a marker of future tense reference:

(1) Mary will be in the opera now.
(2) Mary will sometimes go to the opera in her tracksuit.
(3) Mary will go to the opera tomorrow night.

I demonstrate that when we adopt an approach to temporality based on event semantics (e.g. Parsons [15]; Kamp and Reyle [10]; Pratt and Francez [16]), the classification of *will* as modal turns out to be the most satisfactory solution. For this purpose I combine the analysis in Discourse Representation Theory (henceforth: DRT, Kamp and Reyle [10]) with the theory of default interpretations (e.g. Jaszczolt [6], [7], [8], [9]) and use the properties of (i) the intentionality of mental states and (ii) its pragmatic equivalent of communicative, informative and referential intentions in communication in order to show that the degrees of intentions involved result in different interpretations of *will*. The strongest referential intention directed at the eventuality (state, event or process) results in the strongest commitment to the communicated eventuality and by the same token to the 'weakest degree of modality'.

The discussion of the properties of *will* is supplemented with a discussion of the semantic category of futurity. Sentence (3) is juxtaposed with expressions of futurity that use futurative progressive and tenseless future as in (4) and (5) respectively:

(4) Mary is going to the opera tomorrow night.
(5) Mary goes to the opera tomorrow night.

It is demonstrated that since the three readings differ as to the degree of modality, they can be given one overarching semantic representation. Since future *will* is best accounted for with reference to possible worlds (see e.g. Parsons [13], [14]), it is not qualitatively different from modal *will*. Independently of using world-time units, the purely future *will* in (3) turns out as modal since it exhibits affinities with (1) and (2) on one hand, and (4) and (5) on the other, that are best explained by a scale of epistemic modality. The gradation of intentions strongly suggests that *will* is modal. Instead of the ambiguity/temporality/modality trilemma, there is a gradation of the strength of intending the eventuality that results in various degrees of modal meaning communicated by *will*.

I corroborate this argument by placing *will* in the framework proposed in Grice [4]. According to Grice's Equivocality Thesis, alethic and deontic modalities are univocal, derived from one conceptual core of *acceptability*. I propose that Grice's acceptability can be introduced as a modal operator (ACC) to Discourse Representation Theory, replacing the current unsatisfactory treatment of *will* that relies on a linear structure of the future and on representing firstly tenses and only derivatively temporality.

### 2 Futurity in Default Semantics

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The main claim of Default Semantics is that utterances come with default interpretations. The dominant view in recent semantics and pragmatics is that in order to explain multiple readings of, let us say, propositional attitude sentences, sentences with sentential conjunction *and*, or negation, we have to postulate that semantic representation is underspecified as to some aspects of meaning, and further pragmatic processes in the form of (i) the developments of the logical form or explicature (Relevance theory) or (ii) implicatures (neo-Griceans) produce one exact reading. In contrast to this view, the theory of Default Semantics contains only one level of representation, derived from the structure and properties of mental states. The general picture is this. People have various mental states, such as believing, doubting, fearing, knowing. Some of these states, like for example the ones just enumerated, necessarily have an object. In other words, they are intentional. Intentionality means directness, being 'about' an object – be it real object, mental object, or an ontologically unspecified eventuality, depending on the particular view or a particular mental state. Now, language is one of the vehicles of mental states (and the most important one). The properties pertaining to thoughts, beliefs, etc. will then also hold of linguistic expressions associated with them. On the level of linguistic expressions, this property of intentionality is realised as a property of an utterance's coming with intentions. In particular, the speaker is assumed by the addressee to intend to communicate a message through this utterance, and derivatively to inform about something and to refer to an object or eventuality.

Intentionality can be stronger or weaker. For example, reports on people's beliefs or other propositional attitudes can be *de re*, about a particular, known individual and come with strong intentionality, or they can be *de dicto*, about the proposition as a whole, whoever its subject might be. In the latter case intentionality is weaker. Just as intentionality allows for degrees, so do their realizations in the forms of intentions in communication. I will now refer to this statement as the principle of Degrees of Intentions (DI):

DI: Intentions come in various sizes, i.e. they allow for degrees.

Let us see how this theory applies to expressions of temporality. In the case of the English *will*, we have three possible standpoints as far as its meaning is concerned: (i) it expresses future tense (and tense is not subsumed under modality; (ii) it expresses modality; and (iii) it is ambiguous between tense and modal senses. The ambiguity position is easily rejected by Grice's [3] methodological principle called Modified Occam's Razor: *Senses (linguistic meanings) are not to be multiplied beyond necessity.* Communicating modality by means of *will* can be intended very strongly, less strongly, or to various other degrees. If we accept this gradation of intentions, then Default Semantics renders this choice between (i) and (ii) unnecessary. Instead, various degrees of intentions correspond to various interpretations and neither ambiguity nor underspecification ensues.

In order to develop this approach, we need two more principles of Default Semantics: the Parsimony of Levels and the Primary Intention. In addition to degrees of intentions, Default Semantics adheres to a principle of parsimony with respect to the number of proposed levels of meaning. The original semantic representation (logical form) is the output of the compositional process of meaning construction and combines information coming from sentence structure and individual concepts. This representation is frequently in need of further enrichment before it can count as a faithful representation of the intended meaning. However, this does not yet mean that there is any need in our theory for such a level of underspecified representation. As we know from DI, utterances come with different strengths of intentions. This degree of intending is correlated with the strength of intentionality of the corresponding mental state. The information from this degree of intentionality merges with the information from compositionality (i.e. with the logical form) and produces a complete propositional representation. This economy of levels of meaning is summarised in the principle of the Parsimony of Levels:

POL: Levels of senses are not to be multiplied beyond necessity.

So, instead of adopting the underspecified semantic representation and the fully developed propositional representation, we have a more economical alternative of one meaningful representation to which the properties of the linguistic expression and the properties of the underlying mental state contribute, as it were, on equal footing. Meaning is compositional, but more fundamentally, it is also a result of having a thought, a meaningful mental state. The only way to represent this seems to be to recognize the level of meaning to which both compositionality and intentionality contribute. This level is the propositional representation and it is the only level we need in the theory. I call this level a *compositionality-intentionality merger* (Jaszczolt [8], [9]).

The strongest intentionality means the strongest commitment to the proposition and hence the 'weakest modality'. A mental state is 'strongly about' some objects or situations and it is only through



some context-dependent dispersal of this intentionality that the intentionality can become weakened. Since the strongest intentionality means the strongest aboutness, the corresponding readings of utterances are the ones, which secure the referent of the speaker's utterance, be it an individual or a situation. This is summarised in the Primary Intention principle:

Primary Intention (PI): The primary role of intention in communication is to secure the referent (individual object or individual eventuality) of the speaker's utterance.

### 3 Modal default and the ACC operator

Grice [4], p. 90 proposed that modals are 'univocal across the practical/alethic divide'. He called this theory an Equivocality Thesis. In the formal argument he introduced a rationality operator 'Acc' meaning 'it is (rationally) acceptable that'. If this is the case, then it is at least plausible that *will*, being a species of modality for the reasons to do with avoiding unnecessary ambiguity or underspecification, can be subsumed under the same category of acceptability. Namely, there is epistemic *will*, derived from the concept 'it is acceptable that', followed by the specification of time. This will account for the modal status of *will* and allow for its differing time reference.[1] Acceptability, meaning 'it is reasonable to think that', 'it is rationally plausible that', allows for degrees. An event can be more, or less, acceptable due to being more, or less, certain, allowing for more, or less, commitment on the part of the speaker. For example, dispositional necessity in (2) comes with stronger acceptability than epistemic necessity in (1), which in turn comes with stronger acceptability than the regular future *will* in (3). In (3), the reading is 'it is to be expected that she will go', 'she will probably go'.

In (3), it is not only the future time reference that we have to represent but also the degree of acceptability. First, we have to distinguish degrees of commitment to the proposition. In other words, we need degrees of modality. We can use here a device well known from hidden-indexical theory where the *type of mode of presentation* accounts for the differences between different readings of, say, propositional attitude reports (see Schiffer [17], [18], [19]). On Schiffer's [19] account, sentence (6) has the logical form as in (7):

(6) Ralph believes that Fido is a dog.

(7) $\exists m(\Phi^* m \ \& \ Bel(Ralph, <Fido, doghood>, m))$

where $\Phi^*$ is 'an implicitly referred to and contextually determined type of mode of presentation' (Schiffer [19], p. 503).

We could use this principle of the type of *m* ($\Phi^*m$) for futurity. Sentences (3)-(5) will now be represented by a partial DRS in *Fig. 1:

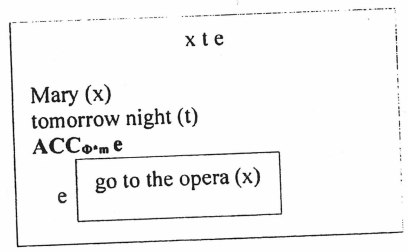


*Fig. 1

Fig. 1 will not suffice, though. Schiffer's $\Phi^*m$ suffers from overdetermination, it provides more information than is necessary for getting the truth conditions right. I propose instead the degrees to which *m* has to be specified. In other words, *m* can be coarsely-grained or finely-grained and we have to allow the varying degrees of detail through varying $\Phi^*$. I introduce $\Delta^n m$ for the degree *n* of fineness of detail of m, ranging from 0 (no relevance of m) to 1. The partial DRSs for (3)-(5) will now look as in Fig. 2, with the $\Delta^n$ varying from, let us say, $\Delta^{tf}$ for the tenseless future form in (5), through $\Delta^{fp}$ for the futurative progressive in (4), to $\Delta^{rf}$ for the regular future in (3):

[1] In addition, there is substantial evidence that modality has semantic scope over time, not the other way round (see Nuyts [12], p. 335).

xte

Mary (x)
tomorrow night (t)
**$ACC_{\Delta^{n}_{m}}$ e**

e | go to the opera (x)

Fig. 2

These three indices correspond to three degrees of modality, derived from the three degrees of informative intention and at the same time three degrees of intentionality of the corresponding mental state, as summarized in the DI principle. In $\Delta^{tf}$, reference is made to the future event without expressing any degree of detachment from the proposition expressed. Hence, this is the case of the strongest intentionality. In $\Delta^{fp}$, the degree of commitment of the speaker to the proposition expressed is lower and hence a higher degree of modality is involved. Modality is in an inversely proportional relation to the degree of commitment or assertability, possibility, evidence, etc. It is also in an inversely proportional relation to the degree of intentionality of the corresponding mental state as well as to the degree of the communicative intention with which the proposition was uttered. In $\Delta^{rf}$, we have the highest degree of modality and the lowest degree of commitment.

In this proposal, I have departed from the DR-theoretic practice, on Kamp and Reyle's [10] version, of representing *tenses*. Instead, I focussed on the dependencies between tenseless future, futurative progressive and regular future tense in relegating the differences to $\Delta^{n}$m. This move was dictated by the earlier proposal that temporality, at least with respect to the future, if not generally, is more adequately described as modality, degree of commitment, or ACC. I have combined (i) an investigation of *futurity* as a semantic category with (ii) an investigation of the auxiliary *will*. The first resulted in the representation in Fig. 2, with *n* of $\Delta^{n}$m varying between tf, fp and rf. These values represent some, as yet unspecified, points on the scale of n ranging from 1 to 0 as in Fig. 3:

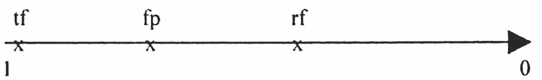


Fig. 3

The placement of the values on the scale is arbitrary as it has not been determined. While we know the relative positions of *tf*, *fp* and *rf* from the properties of use of these forms, their absolute placement on the scale will require a detailed empirical study.

Problem in (ii) concerns examples (1)-(3). (3) is well accounted for by ACC and $\Delta^{n}$m as in Fig. 2. As far as (1) and (2) are concerned, we can now account for them by a relative comparison of the strength of ACC in (1) and (2) with that of the regular future in example (3). Firstly, from $\Delta^{n}$m and Fig. 3, we adopt the position that temporal markers have their unmarked, default interpretations. Just as 'will go' by default expresses simple future and the strongest modality out of (1)-(3), so 'goes' by default expresses simple present and 'is going' continuous present. Kamp and Reyle's analysis works well for these default meanings. Where it becomes inadequate is the departures from these defaults such as tenseless future of (5), futurative progressive in (4), and also *will* of epistemic and dispositional necessity as in (1) and (2) respectively. As was presented above, the default sense of *will* is accounted for by ACC and $\Delta^{rf}$m. Now, just as the epistemic necessity *will* and dispositional necessity *will* are not the default uses of *will*, so tenseless future is not the default use of the form 'goes' nor futurative progressive a default use of 'is going'. Each of these expressions can be used with its default sense or with a sense that departs from this default. This departure corresponds to different strength of ACC, explained by different degrees of intentionality and relevant intentions as in the DI principle. In short, scales of intentionality are useful in two ways. Firstly, we can represent that future time reference is scalar, as in Fig. 3 for (3)-(5), adding other forms such as epistemic *may*, epistemic *can, might, could* with future-time reference towards the 0 end of the scale. But secondly, and more importantly, we can present the interrelations between different uses of a particular linguistic form such as 'will', 'goes' or 'is going'. Just as future time reference has its default expression in (3) rather than (4) or (5), so every such expression belongs to its own scale of defaults and departures from defaults. In this way, the sense of *will* in (3) is the default among (1)-(3), with the weakest intentionality and the strongest modality.



Regular future *will* acquires the DRS with the ACC operator and the mode of presentation m of the degree $\Delta^{rf}$m. *Will* of epistemic necessity in (1) can now be presented as overriding ACC $\Delta^{rf}$m by the condition 'now (t)'. Even if the temporal adverb 'now' were not overtly present in the sentence, it would have to be recovered from the context. DRSs have means of accounting for this type of conversational inference. If 'now (t)' were not communicated, *will* would remain of the default, ACC $\Delta^{rf}$m type.

In order to distinguish epistemic *will* from epistemic *must* etc, we specify in the DRS the route to ACC. We will represent it as ACC $\Delta^{rf}$m $\rightarrow_c$ ACC. The symbol '$\rightarrow_c$' stands for 'contextually results in'. The partial DRS for sentence (1), repeated below, is now as in Fig. 4:

xts

Mary (x)
now (t)
**$ACC_{\Delta^{rf}_{m}} \rightarrow_c ACC$**
ACC s

s | be in the opera (x)

Fig. 4

The dispositional necessity *will* of (2) acquires an analogous representation. The route for ACC is $ACC_{\Delta^{rf}_{m}} \rightarrow_c$ ACC and the difference between epistemic and dispositional necessity is guaranteed by the information contained in the adverb – either overtly expressed or recovered from the context. The partial DRS for (2) is as in Fig. 5:

xte

Mary (x)
sometimes (t)
**$ACC_{\Delta^{rf}_{m}} \rightarrow_c ACC$**
ACC e

e | go to the opera in x's tracksuit (x)

Fig. 5

The difference between 'will' and, say, 'would' is maintained by retaining the route $ACC_{\Delta^{rf}_{m}} \rightarrow_c$ ACC in the DRS.

## 4 Concluding remarks

The notion of modality that subsumes all the senses of *will* acquires theoretical support in Grice's notion of acceptability that I translated into the DR-theoretic operator ACC $\Delta^{n}$m. By introducing ACC to DRT, we can replace the listing of DRSs associated with different expressions of futurity by one DRS that shows different values for ACC as in (3)-(5). These values are placed on the scale of intentionality, as specified by the POL, DI and PI principles of Default Semantics. At the same time, we can establish interrelations between different uses of *will* by accounting for the degrees of intentionality (including default intentionality) as in (1)-(3).

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# Imperatives and Tense

**Rosja Mastop***

A popular analysis of imperatives is to treat them as non-finite clauses. Platzack & Rosengren [8] claim that syntactically this means that imperatives do not have a Tense or Mood projection nor do they have a fully grammatical subject. Semantically, it is often taken to mean that imperative sentences do have a propositional content, but not the truth conditional extension of declaratives, because they are not asserted as being true at any time in the actual world, as argues Huntley [6]. Apart from the fact that this is a highly problematic deviation from the way intensions and extensions are normally related in semantics, this account also does not suffice as an explanation of the different constraints on forming meaningful declaratives and imperatives respectively.

A simple example of such a constraint is that imperatives always have a second person or first person plural subject, since the act of directing someone to do something requires that this someone be the addressee. Another such example that can be found in the literature is, that imperatives are always future oriented:

(1) a. Do it tomorrow.
b. ?Do it yesterday.

(2) a. Go home.
b. #Went home.

The reason for this is, that telling someone to do something implies that the addressee has a choice, and we may assume that the past is 'fixed'.

Finally, imperatives are taken not to embed, though it is often unclear what authors saying so mean by it. Han [5] is most specific about this, claiming that in no language the imperative morphology appears in non-matrix clauses.

## 1 Imperatives lack Tense

Here I will focus on the second point, the future orientation of imperatives, in relation to the claim that they do not have Tense. In the examples above we already saw that imperatives, or at least the English imperatives, do not have a past tense. Some data have been introduced to contest this. First of all, the following example has been discussed by several authors.

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(3) Please don't have had an accident.

If this were an imperative sentence, then clearly imperatives would at least have a present perfect. However, there are some clear indications that this example should not be classified as imperative. It can only be uttered in the absence of the (implicit) subject. It is only used as a kind of prayer. Also, the sentence in these uses lacks any form of directive force: it is not a command, request, advice, permission or proposal. Moreover, it can still be interpreted as future oriented. The speaker hopes that it *will turn out to be the case* that the subject did not have an accident.

Perhaps the most serious candidate for a past tense imperative is the following construction from Dutch, where we find a past perfect (*voltooid verleden tijd*) construction in imperatives, meaning that some action was not performed in the past (finished), but should have been.[1]

(4) Had die appel dan ook opgegeten.
Have-2sg-PAST that apple PART PART eat.up-PRT
'You should have eaten that apple.'

Bennis [2] considers the past auxilliary here to indicate irrealis rather than past, and consequently he classifies these sentences as optatives. But there is a clear difference between this construction and 'real' optatives:

(5) Was Jan maar/*toch thuisgebleven.
Be-3s-PAST Jan PART home.stay-PRT

With *maar* the sentence is possible, with third person subject and an optative interpretation (*would that Jan had stayed at home*), but *toch* can only be used here when the sentence has the addressee as the subject, forcing the directive reading (*you should have stayed at home*).

I am inclined to agree with Bennis that the past indicates irrealis, but that means that holding on to the view that imperatives do not have Tense will result in admitting that in Dutch at least they do have Mood.

## 2 Imperatives have Aspect

If we accept the claim that imperatives do not 'have' Tense, but merely direct the addressee to perform an action in the (immediate) future, we are still faced with the fact that imperatives do show sensitivity to aspectual distinctions (at least in some languages). Restricting ourselves to English, a first observation is that imperatives never contain individual-level statives.

1. PRT stands for participle, PART for particle. A similar observation is made with respect to Syrian Arabic, reported in Palmer [7]. Also to be found there, are examples from Cheyenne of what seems to be a distinction between a present and a futurate imperative.



(6) a. #Be identical twins.
b. Be a good boy.

The second of these is stage-level, which may be concluded from the fact that it also has a perfect. So stage-level statives are possible, and amongst those also *progressives* and *perfects.*

(7) a. Be standing at the gate at five o'clock.
b. Have your homework finished before the next class.

These stage-level statives often require a frame adverbial. The examples here would not be possible without the temporal *anchoring* in the embedded clauses. Steedman [9], amongst many others, claims that this is necessary for past and future tenses, because they introduce an existentially quantified temporal variable that has to be anchored to some backgrounded information. The embedded event time determines the reference time of the main clause. But here we find some differences between imperatives and declaratives as well.

(8) a. When I won against Bobby Fisher, I used the Ruy Lopez opening.
b. ?When you win against Bobby Fisher, use the Ruy Lopez opening.

(9) a. Before you came in, I was checking my email.
b. Harry was already collecting stamps before was six years old, but he lost interest shortly before his sixth birthday.
c. Be out of town before the lecture is given #but be back in time to welcome the guests.
d. #Be already waiting at the corner long before six.

First of all, with *when*, as Steedman argues, the reference time of the main clause can be anywhere within the event time of the embedded clause. It can also precede the achievement of the embedded clause, as in (8a). But for imperatives the reference time always has to *follow* the event time of the *when clause*. Secondly, with *before*, the analysis of Beaver & Condoravdi [1] is, that the 'earliest' time[2] of the embedded clause event comes somewhere after the reference time of the main clause. The default seems to be that the events follow eachother immediately, as in (9a), but this can be changed by such qualifications as *already*, *long before*, *some time before*, and intonation, see (9b). For imperatives such cancellation is not possible, as the last two examples show.

The reason for these differences could be, that the function of the reference time is not entirely the same for imperatives as for declaratives. The reference time of a declarative can be seen as a *realis* marker: everything preceding it is asserted, whatever follows it is at best expected, intended, or merely possible (cf. Fernando [3]). Imperatives do not assert, but direct the addressee to perform some action, with the purpose of inducing some state change. Con-

2. This is the culmination point of telic events and the inception point of atelic ones.

sequently, the reference time specifies the moment at which the action is to be performed, and so functions as a *deadline*. At that time the result of the action, the outcome state, must be observable. This means amongst others that a *when* clause determines the point at which this state change is to be accomplished, and a *before* clause tells the agent at which time the result of his action has to obtain.

If the reference time functions as a deadline, the action is to be concluded then and no later. Therefore an anchor that only partially determines this point, like the one in (9d), does not make sense. In effect then, there is simply nothing after the deadline available for reference. This may be part of what is meant by imperatives 'not having tense': there simply is no timeline represented beyond the reference time of the directive. This approach would be in line with an understanding of non-finiteness along the lines of Tomasello [10], who states that for children, before acquiring finiteness,

> events and states are "what we are doing" or "what is going on" intentionally, which makes them not interchangeable, and so children relate to them on an individual basis only. ([10], pp. 140 – 141)

Below I will give an account of how we can then think of a formal event semantics for imperatives.

## 3 Event Semantics and Imperatives

For this semantics, I will make use of the approach taken by Fernando [3]. The advantages of it are, that it distinguishes Tense from Aspect—so that we can see in what sense imperatives might be Tenseless—and it has a relatively simple implementation of aspectual differences between the simple, progressive and perfect. The main idea underlying this work is that we can think of event types as finite state automata, having (depending on the aktionsart) an inceptive and a progresssive state, which culminates in a consequent state. Or, equivalently, we may concieve of these event types as the regular languages $L$ accepted by these automata. They consist, then, of strings of those states: just as movies consist of sequences of stills.[3]

Aspectual operators add a reference time $R$ to those regular languages, along the lines of Reichenbach's analysis. We depart here somewhat from the formalisation chosen by Fernando, who uses one reference point. Instead, here we will make use of an interval, because both beginning and end of the reference time will be relevant for the analysis. The operation & of superposition of one

3. Formally, such a language consists of sequences of the labels of the nodes of the automaton. Those labels are sets of individual level statives. So if $\mathcal{P}$ is the set of local statives, then the inceptive state $i(L)$, progressive $p(L)$ state and culminative state $c(L)$ are all subsets of $\mathcal{P}$. The regular language will be $i(L)p(L)^+c(L)$. Here and in the following, $+$ is the positive Kleene star (one or more times), and $*$ is the Kleene star (zero or more times).



regular language on another is defined precisely by Fernando.

$$\begin{array}{lcll} \mathrm{SIMP}(L) & = & \emptyset^* L \emptyset^* \;\&\; \{R\}^+ & E \sqsubseteq R \\ \mathrm{PROG}(L) & = & L \;\&\; \emptyset^+\{R\}^+\emptyset^+ & R \sqsubset E \\ \mathrm{PERF}(L) & = & L\{R\}^+ & E < R \end{array}$$

The perfect places the reference time after the completion of the event. To account for the various readings of the present perfect—the present relevance and the 'existential readings'—Fernando assumes a set of *inertial formulae*, $Inr$. The inertial formulae true when the event culminates remain true throughout the entire reference time. Fernando calls this *inertial flow*. In case the reference time is the speech time, the result will be that the consequent state continues to the present (hence the present relevance).

Event tokens are understood as the realization of an event type on a model. For this, we introduce a set of times and a successor relation over it. If $\vec{t^n}$ is an interval of such a temporal frame and $\mathcal{P}$ a set of local stative sentences, then $e : \vec{t^n} \rightarrow \wp(\mathcal{P})^n$ is an event token. We say that $e$ is of type $L$, notation $e : L$, if $e(t_1)\ldots e(t_n) \in L$. Also, we will use $R(e)$ for the set of times $t \in dom(e)$ such that $R$ occurs in $e(t)$. Finally we come to the definition of an eventive proposition $\psi$ (interpreted as some event type) being true in a model at a point in time $t \in T$. Let $M : T \rightarrow \mathcal{P}$ be a model.

$$M, t \models asp(\psi) \text{ iff } \exists e : \mathrm{ASP}(L_\psi), \text{ such that } \begin{array}{l} t = max(R(e)) \text{ and} \\ \forall t' \in real(e) : e(t') \subseteq M(t') \end{array}$$

Where $real(e) = \{t \in dom(e) \mid t \leq max(R(e))\}$. The reference time functions as a *realis* marker in the sense explained above.

Tense can be added by the standard Priorean existential modal operators **P** and **F**. But the anchoring condition defended by Steedman and others requires that what falls under these operators must be divided into a topicalised, presupposed anchoring event and a focussed, asserted event. As an example, the meaning of a *when* sentence like (8a) is formulated below.

$M, t \models \mathbf{P}(asp(\psi) \textit{ when } asp'(\chi))$ iff $\exists t' < t$,
(a) $\exists e : \mathrm{ASP}(L_\psi)$, $\exists e' : \mathrm{ASP}'(L_\chi)$
(b) $t' = min(R(e))$ and $t' \in dom(e')$
(c) $\forall t'' \in (dom(e) \cup dom(e')) : t'' \leq max(R(e)) \Rightarrow (e(t'') \cup e'(t'')) \subseteq M(t'')$

The second clause says that the past time introduced by the past operator is in the event time of the *when* clause and functions as the beginning of the reference time of the main clause. The last clause expresses that the two event tokens are witnesses for the respective sentences $asp'(\chi)$ and $asp(\psi)$. The maximum of the (main clause) reference time still functions as a realis marker. With *before* only the (b) clause is different. It states that $t' = max(R(e))$ and $t' < earliest(e')$. The default is, that $earliest(e')$ follows immediately after $t'$. As a consequence the before clause is not asserted: it lies beyond the realis marker $max(R(e))$.

Now let us turn to imperatives. A main assumption, in agreement with Hamblin [4], will be that imperatives do not have a truth value in any sense of the word, but instead they update the commitment slate of the addressee. Such a commitment slate $\tau$ is a set sets of event tokens. Intuitively, these sets are different lists, or schedules the agent may pick in order to follow up on his or her commitments. The update of a commitment slate with an imperative is defined here.

$$\tau[asp(\psi), t] = \{(\pi \cup \{e\}) \mid \pi \in \tau \;\&\; e : \mathrm{ASP}(L_\psi) \;\&\; min(R(e)) = t\}$$

The speech time is the initial element of the reference time. If we combine this with *future orientation*—the fact that an action can only be commanded if its inceptive stage lies in the future—we get the correct prediction that only simple present imperatives need no temporal anchoring.

The requirement that some result of the action be observable at the deadline is then accounted for by the following observations. If we are dealing with a simple or perfect imperative, then its result state will be the consequent state achieved at the end of the event. The maximum of the reference time will therefore lie after the event and *inertial flow* will ensure that this consequence still obtains at that point when it matters. The progressive represents an action in progress and does not imply any definitive result. The deadline will therefore have to be in the progressive state itself. In either case this means that the time pointed to by an anchoring embedded clause is in the reference time itself, or adjacent to it, as in the case of *before*.

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# General Program

# On choice-offering imperatives

**Maria Aloni***

## 1 Introduction

The law of propositional logic that states the deducibility of *either A or B* from *A* is not valid for imperatives (Ross's paradox, cf. [9]). The command (or request, advice, etc.) in (1a) does not imply (1a) (unless it is taken in its *alternative-presenting* sense), otherwise when told the former, I would be justified in burning the letter rather then posting it.

(1) a. Post this letter! $\not\Rightarrow$ b. Post this letter or burn it!

Intuitively the most natural interpretation of the second imperative is as one presenting a choice between two actions. Following [2] (and [6]) I call these *choice-offering* imperatives. Another example of a choice-offering imperative is (2) with an occurence of Free Choice 'any' which, interestingly, is licensed in this context.

(2) Take any card!

Like (1a), this imperative should be interpreted as carrying with it a permission that explicates the fact that a choice is being offered.

Possibility statements behave similarly (see [8]). Sentence (3b) has a reading under which it cannot be deduced from (3a), and 'any' is licensed in (4).

(3) a. You may post this letter. $\not\Rightarrow$ b. You may post this letter or burn it.

(4) You may take any card.

In [1] I presented an analysis of modal expressions which explains the phenomena in (3) and (4). That analysis maintains a standard treatment of 'or' as logical disjunction (contra [11]) and a Kadmon & Landman style analysis of 'any' as existential quantifier (contra [3] and [4]) assuming, however, an independently motivated 'Hamblin analysis' for $\vee$ and $\exists$ as introducing sets of alternative propositions. Modal expressions are treated as operators over sets of propositional alternatives. In this way, since their interpretation can depend on the alternatives introduced by 'or' ($\vee$) or 'any' ($\exists$) in their scope, we can account for the free choice effect which arises in sentences like (3b) or (4). In this article I would like to extend this analysis to imperatives. The resulting theory will allow a unified account of the phenomena in (1)-(4). We will start by presenting our 'alternative' analysis for indefinites and disjunction.

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## 2 Indefinites and disjunction

Indefinites (e.g. 'any') and disjunction (e.g. 'or') have a common character reflected by their formal counterparts $\exists$ and $\vee$. Existential sentences and logical disjunctions assert that at least one element of a larger set of propositions is true, but not which one. Both constructions can be thought of as introducing a set of alternative propositions and, indirectly, raising the question about which of these alternatives is true. In what follows I propose a formal account of the sets of propositional alternatives introduced by indefinites and 'or' (cf. [1]).

I recursively define a function $[\bullet]_{M,g}$ where $M$ is a pair consisting of a set of individuals $D$ and a set of worlds $W$, and $g$ is an assignment function. Function $[\bullet]_{M,g}$ maps formulae $\phi$ to sets of pairs $\langle w, s\rangle$ consisting of a world $w \in W$ and a sequence of values $s$, where the length of $s$ is equivalent to the number $n(\phi)$ of surface existential quantifiers in $\phi$, – for atoms and negations, $n(\phi) = 0$; for $\phi = \exists x\psi$, $n(\phi) = 1 + n(\psi)$, and for $\phi = \psi_1 \wedge \psi_2$, $n(\phi) = n(\psi_1) + n(\psi_2)$. (By $[\![\alpha]\!]_{M,w,g}$ I refer, as standard, to the denotation of $\alpha$ in $M$, $w$ and $g$.)

**Definition 1**

1. $[P(t_1, ..., t_n)]_{M,g} = \{\langle\langle\rangle, w\rangle \mid \langle[\![t_1]\!]_{M,w,g}, ..., [\![t_n]\!]_{M,w,g}\rangle \in [\![P]\!]_{M,w,g}\}$;
2. $[t_1 = t_2]_{M,g} = \{\langle\langle\rangle, w\rangle \mid [\![t_1]\!]_{M,w,g} = [\![t_2]\!]_{M,w,g}\}$;
3. $[\neg\phi]_{M,g} = \{\langle\langle\rangle, w\rangle \mid \neg\exists s : \langle s, w\rangle \in [\phi]_{M,g}\}$;
4. $[\exists x\phi]_{M,g} = \{\langle ds, w\rangle \mid \langle s, w\rangle \in [\phi]_{M,g[x/d]}\}$;
5. $[\phi \wedge \psi]_{M,g} = \{\langle s_1 s_2, w\rangle \mid \langle s_2, w\rangle \in [\phi]_{M,g}\ \&\ \langle s_1, w\rangle \in [\psi]_{M,g}\}$.

Disjunction $\vee$, implication $\rightarrow$ and universal quantification $\forall$ are defined as standard in terms of $\neg$, $\wedge$ and $\exists$. Truth and entailment are defined as follows.

**Definition 2** [Truth and entailment]

(i) $M, w \models_g \phi$ iff $\exists s : \langle s, w\rangle \in [\phi]_{M,g}$;
(ii) $\phi \models \psi$ iff $\forall M, \forall w, \forall g : M, w \models_g \phi \Rightarrow M, w \models_g \psi$.

In this semantics, a formula is associated with a set of world-sequence pairs, rather than, as usual, with a set of worlds. This addition is essential to derive the proper set $\text{ALT}(\phi)_{M,g}$ of alternative propositions induced by formula $\phi$, which is defined as follows.

**Definition 3** $\text{ALT}(\phi)_{M,g} = \{\{w \mid \langle s, w\rangle \in [\phi]_{M,g}\} \mid s \in D^{n(\phi)}\}$.

For example, the set $[P(x)]_{M,g} = \{\langle\langle\rangle, w\rangle \mid [\![x]\!]_{M,w,g} \in [\![P]\!]_{M,w,g}\}$ determines the singleton set of propositions {that $x$ is $P$}. More interestingly, the set $[\exists x P(x)]_{M,g} = \{\langle\langle d\rangle, w\rangle \mid d \in [\![P]\!]_{M,w,g}\}$ determines the set of alternatives {that $d_1$ is $P$, that $d_2$ is $P$, ...}, containing as many elements as there are possible values for the quantified variable $x$.

On this account, the propositional alternatives introduced by a sentence are defined in terms of the set of possible values for an existentially quantified variable. To properly account also for the alternatives introduced by disjunctions, I propose to add to our language, variables $p$, $q$ ranging over propositions, so that, for example, we can write $\exists p({}^{\vee}p \wedge {}^{\vee}p = A)$ for $A$, where the operator



$^{\vee}$ receives the standard interpretation, so that, for example, $[\![{}^{\vee}p]\!]_{M,g,w} = 1$ iff $w \in g(p)$. In interaction with $\exists$ or $\vee$, this addition, otherwise harmless, extends the expressive power of our language in a non-trivial way. Although the (a) and (b) sentences below are truth conditionally equivalent, the sets of alternatives they bring about, depicted on the right column, are not the same. While the (b) representations introduce singleton sets, the (a) representations induce genuine sets of alternatives.

(5) a. $\exists p({}^{\vee}p \wedge ({}^{\vee}p = A \vee {}^{\vee}p = B))$ — a′. [ $A$ | $B$ ]

b. $\exists p({}^{\vee}p \wedge {}^{\vee}p = A \vee B)$ — b′. [ $A \vee B$ ]

(6) a. $\exists p({}^{\vee}p \wedge \exists x({}^{\vee}p = A(x)))$ — a′. [ $A(d_1)$ | $A(d_2)$ | ... ]

b. $\exists p({}^{\vee}p \wedge {}^{\vee}p = \exists x A(x))$ — b′. [ $\exists x A(x)$ ]

That these alternatives are needed is seen when we consider question semantics. If we take questions $?\phi$ to denote the sets of alternatives induced by $\phi$, the pair in (5) allows us a proper representation for the ambiguity of questions like 'Do you want coffee or tea?' between an alternative reading (expected answers: coffee/tea), and a polar reading (expected answers: yes/no) (see [10]). The sets of alternatives induced by (6a) and (6b) can serve as denotations for constituent questions (e.g. 'who smokes') and polar existential questions (e.g. 'whether anybody smokes') respectively.

## 3 Imperatives

While assertion have truth conditions, imperatives have *compliance conditions*. Someone cannot be said to understand the meaning of an imperative unless he recognizes what has to be true for the command (or request, advice, etc.) issued by utterance of it to be complied with. The framework presented in the previous section supplies us with a straightforward method to characterize the compliance conditions of imperative $!\phi$, namely by identifying them with the set of alternatives induced by $\phi$. For example, the compliance conditions of the imperative 'Post this letter!' will be the singleton set containing the proposition 'that the addressee posts the letter'.[1] Crucially choice-offering imperatives will involve genuine sets of alternatives. For example, the compliance conditions of 'Post this letter or burn it!', on its choice-offering reading, will contain the two propositions: 'that the addressee posts the letter' and 'that the addressee burns the letter'. Each of these propositions represents a possible way to comply with the command (or request, advice, etc.) expressed by the imperative.

Strictly speaking imperatives lack truth conditions. This would suggest to identify their meaning with their compliance conditions. There is a sense,

1. We are bypassing the fact that imperatives deal with future actions, so the relevant proposition here should be 'that the addressee will post the letter'. See Rosja Mastop's contribution to this volume 'Imperatives and Tense'.

however, in which the utterance of an imperative expresses some fact about the desire state of the speaker. In order to account for this intuition, in this article, I shall assume that imperatives $!\phi$ denote propositions that specify desirable situations. This means that they are interpreted with respect to a modal base $A_w$ expressing the desires of (one of) the participants to the conversation at world $w$.

**Definition 4** [Imperatives] $[!\phi]_{M,g} = \{\langle\langle\rangle, w\rangle \mid \forall\alpha \in ALT(\phi)_{M,g} : \exists w' \in A_w : w' \in \alpha \ \&\ \forall w' \in A_w : \exists\alpha \in ALT(\phi)_{M,g} : w' \in \alpha\}$

On this account, !' is an operator over the set of propositional alternatives introduced in its scope. Imperative $!\phi$ is true in $w$ iff (i) *every* alternative induced by $\phi$ is *compatible* with the desire state $A_w$; (ii) the union of all these alternatives is *entailed* by $A_w$. Intuitively, clause (ii) expresses the fact that if I say 'Post the letter or burn it!' then, in each of my desirable worlds, it should hold that either the letter is posted or burnt. Clause (i) expresses the fact that, in this case, my desires must be consistent with both options.

In this framework we can give a straightforward treatment of 'embedded uses' of imperatives like in 'Vincent wants you to post this letter'. We first define a relation of entailment between desire states and imperatives, as follows. State $\sigma$ *entails* $!\phi$, $\sigma \models_{M,g} !\phi$ iff $\exists w : M, w \models_g !\phi$ and $A_w = \sigma$. We then assume that a sentence like 'Vincent wants $\phi$!' is true in $w$ iff Vincent's desire state in $w$ entails $!\phi$.

Let us see now how the choice-offering imperatives discussed in the introductory part of the article are analyzed in this framework.

*Applications* Example (7) is ambiguous between a choice-offering reading, represented in (7a), and an alternative-presenting reading in (7b).

(7) Post this letter or burn it!

a. $!\exists p({}^{\vee}p \wedge ({}^{\vee}p = A \vee {}^{\vee}p = B))$ a′. $\boxed{A}$ $\boxed{B}$

b. $!\exists p({}^{\vee}p \wedge {}^{\vee}p = A \vee B)$ b′. $\boxed{A \vee B}$

The choice-offering reading involves the set containing the two propositions: 'that the addressee posts the letter' and 'that the addressee burns the letter', both expressing a possible way of complying with the imperative. The weaker reading in (7b) instead induces the singleton set containing the proposition 'that the addressee posts the letter or burns it'. Since, by clause (i) of our definition, all the alternatives induced by the embedded clause must be consistent with the modal base, only on this second reading is the sentence compatible with a subsequent imperative: 'Do not burn the letter!' Assuming a standard treatment of $\Diamond$ and $\Box$, the following holds:

(8) a. $!\exists p({}^{\vee}p \wedge ({}^{\vee}p = A \vee {}^{\vee}p = B)) \models \Diamond A, \Diamond B, \Box(A \vee B)$

b. $!\exists p({}^{\vee}p \wedge {}^{\vee}p = A \vee B) \not\models \Diamond A, \Diamond B$

Example (9a) is analyzed as in (9b) which induces the set containing the propositions 'that the addressee takes the ace of hearts', 'that the addressee takes the king of spades', ...

(9) a. Take any card!

b. $!\exists p({}^{\vee}p \wedge \exists x({}^{\vee}p = A(x)))$ b′. $\boxed{A(d_1)}$ $\boxed{A(d_2)}$ $\boxed{\ldots}$

Compare (9) with the following two examples where no choice is being offered:

(10) a. Take every card!

b. $!\exists p({}^{\vee}p \wedge ({}^{\vee}p = \forall x A(x)))$ b′. $\boxed{\forall x A(x)}$

(11) a. Take a card!

b. $!\exists p({}^{\vee}p \wedge {}^{\vee}p = \exists x A(x))$ b′. $\boxed{\exists x A(x)}$

In principle our semantics predicts (11b) as second possible reading for sentence (9a). Intuitively, however, (9a) never obtains such a 'pure' existential meaning. Imperative 'Do not take the ace!' would never be acceptable after (9a). Our representation (9b) accounts for this fact, because it entails that any card may be taken. Representation (11b), instead, lacks this entailment.

(12) a. $!\exists p({}^{\vee}p \wedge \exists x({}^{\vee}p = A(x))) \models \forall x \Diamond A, \Box\exists x A$

b. $!\exists p({}^{\vee}p \wedge {}^{\vee}p = \exists x A(x)) \not\models \forall x \Diamond A$

In order to explain why reading (11b) is not available for sentence (9a), I will use Kandom and Landman's analysis of *any* (see [7]). According to their account, *any* phrases are indefinites which induce maximal *widening* of the domain as part of their lexical meaning. Crucially this widening should be for a reason, namely, they propose, the *strengthening* of the statement made. If we define the strength of an imperative in terms of entailment, $\models$, in the 'pure' existential reading (11b), widening the domain would weaken the statement. This explains why this reading is not available for the *any*-sentence (9a). But what about the 'free choice' reading in (9b)? Why is this available? Unfortunateky widening the domain in this case does not make our statement stronger. None of the wide or the narrow interpretation of sentence (9b) entail the other. We lack then an explanation of why (9a) can be interpreted at all. In order to solve this problem we have to say something more about in what sense an imperative can be said to be stronger than another.

In this framework, we have a number of alternative options for defining the relative strength of imperatives. Entailment is one possibility. The following two are other particularly interesting options.

1. $!A \approx\!\!\!\!\models_1 !B$ iff $\forall\alpha \in ALT(A) : \exists\beta \in ALT(B) : \alpha \subseteq \beta$;
2. $!A \approx\!\!\!\!\models_2 !B$ iff $\forall\beta \in ALT(B) : \exists\alpha \in ALT(A) : \alpha \subseteq \beta$.

Intuitively, imperative $!A$ is as strong$_1$ as $!B$, $!A \approx\!\!\!\!\models_1 !B$ iff each way of complying with $!A$ is also a way of complying with $!B$. Whereas $!A \approx\!\!\!\!\models_2 !B$ holds iff any way of complying with $!B$ is part of a strategy to comply with $!A$. If $!\phi \approx\!\!\!\!\models_1 !\psi$ and $!\phi \approx\!\!\!\!\models_2 !\psi$, then $!\phi \models !\psi$.

If $!A$ and $!B$ denote singleton sets, $\approx\!\!\!\!\models_1$ and $\approx\!\!\!\!\models_2$ (and $\models$) define the same notion. For example, imperative (13a) is stronger than (13b) according to both notions. Indeed, every way of satisfying (13a) satisfies (13b), and to satisfy (13b) is part of a strategy to satisfy (13a).

(13) a. Put all books in your bag! b. Put the *Tractatus* in your bag!

Once choice-offering imperatives enter the picture though, the two notions give opposite results (by $!(A \vee_c B)$ I refer to the free choice reading of a disjunctive imperative e.g. (7a)):

(14) a. Post this letter! b. Post this letter or burn it!

c. $!A \mathrel{|\!\approx_1} !(A \vee_c B)$ and $!(A \vee_c B) \mathrel{\not|\!\approx_1} !A$

d. $!A \mathrel{\not|\!\approx_2} !(A \vee_c B)$ and $!(A \vee_c B) \mathrel{|\!\approx_2} !A$

e. $!A \not\models !(A \vee_c B)$ and $!(A \vee_c B) \not\models !A$

Sentence (14a) is strictly stronger$_1$ than (14b), because posting the letter is a way to satisfy (14b), but burning the letter is not a way to satisfy (14a). On the contrary, sentence (14b) is strictly stronger$_2$ than (14a), because posting the letter is part of a strategy to satisfy (14b), but there is a way to satisfy the latter, namely burning the letter, which is not part of a strategy to satisfy (14a).

Going back to our example (9), in the 'pure' existential readings in (11b), widening the domain makes our statement weaker according to all notions $\models$, $|\!\approx_1$ and $|\!\approx_2$. This explains why this reading is not available for the *any*-sentence in (9). In the 'free choice' reading in (9b), widening makes the statement weaker according to notion $|\!\approx_1$, but stronger according to notion $|\!\approx_2$. This, I suggest, supplies enough reason for widening to occur.

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# Plural times and temporal modification


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**Abstract**

We propose a semantics with plural entities and plural times that accounts for cumulative relations between plural arguments and temporal expressions within a clause. The semantics equips nominal, verbal and sentential meanings with temporal context variables and treats temporal PPs and clauses as temporal generalized quantifiers [6, 7]. The mediation of temporal context variables also allows cumulative relations to percolate between an argument in a main clause and one in a temporal clause, in apparent violation of locality restrictions. Plural times form a semilattice structure [5] imposed on the set of intervals; no interaction is observed between this and the internal temporal structure of intervals.


## 1 Introduction

Plural arguments (subject or object) may exhibit cumulative relations (also called codistributive relations) with temporal and locative expressions.

(1) The conferences ended on Tuesday, Wednesday and Thursday.

(2) Bob buried the witnesses in basements and garbage dumps.

Sentence (1) does not imply that each conference ended more than once: the sentence can be true in virtue of a cumulative inference if each conference ended on one of Tuesday, Wednesday and Thursday, and on each of the three days at least one conference ended. Likewise, sentence (2) may be true if Bob only buried each witness in one place.

The denotation of a plural expression like on Tuesday, Wednesday and Thursday is a plural object rather than a long time interval. Sentence (1) contrasts with the one below.

(3) The conferences ended between Tuesday and Thursday.

If all the conferences ended on one day (say Tuesday, or Wednesday) then (3) is true while (1) is false. It is therefore the plurality of the temporal expression that gives rise to the cumulative inference in (1). We develop a semantics in which plural temporal expressions denote plural temporal objects.


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Cumulative relations also obtain between arguments of a main clause and a temporal clause: sentence (4) is true even though Andrew Johnson did not take office after Kennedy died.

(4) Andrew Johnson and Lyndon B. Johnson took office after Lincoln and Kennedy died.

This appears to contradict the observation that cumulative readings are restricted to plural arguments that are co-predicates [2]. We show that the restriction does not apply to temporal clauses because temporal (and locative) modification uses context variables [3, 6, 7, 9]: such variables allow cumulative relations to pass through, so there is no need for a direct cumulative relation between an argument in the main clause and one in the embedded clause.

## 2 Plural times

We present a minimal extension of the theories of temporal and locative modification in [3, 6, 7, 9] to pluralities, both of entities and of times (locations are omitted for brevity). We assume a domain sorted into two types; in each subdomain, individuals and pluralities are of the same semantic type [5]—$e$ for entities and $i$ for time intervals. Each subdomain constitutes a semilattice which is isomorphic to a structure where pluralities are freely formed sets of individuals. Atoms of type $e$ are individual entities. Atoms of type $i$ are intervals: given a time axis $\langle A, \leq \rangle$ which is a set of instants $A$ ordered by a precedence relation $\leq$ (a total ordering), we define a *basic interval* as any subset of $A$, so the set of basic intervals $I_{basic}$ is the power set of $A$: $I_{basic} =_{\text{df}} \{ i \mid i \subseteq A \}$. These basic intervals form the atoms of the semilattice $I$ of plural time intervals.

We note that distinct plural time intervals can occupy overlapping and even identical parts of the time axis; in this respect the relation between the semilattice $I$ and the set of instants $A$ is similar to the relation noted by Link between count individuals and the matter that they consist of (e.g. the cards and the deck of cards refer to distinct individuals constituted of the same substance matter [5, p. 304]). The different structures serve distinct purposes: the time axis determines precedence relations among (basic) intervals, while the semilattice accounts for plurality.

## 3 Temporal modification

Representations are enriched by temporal context variables, which are variables of type $i$ that stand for time frames for the evaluation of sentences [6, 7]. Free temporal context variables denote the overall temporal context of evaluation, and are marked with a hat in order to make them visually salient: $\hat{\imath}$.

Verbal predicates have a temporal argument, which is temporally included in the context of evaluation $\hat{\imath}$ and existentially quantified. This results in the



following meaning representation for the sentence the conferences ended.

$$\exists i' [i' * \subseteq \hat{\imath} \wedge *\mathbf{end}(\mathbf{the\text{-}confs})(i')]$$

Predication is plural by default; the plurality operator '$*$' on the binary relations **end** and '$\subseteq$' allows for a cumulative inference [8]:

$$*\mathcal{R}(a)(b) =_{\text{df}} \forall a' \in \text{AT}(a)\, \exists b' \in \text{AT}(b)\, [\mathcal{R}(a')(b')] \wedge \\ \forall b' \in \text{AT}(b)\, \exists a' \in \text{AT}(a)\, [\mathcal{R}(a')(b')]$$

($\mathcal{R}$ is of type $\sigma\tau t$, $a$ of type $\sigma$, and $b$ of type $\tau$, where $\sigma$, $\tau$ range over types $e$ and $i$; AT maps any singular or plural entity or interval to the set of its atoms in the appropriate semilattice structure).

The expressions Tuesday, Wednesday, and Thursday in (1) act like proper names, but it is more convenient to think of them as properties of intervals (type $it$): $\lambda i.\mathbf{Tue}(i)$, $\lambda i.\mathbf{Wed}(i)$, $\lambda i.\mathbf{Thu}(i)$. The natural language conjunction and has a cumulative denotation, defined in terms of the join operation '$\oplus$' on individuals: an object $\alpha$ is in the denotation of a coordinate expression if it is the join of two objects $\alpha_1$ and $\alpha_2$, where $\alpha_1$ is in the denotation of the first conjunct and $\alpha_2$ is in the denotation of the second [4, 5].

$$\text{and}^{(et)(et)(et)} \rightsquigarrow \lambda P \lambda Q \lambda x. \exists x_1, x_2 [x = x_1 \oplus x_2 \wedge P(x_1) \wedge Q(x_2)]$$
$$\text{and}^{(it)(it)(it)} \rightsquigarrow \lambda I \lambda J \lambda i. \exists i_1, i_2 [i = i_1 \oplus i_2 \wedge I(i_1) \wedge J(i_2)]$$

This meaning of and is used in the coordinate temporal NP Tuesday, Wednesday and Thursday; the temporal context variable $\hat{\imath}$ is added by means of a contextualization operation, which maps any temporal property $\lambda i.J(i)$ to the property $\lambda i.i * \subseteq \hat{\imath} \wedge J(i)$.

$$\lambda i.i * \subseteq \hat{\imath} \wedge \exists i_1, i_2, i_3 [i = i_1 \oplus i_2 \oplus i_3 \wedge \mathbf{Tue}(i_1) \wedge \mathbf{Wed}(i_2) \wedge \mathbf{Thu}(i_3)]$$

The contextualized temporal NP turns into a temporal generalized quantifier through the application of an implicit determiner $\lambda I \lambda J \exists i.[I(i) \wedge J(i)]$, on par with temporal NPs with an explicit determiner like (during) every meeting or (after) some conference (the determiner here is existential, but other cases call for definite and universal determiners, see [6, 7]).

$$\lambda J. \exists i [i * \subseteq \hat{\imath} \wedge \exists i_1, i_2, i_3 [i = i_1 \oplus i_2 \oplus i_3 \wedge \mathbf{Tue}(i_1) \wedge \mathbf{Wed}(i_2) \wedge \mathbf{Thu}(i_3)] \wedge J(i)]$$

This temporal generalized quantifier applies to the temporal property formed by abstracting over the free temporal context variable of the main clause.

$$\lambda \hat{\imath}. \exists i' [i' * \subseteq \hat{\imath} \wedge *\mathbf{end}(\mathbf{the\text{-}confs})(i')]$$

$$\exists i [i * \subseteq \hat{\imath} \wedge \exists i_1, i_2, i_3 [i = i_1 \oplus i_2 \oplus i_3 \wedge \mathbf{Tue}(i_1) \wedge \mathbf{Wed}(i_2) \wedge \mathbf{Thu}(i_3)] \\ \wedge \exists i' [i' * \subseteq i \wedge *\mathbf{end}(\mathbf{the\text{-}confs})(i')]]$$

The final representation allows for the desired cumulative inference: the sentence is true if there exist (plural) intervals $i$ and $i'$, such that each of the conferences ended on (at least) one atomic part of $i'$, each such part is a subinterval of (at least) one atomic part of $i$, and each of those parts is Tuesday, Wednesday or Thursday—this entails that each conference ended on (at least) one of Tuesday, Wednesday and Thursday; also, each of Tuesday, Wednesday and Thursday is an atomic part of $i$, each such part includes at least one atomic part of $i'$, and on each of those parts at least one conference ended—this entails that on each of Tuesday, Wednesday and Thursday, at least one of the conferences ended.

Similar cumulative inferences obtain with plural common nouns. Sentence (5) is true if each conference took place on either a weekend or a holiday, provided that at least one took place on a weekend and one on a holiday.

(5) The conferences took place on weekends and holidays.

The temporal common nouns weekends and holidays are predicates of time intervals (type $it$): $\lambda i.{*}\mathbf{weekend}(i)$, $\lambda i.{*}\mathbf{holiday}(i)$. A plural one-place predicate ${*}\mathcal{P}$ is true of an argument just in case $\mathcal{P}$ is true of each of its atomic parts [5].

$${*}\mathcal{P}(a) =_{\text{df}} \forall a' \in \text{AT}(a)[\mathcal{P}(a')]$$

($\mathcal{P}$ is of type $\sigma t$ and $a$ of type $\sigma$, where $\sigma$ ranges over types $e$ and $i$).

Conjunction in the coordinate NP weekends and holidays is cumulative; the meaning is contextualized, and an existential determiner turns it into a temporal generalized quantifier.

$$\lambda J.\exists i[i \mathrel{*\subseteq} \hat{\imath} \wedge \exists i_1, i_2[i = i_1 \oplus i_2 \wedge {*}\mathbf{weekend}(i_1) \wedge {*}\mathbf{holiday}(i_2)] \wedge J(i)]$$

The preposition on denotes identity on temporal generalized quantifiers, and the result applies to the meaning of the sentence the conferences took place, which is prefixed with $\lambda\hat{\imath}$.

$$\begin{aligned} &\lambda J.\exists i[i \mathrel{*\subseteq} \hat{\imath} \wedge \exists i_1, i_2[i = i_1 \oplus i_2 \wedge {*}\mathbf{weekend}(i_1) \wedge {*}\mathbf{holiday}(i_2)] \wedge J(i)] \\ &\quad (\lambda \hat{\imath}.\exists i'[i' \mathrel{*\subseteq} \hat{\imath} \wedge {*}\mathbf{take\text{-}place(the\text{-}confs)}(i')]) \\ &= \exists i[i \mathrel{*\subseteq} \hat{\imath} \wedge \exists i_1, i_2[i = i_1 \oplus i_2 \wedge {*}\mathbf{weekend}(i_1) \wedge {*}\mathbf{holiday}(i_2)] \\ &\quad \wedge \exists i'[i' \mathrel{*\subseteq} i \wedge {*}\mathbf{take\text{-}place(the\text{-}confs)}(i')]] \end{aligned}$$

(An additional requirement which is not modeled here is that the conferences should take place on at least two weekends and two holidays; this follows if we take the plural morphemes on weekends and holidays to denote literal semantic plurality. See [1] for an account of this phenomenon, called *multiple plurality*.)

## 4 Coordinate temporal PPs and prepositions

Cumulative readings also obtain with coordinate preposition phrases, but only with those that are not quantificational.

(6) The conferences took place before an earthquake and after a hurricane.

(7)#The conferences took place before most earthquakes and after each hurricane.

The absence of a cumulative reading for (7) suggests that cumulative conjunction is not available for (temporal) generalized quantifiers; the fact that a cumulative reading is available for (6) leads to the conclusion that the coordinate PPs are of a lower type than that of generalized quantifiers, and therefore temporal prepositions like before and after can modify NPs of such lower type. The



following is the denotation of before as a modifier of temporal common nouns ($J$ is a variable of type $it$, and **before** is a temporal function of type $iii$ which takes a temporal context $i$ and a time interval $i'$ such that $i' \subseteq i$ and returns the interval from the beginning of $i$ to the beginning of $i'$ [3, 6, 7]).

$$\lambda J\lambda i.i \mathrel{*\subseteq} \hat{\imath} \wedge \exists i'[J(i') \wedge i{=}\mathbf{before}(\hat{\imath}, i')]$$

Such meanings modify the temporal meanings of an earthquake and a hurricane.

$$\lambda i.i \mathrel{*\subseteq} \hat{\imath} \wedge \exists i'[\mathbf{quake}(i') \wedge i{=}\mathbf{before}(\hat{\imath}, i')]$$

$$\lambda i.i \mathrel{*\subseteq} \hat{\imath} \wedge \exists i'[\mathbf{hurric}(i') \wedge i{=}\mathbf{after}(\hat{\imath}, i')]$$

Cumulative conjunction applies to the resulting meanings.

$$\begin{aligned} \lambda i.\exists i_1, i_2[i = i_1 \oplus i_2 \wedge i_1 \mathrel{*\subseteq} \hat{\imath} \wedge \exists i_1'[\mathbf{quake}(i_1') \wedge i_1{=}\mathbf{before}(\hat{\imath}, i_1')] \\ \wedge\, i_2 \mathrel{*\subseteq} \hat{\imath} \wedge \exists i_2'[\mathbf{hurric}(i_2') \wedge i_2{=}\mathbf{after}(\hat{\imath}, i_2')]] \end{aligned}$$

This is followed by an implicit determiner and application to the main clause.

$$\begin{aligned} \exists i[i \mathrel{*\subseteq} \hat{\imath} \wedge \exists i_1, i_2[i = i_1 \oplus i_2 \wedge \exists i_1'[\mathbf{quake}(i_1') \wedge i_1{=}\mathbf{before}(\hat{\imath}, i_1')] \\ \wedge\, \exists i_2'[\mathbf{hurric}(i_2') \wedge i_2{=}\mathbf{after}(\hat{\imath}, i_2')]] \\ \wedge\, \exists i''[i'' \mathrel{*\subseteq} i \wedge {*}\mathbf{take\text{-}place(the\text{-}confs)}(i'')]] \end{aligned}$$

Coordinate temporal prepositions can also be interpreted cumulatively (for a non-cumulative interpretation of coordinate prepositions see [3]).

(8) The conferences took place before and after some holiday.

Prepositions are coordinated at the lowest possible type, namely $iii$.

$$\text{and} \rightsquigarrow \lambda f^{iii}\lambda g^{iii}.\lambda i\lambda i'.f(i, i') \oplus g(i, i')$$

$$\text{before and after} \rightsquigarrow \lambda i\lambda i'.\mathbf{before}(i, i') \oplus \mathbf{after}(i, i')$$

The coordinate PP before and after applies to the $it$-type meaning of some holiday (note that holiday is singular, and **holiday** is only true of atomic intervals).

$$\lambda i.i \mathrel{*\subseteq} \hat{\imath} \wedge \exists i'[\mathbf{holiday}(i') \wedge i = (\mathbf{before}(\hat{\imath}, i') \oplus \mathbf{after}(\hat{\imath}, i'))]$$

The result turns into a temporal generalized quantifier through an existential determiner, and modifies the main clause yielding the desired meaning.

$$\begin{aligned} \exists i[i \mathrel{*\subseteq} \hat{\imath} \wedge \exists i'[\mathbf{holiday}(i') \wedge i = (\mathbf{before}(\hat{\imath}, i') \oplus \mathbf{after}(\hat{\imath}, i'))] \\ \wedge\, {*}\mathbf{take\text{-}place(the\text{-}confs)}(i)] \end{aligned}$$

## 5 Temporal clauses

Temporal clauses too denote temporal generalized quantifiers; these are derived through an implicit determiner, much like with temporal NPs [6, 7]. The temporal adjunct clause after Lincoln and Kennedy died denotes the following temporal generalized quantifier; ${*}\mathbf{after}$ is a plural temporal function, mapping a context $i$ and a plural time interval $i' = i_1' \oplus \cdots \oplus i_n'$ to a different plural interval $i'' = i_1'' \oplus \cdots \oplus i_n''$ where for each $k \leq n$, $i_k'' = \mathbf{after}(i, i_k')$.

$$\lambda J.\exists i[i \mathrel{*\subseteq} \hat{\imath} \wedge {*}\mathbf{die}(\mathbf{al} \oplus \mathbf{jfk})(i) \wedge J({*}\mathbf{after}(\hat{\imath}, i))]$$

This temporal generalized quantifier modifies the main clause, resulting in the following representation for sentence (4).

$$\exists i[i \ast\!\subseteq \hat{\imath} \wedge \ast\mathbf{die}(\mathbf{al} \oplus \mathbf{jfk})(i) \wedge \exists i'[i' \ast\!\subseteq \ast\mathbf{after}(\hat{\imath}, i) \wedge \ast\mathbf{take\text{-}office}(\mathbf{aj} \oplus \mathbf{lbj})(i')]]$$

Cumulative relations between the plural arguments in the main clause and the temporal modifier clause are mediated by the temporal context variables: there exist (plural) intervals $i$ and $i'$, such that each of Andrew Johnson and Lyndon B. Johnson took office in (at least) one atomic part of $i'$, each such part is after (at least) one atomic part of $i$, and in each of those parts (at least) one of Lincoln and Kennedy was assassinated. A similar inference goes through in the other direction. This explains why temporal clauses are not subject to the generalization that cumulative relations are sensitive to locality constraints [2].

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# Semantics and Typology of Dative Subject (On the Georgian Data)

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Abstract

*Based on a cross-linguistic study of the constructions with the dative core argument some conclusions are formulated: Such constructions are characteristic for the affective verbs. The subject of the affective verbs does not act according to its "free will". That is, it is far from the prototypical subjects. In the majority of languages such deviation from the prototype is represented by the marked, non-canonical linguistic structures, where S stands in marked, Dative (or any other oblique) case*

*In Georgian due to this universal tendency S of the affective verbs stands in the marked, Dative case and respectively triggers Dative argument's (M-type) person markers in the verb form.*

## I. Typological Data

Many languages of the world exhibit constructions with the dative core argument:

(1) Latin – *Mihi est liber (I have a book)*
*I.Dat be book.Nom*

(2) German – *Mir geffalen diese Bücher (I like these books)*
*I.Dat like these books.Nom*

(3) Russian – *Mne nravitsja kniga (I like the book)*
*I.Dat like book.Nom*

(4) Modern Hebrew – *Atsu la (She is sad)*
*sad she.Dat*

(5) Turkish – *Bana para lazIm (I need money)*
*I.Dat money.Nom need*

(6) Spanish – *Me gusta la cerveza (I like the beer)*
*I.Dat like the beer.Nom*

(7) Hindi – *Use gussa aayaa (He became angry)*
*he.Dat anger.Nom came*

(8) Kannada – *avanige jvara bantu (He got a fever)*
*he.Dat fever.Nom came*

(9) Japanese – *Kenga Miega sukida (Ken likes Mie)*
*Ken.Nom Mie.Nom like*

(10) Korean – *nayka nuktayka mwusepta (I am afraid of the wolf)*
*I.Nom wolf.Nom afraid.Ind*

(11) Sinhala – *maTA lamayawA penAwa (I see the child)*
*K.Dat child.Acc see.Pres*

(12) Nepali – *aaja malaaii laaDo laayo (I feel it cold today)*
*today I.Dat cold feel.Masc*

(13) Tamil – *avanukku muham malarndadu (His face bloomed; he felt pleasure)*
*he.Dat face bloom.Past.it*

(14) Newari – *jita dhebaa yawa maai (I need a lot of money)*
*I.Dat money.Nom much need*

(15) Imbabura Quechua – *nucataca umata nanawanmi (My head hurts)*
*I.Acc.Top head.Acc hurt.1Obj.3.Wit(=witnessed)*

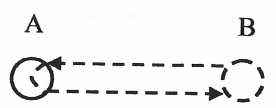
(16) Romanian – *pe noi ne doare capul (We have a headache)*
*Acc we 1Pl.Acc.Clit hurt.3Sg head.3Sg.Masc.Nom*

## II. Semantics of Affective Verbs

These constructions differ from the canonical ones of the same languages. As a rule, they are characteristic for the predicates with specific semantics: (a) Possession/Existence; (b) Psychological state; (c) Physiological state; (d) Visual/auditory perception; (e) Modal state (may/must). The main and common feature for the subjects of these predicates (res. affective verbs) is that they do not act according to their 'free will' and do not control their own action – feelings, emotions, perceptions. So, the S of affective verbs is far from the prototypical subjects, which control their actions and act according to their free will. In the majority of languages such deviation from the prototype is represented by the marked, non-canonical linguistic structures. In these structures S instead of the canonical form (nominative – for Nominative/Accusative languages, or ergative – for Ergative/Absolutive languages) stands in marked Dative (or any other oblique – Genitive, Accusative, Instrumental) case.

## III. Cognitive Explanation: Conceptual Model

Conceptual relations which define the peculiarities of such non-canonical constructions could be represented by the following model:




*B* involuntarily causes either mental, psychological, or physiological state of the core argument (*A*). *A* feels this state and directs its own emotions to *B*; e.g.: *to hate, to love, to like* and etc. There are cases when *B* is uncertain, undefined argument. In such cases feelings stay within *A*; e.g.: *to be cold, to be angry, to be hungry.*
Semantically *B* can be qualified as "Stimulus" and *A* as "Experiencer."



## IV. Different Possibilities of Coding

In natural languages there are no special forms (cases) for these *A*(Exp.)/*B*(St.). Each language selects its own strategy in the case marking of these arguments. Some features of the conceptual relations (of the model) are actualized: Cognitively *A* and *B* are considered in the resemblance (closeness) to the main semantic roles and are coded respectively as Ag, P, Ad, Inst. or others.
E.g. in German, as *A* receives some stimulus from *B*, Experiencer is identified with Addressee and stands in Dative, while *B* is regarded as the causer and respectively stands in Ag's case – Nominative: *Mir* (We-dat.) *geffalen* (like) *diese* (these) *Bücher* (Books-nom.).
The same cognitive processes define linguistic structures of affective verbs in Russian, Spanish and others (see (1),(2),(3),(5),(7),(8)).
In English, when Stimulus is undefined, *A*'s state is actualized and, as a result, descriptive constructions arise: *I am cold, I am hungry, I am angry.* When both arguments are decisive, Experiencer is identified with Ag and Stimulus with P; e.g. *I (Nom) love you (Acc), You (Nom) hate me (Acc).*
In Japanese, both nouns are marked as Ag and the construction with two nominative arguments leads us to think that cognitively *A* and *B* (both) are defined as active arguments: *B* causes something, while *A* directs its own action to *B*: *Ken-ga* (Ken-nom) *Mie-ga* (Mie-nom) *sukida* (Likes). Same constructions exist in Korean: *Ṇay-ka* (I-Nom) *nuktay-ka* (wolf-Nom) *mwusep-ta* (afraid-Ind).

There are many other alternatives of markedness:

Bengali – *taar TthaaNdaa laaglo (He got chilled)*
*he.Gen cold affected*

Here Experiencer is regarded as the Possessor of the state.

Sinhala – *lamAya-atin kooppe biNduna ('The child (inadvertently) broke the cup')*
*child-Inst cup.Nom break.Past.P*

Involuntary action of *A* argument is identified with the Instrument and *B* is qualified as the Subject. Same constructions exist in Hindi:

Hindi – *bacce se shiishaa TuuT gayaa (The child (inadvertently) broke the mirror)*
*child Inst mirror break went.Pass*

Examples from Imbabura Quechua (15) and Romanian (16) show that *A*'s state and *B*'s passive, inactive character is identified with Patient and respectively both are represented by Accusative.

Alternative models for the linguistic structuring of the conceptual relations may also exist within one concrete language; e.g. in Russian the construction with the affective verb *to love* could be represented by the following structures with the different pragmatic value:

(I) *Ja ljublju tebja (I love you)*
*I.Nom love you.Acc*

(II) *Mne ljubo (I love = somebody/something is stimulus of my love)*
*I.Dat love*

In the construction (I) Experiencer is identified with Ag, while in (II) it is identified with Ad. Stimulus in (I) is marked as P, while in (II) it is marked as Ag. Presented conceptual model gives the possibility for the both interpretation: (I) actualises *A* arguments' "activity", while (II) actualises *B*'s "activity".

Even though strategies of marking are different, one universal tendency can be identified: Constructions with affective verbs build an opposition with canonical constructions. They are constructed as the non-canonical, marked ones, where Subject stands in marked (mostly Dative) case.

## V. The Data of the Georgian Language

In Georgian alongside with this generalization affective verbs build non-canonical constructions which are called inversive. According to the general tendency S stands there in dative case and triggers the M-type person markers (see below) in the verb forms.

E.g. *me m – iq'var - s deda (I love mother)*
*I.Dat I.Dat-love-3Nom mother.Nom*

In Georgian we have the same interpretation of the conceptual model as in German, Spanish or others (see (1), (2), (3), (5), (7), (8)).
If Stimulus is not defined, the verb form still has the same structure and "empty" marker of "unknown" Stimulus is presented:

*me m – civ – a (I am cold)*
*I.Dat I.Dat-cold-it.Nom*

In general, Georgian has two types of verbal person affixes, the V-type and the M-type:

| | V-type sing. | V-type pl. | | M-type sing. | M-type pl. | |
|---|---|---|---|---|---|---|
| I | v- | v- | -t | m- | gv- | |
| II | - | | -t | g- | g- | -t |
| III | -s,a,o | | -n,en,an, nen,es | h,s,ø- / ø- | h,s,ø- (-t) / ø- | |

Traditionally the V-type affixes are considered to be subject markers, while the M-type are object markers. However, this is not always the case: In the perfective-resultative tense forms and also with affective verbs the subject appears with the M-type and object with the V-type. For that reason most Georgian scholars qualify these forms as inversive ones. The M-type and the V-type markers can also create an opposition between the verb forms, which represent the difference between the actions whose subjects act either according to their 'free will' or without their 'free will '; e.g.:

(a) ga-v-t'exe sk'am-i (I broke a chair)
Prev.-I-broke chair.Nom
(b) ga-m-it'q'da sk'am-i (I broke a chair (invol.))
Prev.-I-broke.Pass chair.Nom

(a) da-v-xarje pul-I (I spent money)
Prev.-I-spent money.Nom
(b) da-m-exarja pul-i (I spent money (invol.))
Prev.-I-spent.Pass money.Nom

(a) da-v-karge pul-i (I lost money)
Prev.-I-lost money.Nom
(b) da-m-ek'arga pul-i (I lost money (invol.))
Prev.- I- lost.Pass money.Nom

(a) v - mgheri (I sing a song)
I- sing
(b) m-emdhereba (I am in the mood of singing)
I-sing.Passive



(a) v-icini (I laugh)
I- laugh
(b) m- ecineba (Something makes me laugh)
I- laugh.Passive

(a) v- t'iri (I cry)
I-cry
(b) m-et'ireba (Something makes me cry)
I-cry.Passive

In the examples (a) S acts with its 'free will', while in the examples (b) S acts without its 'free will'(= involuntary, inadvertently).
In Georgian it seems more adequate to analyze the M-type and V-type markers without any functional qualification on the base of the semantic roles and the semantic feature: 'free will of arguments'. This feature plays an important role in the person alignment and defines appearance of either the M or the V-type of markers:

I. The argument whose free will is not included in the situation (or it is unknown whether its free will is included or not) triggers the M-type affixes. (Semantically such are: Addressee, Experiencer, an actually "unknown" Ag of perfective tense forms)[1]

II. The argument that acts according to its free will triggers the V-type affixes (such is Ag).

III. The argument whose free will is not relevant for the situation (such is P), triggers
   a. The V-type, if it is *only* argument linked with the verb (P);
   b. The V-type, if other argument's free will is not included in the situation (constructions: P-Ad, or P-Exp, or P-unknownAg);.
   c. The M-type, if other argument's free will is included in situation (construction – P-Ag);
   d. Zero, if all other (both) arguments (with +[fw] and with –[fw]) are linked with the verb (construction – Ag-P-AD).

These rules are hierarchically organized: I>II>IIIa>IIIb/IIIc>IIId. As a result various morphological verb forms arise.

E.g.: The form *m-i-q'var-s (I love (s)he)* is a result of the following derivational processes: Exp.(I) is the role which acts without its own 'free will'. Thus, according to I-rule it is marked in the verb form by the M-type marker *m-*.The next argument is qualified as P, (the argument, whose 'free will' is included) and according to II-rule it is represented by the V-type marker *-s*. Thus, the form *miq'vars* is constructed by the rules I > II: First of all M-type marker *m-* appears (according to I-rule) and then *-s* (according to II-rule).
Forms – *v-xat'av(I draw it)* or *m-xat'av(You draw me)* – are derived by the rules II>IIIc; and so on:

*s-civ-a ((S)he is cold)* —— I>II
*cxovrob-s ((S)he lives)* —— II
*ixat'eb-a (It is drawn)* ——— IIIa
*xat'av-s ((S)he draws it)* —— II>IIIc
*v-uxatav (I draw it for him/her)* —— II>IIIc
*m-ixat'av-s ((S)he draws it for me)* —— I>II >IIId
*g-axat'vineb-s ((S)he lets me draw)* —— II>II>IIId
*v-uq'var-var ((S)he loves me)* ——— I>II

[1] Georgian Perfect forms demonstrate the additional semantic nuance: "apparently", "it seems", "probably". They represent the following aspectual situation: The speaker sees the result of the action, (s)he does not pay any attention to Ag (or (s)he is not sure; or (s)he does not actually know; or (s)he merely forgets, who was the Agent of the action), but because of the actually presented result (Patient), (s)he says, what "apparently" happened; e.g. dauxat'avs (It seems that (s)he has drown), ucxovria (Apparently (s)he has lived), aushenebia (Apparently, he has built it) and so on.

These rules demonstrate that in Georgian the feature 'free will' is decisive not only for the affective verbs, but it is also decisive for the whole system of the verb concord.

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# Learning and Diachronic Laws for Partial Blocking

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**Abstract**
In this talk we introduce a complete system of diachronic laws for predicting partial blocking. The laws get their justification from an underlying learning model, and the system is *complete* in the sense that all possible meaning shifts predicted by the learning model can be accounted for by using diachronic laws instead. We propose them as an alternative to Horn's division of pragmatic labour and the principle of weak optimality.

## 1 Introduction

Horn's principle of division of pragmatic labour [3] states that marked forms have a tendency to go together with marked meanings, and unmarked forms with unmarked meanings. This accounts for partial blocking phenomena as observed in the following examples:

**(1) a)** John mopped the floor with water / a liquid.
**b)** Black Bart killed the sheriff / caused the sheriff to die.
**c)** Two Americans / Two Latin-Americans have been killed in the plot.

Normally, people use water for mopping a floor, hence the use of the marked form *liquid* indicates that it is not *water* what John used. Normal killing–events are events of direct killing, hence the use of the marked form *cause to die* indicates that it was not a direct killing. The use of the unmarked form *Americans* indicates that US–Americans have been killed.

In general, if $F_1$ and $F_2$ are forms and $M_1$ and $M_2$ are meanings where $F_1$ is preferred over $F_2$ and $M_1$ over $M_2$, then $F_1$ tends to denote $M_1$ and $F_2$ to tends denote $M_2$:

**(2)**
$$\begin{array}{cccc} & M_1 & & M_2 \\ F_1 & \bullet & \longleftarrow & \bullet \\ & \uparrow & & \uparrow \\ F_2 & \bullet & \longleftarrow & \bullet \end{array}$$

Graphs like **(2)** are familiar from Bidirectional Optimality Theory. Blutner's principle of *weak optimality*, or *superoptimality*, is a reformulation and generalisation of Horn's principle in an optimality theoretic framework [2]. A drawback of both principles is their tendency to over–generate blocking phenomena. E.g. for **(1)** b) they predict not only partial blocking for *kill* and *cause to die*, but also for *cause to die* and *made to be killed* and any other more complex phrase classifying a killing–event.

In this talk we are going to explain partial blocking by diachronic laws derived from an underlying learning model. The fundamental learning principle of this model can be summarised as follows: If in every situation where a form $F$ with meaning $\mathbf{f}$ is used for classifying some entity it turns out that this entity is of a stronger type $\mathbf{t} \leq \mathbf{f}$, then the language users will learn to use $F$ as meaning $\mathbf{t}$. This strengthened meaning remains defeasible in principle, hence we call it *associated* meaning.

What do we mean by *diachronic law*? Let $\{F_0, \ldots, F_n\}$ be a set of forms. We assume that they can be linearly ordered according to their complexity. Then a diachronic law will have the form: If in a diachronic stage $i$ the semantic relations between $F_0, \ldots, F_n$ are such and such and there occur only entities of type $\mathbf{t}_0, \ldots, \mathbf{t}_m$, then the semantic relations in stage $i+1$ will be these and that.

As an example we consider **(1)** a). We can simplify and assume that there are only entities of two types: $\mathbf{t}_0 = +water$ and $\mathbf{t}_1 = -water$. Further we can assume that there are only three forms to be considered: $F_0$ = *water*, $F_1$ = *something that is not water*, and $F_2$ = *liquid*. $F_0$ is less marked than $F_2$, and $F_2$ less marked than $F_1$. When is there a reason to use $F_2$ = *liquid* for classifying something that John uses for mopping the floor? If it is water, then the speaker will see that it is water, and hence the choice of the form *water* is most economic. There will never be a reason to use *liquid*, only if, in fact, it is something different from water what John uses. The above learning rule implies that the form *liquid* gets associated with the meaning $-water$. This can be turned into a law:

**(A)** If in stage $i$ $F_0$ is the most economic form with meaning $\mathbf{t}_0$, $F_1$ with meaning $\mathbf{t}_1$, and $F_2$ with meaning $\mathbf{t}_0 \vee \mathbf{t}_1$, and if $F_0 < F_2 < F_1$, then in stage $i+1$ $F_2$ is associated with $\mathbf{t}_1$.

This *law* does not make reference to the type of entities occurring in stage $i$. In **(1)** b) the reason why *kill* gets associated with *direct killing* seems to be that normally only direct killings occur. The fact that only some types are realised gives rise to another list of laws. We will present a complete list. Fortunately, there is only a small number: If we concentrate on the case for two basic types $\mathbf{t}_0, \mathbf{t}_1$ as in **(1)** a), then there are in addition to **(A)** only five laws describing all possible ways of how strengthening of meaning can develop.

## 2 Diachronic Laws in the Situation with two Basic Types

We promised to explain partial blocking by diachronic laws derived from an underlying learning model. First, we provide for a classification of utterance situations where the speaker has to make a choice between forms. Then we shortly introduce the formal learning model. Finally, we show how to derive diachronic laws from this model and use them for determining how and when Horn situations can develop out of Blutner–squares **(2)**.

Is there a complete characterisation of all possible diachronic processes in terms of laws of diachronic change? Given a set of semantically synonymous expressions, how and when can associative learning and speaker's preferences lead to a change in interpretation? We work out an answer for the situation with two basic types.

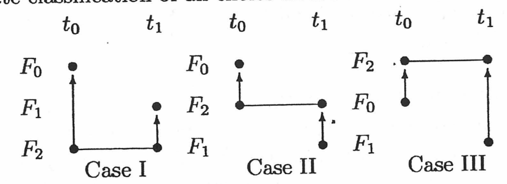
### 2.1 The Classification of Utterance Situations

We make the following assumptions about the utterance situations: The speaker wants to classify some object or event $e$ as being of some type $\mathbf{f}$. It is common ground that he knows $e$. Hence we represent an utterance situation where the speaker has to



make his choice for a form $F$ by a pair $\langle e, \mathbf{f} \rangle$. Lets assume that the classified entities can differ only with respect to one feature and that attribute–value functions that represent the meanings can have only three values, namely $\{-1, 0, 1\}$. Let $m$ be a feature and $[i] := \{F \in \mathcal{F} \mid [F](m) = i\}$. Let $\preceq$ be a linear well–founded order on $\mathcal{F}$ with meaning: $F \prec F'$ iff $F'$ is more complex than $F$. It follows that for each $[i]$ there is a unique minimal form in $[i]$. As the speaker will choose the most preferred form, he has to consider only three forms: The minimal elements of $[-1]$, $[0]$ and $[1]$.

In general, if we consider a situation with two basic types $\mathbf{t}_0$ and $\mathbf{t}_1$, then there are only three forms $F_0, F_1, F_2$ the speaker has to consider for making his choice. Without loss of generality we can assume that $[F_0] = \mathbf{t}_0$, $[F_1] = \mathbf{t}_1$ and $[F_2] = \mathbf{t}_0 \vee \mathbf{t}_1$. Hence, $F_2$ always denotes the form with the wider meaning. We can further assume that in general $F_0$ is preferred over $F_1$. Hence, we arrive at the following complete classification of all choice situations with two basic types:




The topmost form is the most preferred one, the lowest the least preferred. The vertical arrow indicates the speaker's preferences. The horizontal line means that the respective form has an extension which comprises the meaning of both types $\mathbf{t}_0$ and $\mathbf{t}_1$. Examples are: Case I *father, mother, one of the parents* ($F_0 \prec F_1 \prec F_2$); Case II *water, liquid, alcoholic essence* ($F_0 \prec F_2 \prec F_1$); Case III American, North American, Latin American ($F_2 \prec F_0 \prec F_1$). If $F_0$ and $F_1$ are adjacent, then the relation between their complexities is irrelevant. Future classifications of concrete examples is meant up to renaming of types and forms.

### 2.2 Associative Learning

We represent a *diachronic stage* by a triple $\langle E, S, H \rangle$: $E$ is a set of utterance situations of the form $\langle e, \mathbf{f} \rangle$; $S$ is a function from $E$ into forms $\mathcal{F}$ and represents the speaker's choice in all situations in $E$; and $H$ is a function from $\mathcal{F}$ into types and represents the hearer's interpretation of forms. The speaker's choice $S(e, \mathbf{f})$ of a form $F$ is *successful* in $\langle e, \mathbf{f} \rangle$ if $e : H(F) \,\&\, H(F) \leq \mathbf{f}$, i.e. if $e$ is of type $H(F) = H(S(e, \mathbf{f}))$ and if the hearer can therefore infer that it is of type $\mathbf{f}$.

We present a model for associative learning as described above. Assume we are in stage $\langle E, S, H \rangle$. How does the new selection and interpretation strategies in the next stage look like? The basic ideas are:

- The hearer learns that the factual information of an utterance is stronger than its semantics.
- The speaker learns to exploit this situation.

Let us assume that $F$ is a form that the speaker uses in the given stage; then:

$$H^+(F) \;:=\; \min\{\mathbf{f} \in \mathbf{Type} \mid \mathbf{f} \leq H(F) \wedge \|F\| \subseteq [\![\mathbf{f}]\!]\} \tag{2.1}$$

$$S^+(e, \mathbf{f}) \;:=\; \min\{F \in NL \mid e : H^+(F) \leq \mathbf{f}\}. \tag{2.2}$$

$[\![\mathbf{f}]\!]$ denotes the *extension* of $\mathbf{f}$ in $E$, i.e. $[\![\mathbf{f}]\!] := \{e \in E \mid e : \mathbf{f}\}$. $\|F\|$ is the set of all entities where the speaker has in fact used $F$ to classify them, i.e.

$$\|F\| := \{e \in E \mid \exists \mathbf{f} : \langle e, \mathbf{f} \rangle \in E \wedge S(e, \mathbf{f}) = F\}. \tag{2.3}$$

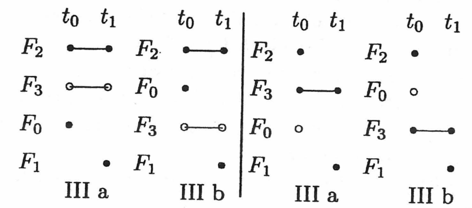
For **(1)** a) this means: As there is only a reason to use *liquid* if the classified entity is not water, it follows that $\|liquid\| \subseteq \{e \in E \mid e : -water\} = [\![-\,water]\!]$. As there is no stronger type than $-water$, we find $H^{+}(liquid) = -water$. For **(1)** b) we find: In the initial stage only direct killings occur; it follows that $\|kill\| \subseteq \{e \in E \mid e : direct\ killing\}$. Hence, $H^{+}(kill) = directly\ killing$. In the following stage there will be a reason to use the form $F' = cause\ to\ die$ only if an hitherto unusual *indirect* killing event occurs. It follows that $H^{++}(F') = indirectly\ killing$.

If $F$ is not used in the given stage, then no strengthening should occur; i.e. $H^{+}(F) := H(F)$. $H^{+}$ and $S^{+}$ describe both, the hearer's and the speaker's learning[1]. The hearer's learning precedes the speaker's, but we put both processes together in one stage[2].

As long as we consider only isolated examples, the associative learning model may be sufficient for explaining the observed data. But if we ask for overall regularities, then it is a great advantage to start with a classification of (1) dialogue situations, as done in Sec. 2.1, and (2) laws that describe how these situations can develop diachronically.

### 2.3 Laws of Diachronic Change

We restrict our considerations further to situations where there is for each type $\mathbf{t}_i$ a situation where the speaker wants to classify the object only as $\mathbf{t}_0 \vee \mathbf{t}_1$; i.e. if $e \in [\![\mathbf{t}_i]\!]$, then $\langle e, \mathbf{t}_0 \vee \mathbf{t}_1\rangle \in E$. What parameters can change diachronically? Beside selection and interpretation strategies, there is only one: The set $E$ of utterance situations. As there are only two basic types, $\mathbf{t}_0$ and $\mathbf{t}_1$, there are only two possibilities how reduced occurrences of entities can have an influence within the associative learning model: Either type $\mathbf{t}_0$ or $\mathbf{t}_1$ is not realised in $E$. If only $\mathbf{t}_0$ is realised, we say that we get the new situation by $\{\mathbf{t}_0\}$–reduction, and if only $\mathbf{t}_1$ is realised, we say that we get the new situation by $\{\mathbf{t}_1\}$–reduction. It is possible that a $\{\mathbf{t}_1\}$–reduction follows a $\{\mathbf{t}_0\}$–reduction: We see reduction always relative to the full situation given by Case I to Case III. $\{\mathbf{t}_i\}$–reduction has the effect that the hearer associates $\mathbf{t}_i$ with the lightest form $F_j$ that could classify $\mathbf{t}_i$–entities. Lets consider the situation for Case III examples. Let $F_3$ be another form with wide meaning but more complex than $F_2$. Which effects has $\{\mathbf{t}_0\}$–reduction? There are only three possible types of situations: Either (a) $F_2 \prec F_3 \prec F_0 \prec F_1$, (b) $F_2 \prec F_0 \prec F_3 \prec F_1$, or (c) $F_2 \prec F_0 \prec F_1 \prec F_3$. For (a) and (b) the situation looks as follows (left side):




The hollow bullets mean that the speaker has never a reason to choose the respective form. $\{\mathbf{t}_0\}$–reduction means that the hearer learns to associate $\mathbf{t}_0$ with the least complex form $F_2$. The situation resulting from learning is depicted at the right side. We see that a Case II situation has emerged. For (c) $\{\mathbf{t}_0\}$–reduction would

1. The learning model is related to *classifier learning* [5].
2. For more information on the associative learning model see [1].



lead to a Case I situation. **(1)** b) is an example for III (a), and if we set $F_3 :=$ *Inhabitant of the American continent*, then **(1)** c) is an example for III (c).

For Case II there can only be two further sub–cases: Either (a) $F_0 \prec F_2 \prec F_3 \prec F_1$, or (b) $F_0 \prec F_2 \prec F_1 \prec F_3$. For Case I there is only one: $F_0 \prec F_1 \prec F_2 \prec F_3$. Reduction and subsequent associative learning yields the following list of laws:

*Reduction Laws:*

**(R1)** II situations turn by $\{\mathbf{t}_1\}$–reduction into I situations where $F_2$ is associated with $\mathbf{t}_1$ and $F_3$ is the lightest expression with meaning $\mathbf{t}_0 \vee \mathbf{t}_1$.

**(R2)** III a) situations turn by $\{\mathbf{t}_i\}$–reduction into II situations where $F_2$ is associated with $\mathbf{t}_i$ and $F_3$ is the lightest expression with meaning $\mathbf{t}_0 \vee \mathbf{t}_1$.

**(R3)** III b) situations turn by $\{\mathbf{t}_0\}$–reduction into II situations where $F_2$ is associated with $\mathbf{t}_0$ and $F_3$ is the lightest expression with meaning $\mathbf{t}_0 \vee \mathbf{t}_1$.

**(R4)** III b) situations turn by $\{\mathbf{t}_1\}$–reduction into I situations where $F_2$ is associated with $\mathbf{t}_1$ and $F_3$ is the lightest expression with meaning $\mathbf{t}_0 \vee \mathbf{t}_1$.

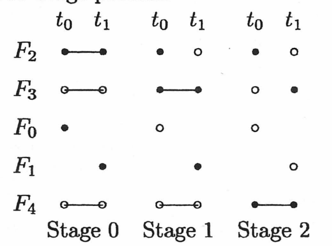
**(R5)** III c) situations turn by $\{\mathbf{t}_i\}$–reduction into II situations where $F_2$ is associated with $\mathbf{t}_i$ and $F_3$ is the lightest expression with meaning $\mathbf{t}_0 \vee \mathbf{t}_1$.

The classification of the resulting state is again meant to be correct up to suitable renaming. The effect of $\{\mathbf{t}_1\}$–reduction in Case II situations is the same as the effect of simple associative learning without reduction. Hence, **(R1)** is covered by the following law:

*Law of Associative Learning:*

**(A)** Case II situations turn into Case I situations where $F_2$ is associated with $\mathbf{t}_1$ and $F_3$ is the lightest expression with meaning $\mathbf{t}_0 \vee \mathbf{t}_1$.

In all other cases the resulting situation is the same as the original one. Now it is not difficult to see how and when we can derive the effects of Horn's division of pragmatic labour for Blutner-squares **(2)**. We need an initial situation with two co–extensive forms $F_2$ and $F_3$ which can develop into a Case I situation where $F_2$ is interpreted either as $\mathbf{t}_0$ or $\mathbf{t}_1$, and $F_3$ as the other one. There are only two such situations: Case III a) and Case III b) situations. For Case III a) the desired Case I situation emerges by a three–stage process:




The second reduction law **(R2)** implies that the situation on the left side turns into the situation in the middle by $\{\mathbf{t}_0\}$–reduction. The case for $\{\mathbf{t}_1\}$–reduction is symmetric. Then, either by the first reduction law, or by the law of associative learning, the situation in the middle turns into the situation on the right. The hollow bullets in the rows for $F_2$ and $F_3$ should indicate that the respective type is still part of the semantic meaning of the form but it is excluded from its actual default interpretation by the hearer. The case for III b) differs from III a) because the first reduction must be a $\{\mathbf{t}_0\}$–reduction. The first two rows of Stage 0 form a Blutner square (2). Let us call a situation like that represented by the first two rows in Stage 2 a *Horn situation*. Blutner's principle of weak optimality diachronically interpreted predicts that the Blutner square in Stage 0 develops into a Horn situation. We can recover this principle as follows:

*The Emergence of Horn Situations: A Horn situation can only develop out of III a) and III b) examples. It emerges as the result of the following two processes:*

$$\text{III a} \xrightarrow{\{\mathbf{t}_i\}\text{–red.}} \text{II} \xrightarrow{\{\mathbf{t}_{1-i}\}\text{–red./learn.}} \text{Horn Sit.}$$

$$\text{III b} \xrightarrow{\{\mathbf{t}_0\}\text{–red.}} \text{II} \xrightarrow{\{\mathbf{t}_1\}\text{–red./learn.}} \text{Horn Sit.}$$

We can also see the result of turning a Case II example into a Case I example as a Horn situation. In this extended sense, there are three types of situations which can develop into Horn situations. For other situations, or other processes we get counter examples for Horn's division of pragmatic labour.

## 3 Conclusions

The diachronic learning model allows only to calculate the associated meaning for each form separately. In comparison, the approach using diachronic laws is much easier to handle and it allows characterising global rules for meaning shifts more straightforwardly. E.g. we did show how and when Horn situations can emerge out of Blutner-squares. Compared to Horn's principle and the principle of weak optimality the diachronic laws have an additional empirical justification because they are derived from an underlying learning theory. They avoid the problem of over–generation and lead to different empirical predictions for when meaning shifts can occur and when not.

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# On Bindability


**Richard Breheny***



**Abstract**
Bindability is the ability of an expression to have its interpretation fixed relative to elements in a scopally superior quantificational expression's domain. There seems to be a bindability generalisation: if context-dependent, then bindable. Two better known accounts of context dependence and bindability are critically considered: the 'hidden variables' and 'presuppositional' approaches. A third account involving coercive lexical mechanisms in a variable-free framework will be offered. The 'bindability generalisation' will be reconsidered in the light of this proposal.


## 1 Bindability Generalisation?

What is the relation between context-dependence and bindability? Certainly, if something is context-dependent it is bindable. Each of the (a)-examples below could be understood according to the (b)-paraphrases in easily imaginable contexts.

(1) a. Every boy broke every bottle
b. Every$_x$ boy in the group broke every bottle he$_x$ was given

(2) a. Everyone who packed a picnic iced up the beers
b. Everyone$_x$ who packed a picnic iced up the beers in the picnics she$_x$ packed

(3) a. When John's house was built, every tradesman finished on time
b. When John's house was built, every$_x$ tradesman finished his$_x$ job on time

(4) a. At the netball tournament, each of the girls playing Goal Defence was tall
b. At the netball tournament, each$_x$ of the girls playing Goal Defence was tall in relation to the members of the age-group she$_x$ was playing under

(5) a. Every sports fan watched the match in a local bar
b. Every$_x$ sports fan watched the match in a [local_to_x] bar

## 2 The Variable-Rich Approach

Pronouns are the paradigm of context-dependent and bindable expressions. There has been a tendency in semantics to assume pronouns are just variable expressions. One way to cash this analysis out would assume that variable assignment functions represent relevant contextual information invoked in a Kaplanian semantic rule for deictic pronouns, as well as playing the usual role in the rule for interpreting variables co-indexed with quantifiers. Thus the different types of pronoun would be the result of the dual use such assignment functions would be put to by the analysis.


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But it seems that this kind of solution does not generalise so readily to the cases discussed above. To see this suppose that the underlying representation for 'tall' contains a variable for the relevant contextual parameter: 'tall' → *[tall_for X]*. Any assignment function containing contextual information could then assign this variable a value. But such functions cannot assign a variable a value relative to an individual in the binding domain of a scopally superior operator (as in (4)) unless there is a second variable in the logical form. The same problem arises for most other context-dependent expressions including QNPs. The way out seems to involve positing not one but two parameters for these expressions, realised as two covert variable components of the relevant expression. The idea would be that one covert variable would be of the type of the individuals in the binding domain and the actual contextual parameter for 'tall' and 'finish' would be fixed in relation to that: 'tall' → *[tall f(x)]*.

This kind of analysis is proposed for QNPs in [10]. The relevant structure is given in (6):

(6) a. $[_{DP}$every $[_{NP}[_{N}$<guest, f(x)>]]]
b. $[\![$<guest, f(x)>$]\!]^c = [\![$guest$]\!]^c \cap [\![$f$]\!]^c([\![$x$]\!]^c)$

Stanley, in [9], argues that no bound-into interpretations are possible without there being some kind of syntactic reflex in the form of a variable-like element. In support of this hidden variable account, Stanley suggests that these expressions are subject to a weak-cross-over constraint, in parallel with pronouns (see also [5]):

(7) a. * Her$_i$ waiters were thanked by every$_i$ hostess
b. ?* Every waiter$_i$ was thanked by every$_i$ hostess

(8) a. * Her$_i$ trip home made every$_i$ reporter nervous
b. ?* The$_i$ trip home made every$_i$ reporter nervous

## 3 Problems for the Variable-Rich Approach

(i) Hidden Variables Are Not Motivated by our intuitive understanding of the expressions that can be bound into. At most, 'tall' intuitively means something relative to some kind of comparison class, not a comparison class relative to an individual. It seems rather that bindability of context-dependent expressions stems not solely from their meaning but from their being interpreted in the 'context' of a quantifier.

(ii) Intensional adjectives in QNPs: What context supplies for the interpretation of QNPs sometimes appears inside, (9), and sometimes outside, (10), the scope of intensional adjectives, making it problematic to know where to hide the variables:

(9) a. Every former girlfriend of Bill was asked to leave.
a'. Every [[former girlfriend of Bill] at the party] was asked to leave.

(10) a. Our boss sends every former employee a Xmas card.
b. Our boss sends every [former [employee of our company]] a Xmas card.



(iii) Multiple Implicit Dependencies: Worse still, there can be more than one implicit bound dependency. In an appropriate situation, 'every$_z$ mistake' in (11)a can be understood as indicated in the gloss in (11)b. Eg, where students write a number of papers which are each marked by three examiners. (See [1] for more examples.):

(11) a. Every$_x$ student was feeling particularly lucky and thought no$_y$ examiner would notice every$_z$ mistake
b. Every$_x$ student thought no$_y$ examiner would notice every$_z$ [mistake made on a paper x turned in and y examines]

If we wanted to pursue a variable-rich approach, given these multiple dependencies, we seem to need to assume that QNP structures contain a plethora of hidden variables at different levels which are vacuously assigned (to what?) when not used.

## 4 The Dynamic, Binding-Accommodation Approach to Presupposition

Partee, in [6] proposes that the bindability generalisation stems from the fact that context dependence brings along presuppositionality. She suggests analysing implicit binding using a dynamic framework where presuppositions can be bound or accommodated in a 'context' created by the restrictor of quantification. Looking again at (4), we could have a DRS suggested in (12):

(12) <∅, {<{x,Y},{goal_defence(x), age_group_of(Y,x)}> ⇒ <∅, {tall_for(x,Y)}>}>

Note here that, as in most cases of implicit binding, we would not only have to resort to accommodation but also to supplying a bridge between the accommodated implicit discourse referent and the binding discourse referent. The analysis goes alright for this example, but it relies generally on the presuppositions being accommodated at the same level as that which the binding could take place. This does not happen with definite descriptions and QNPs. To illustrate, consider (2)a. Let us adopt the framework in [3] for NP presupposition. In the first phase of DRT construction we would have (13) with the unbound presupposition underlined:

(13) [p,p': p ⊢ [x,y: person(x), picnic(y), packed(x,y)], p' = p+[<u>Z</u>: <u>beers(Z)</u>, iced_up(x,Z)], all$_x$p,p']

Where presuppositions cannot be directly bound, they must be accommodated. Global accommodation, as in (14)a, will not work in this case. (14)b is intermediate accommodation and (14)c is most local accommodation. (Some bridging has been included to bring the representations closer to our intuitions):

(14) a. [p,p',r: r ⊢ [Z: beers(Z)] p = r + [x,y,Z: person(x), picnic(y), packed(x,y)], p' = p+[: iced_up(x,Z)], all$_x$p,p']
b. [p,p': p ⊢ [x,y,Z: person(x), picnic(y), packed(x,y), included_in(x,y,Z), beers(Z)], p' = p+[: iced_up(x,Z)], all$_x$p,p']
c. [p,p': p ⊢ [x,y: person(x), picnic(y), packed(x,y)], p' = p+[Z:

included_in(x,y,Z), beers(Z), iced_up(x,Z)], $all_x$p,p']

(14)b says only that all those who packed a picnic with beer iced up their beers. This doesn't square with the intuition that (2)a implies that all picnics contained beer. (14)c looks better, it says that all picnic packers included beer suitably iced up. But things go wrong here if we replace 'every' in (2)a with 'no'. In that case, we still get the global presupposition that every picnic included beers. But the current proposal would imply no picnic included beers. What would capture our intuitions would be a representation like (15)

(15) [p,p',q: p ⊢ [x,y: person(x), picnic(y), packed(x,y)], p' = p+[Z: beers(Z), include_in(x,Z,Y)], $all_x$ p,p', q = p'+[: iced_up(x,Z)], $no/every_x$ p',q]

This gets the facts right for both kind of case, but the global presupposition is universal and not existential. Even though it is the presupposition we intuitively get from (2) and (1), it does not follow from anything in the G&vdS treatment.

Of course, if we think of the plural description in (2) as quantificational (i.e as 'every beer'), then, as with (1), we would get something approaching the right results with most local bridging accommodation (suggested in (1)b and (2)b):

(16) [p,p': p ⊢ [x,y: person(x), picnic(y), packed(x,y)], p' = p+[: [q,q': q ⊢ [u: beer(u)], q' = q + [included_in(x,y,u)], $all_u$q,q'], iced_up(x,u)] $all_x$p,p']

But this representation does not capture the intuitive presuppositions of (1) and (2) - which are universal and global. So, it does not seem that presuppositions are always identified at the same level at which binding takes place. Note also that no reading corresponding to the intermediate accommodation in (14)b is available. This suggests that, really, presupposition and bindability are not connected after all.

## 5 Proposal Using Lexical Manipulation in a Variable-Free Framework

In the variable-free treatment of pronouns in [4], context-dependence and bindability are also run together. Pronouns are type <e,e>, *λx[x]*. Thus the meaning of "Mary likes him" with a free pronoun is functional: *λx[likes'(x)(m)]* with a salient contextual object completing the proposition. Generalising, we could say the meaning of, "Mary is tall" is a function from salient comparison classes to truth values. But this seems to be resisted in [4]. Instead Jacobson proposes a shifting rule for cases like 'tall' only when it is being bound-into. She suggests the same for complex DNPs and descriptions. One can make two comments about this. First, if the implicit parameter of 'tall' is resolved at a lexical level, why not say free pronouns are not functional and invoke a shifting rule when they are bound-into? Such a rule seems to be necessary since pronouns can also have multiple dependencies:

(17) a. $Every_x$ fan at the movie premiere who had photos of the stars asked $every_y$ star to autograph $them_{x,y}$ for them.
b. $them_{x,y}$ = the photos of y which x had



Second, no shifting rule could apply to complex phrases as this would impugn strict compositionality. The shifting that goes on for 'every bottle' in (1) above has an effect that is determined in part by the context. I.e., that the expression ends up meaning *λxλP[every(λy[bottle(y) ∧ was_given(y)(x)])(P)]*. This could not be determined in advance by a semantic rule which does not itself make reference to features of context. So the semantic component of any combinatronic shifting rule for this purpose would itself have to be context dependent. As S&S argued in [10] in relation to a similar proposal, this would make the grammar less than fully compositional.

Our proposal involves two mechanisms for a dynamic lexicon. The first is based on observations in [7] & [8] that even non-context-dependent words can express an ad hoc restricted meaning. Recanati talks, i.a., about contexts where intransitive 'eat' means, 'eat the contextually salient stuff'. We suggest implementing this by (radically) exploiting the idea in [2] of defaults in a generative lexicon. In a word's lexical semantic representation (LSR), attributes can be given values by lexical rules which are only defaults. These can be overridden by discourse principles (cf 'The goat enjoyed the book.'). To allow for general ad hoc restriction, we propose that wild-card qualia attributes can be freely inserted into a LSR. The values for these attributes are fixed at a default uninformative value (eg the top of the relevant inheritance hierarchy). Eg, for 'boy' in (1), we would require the LSR below. The default, uninformative value of the wild-card qualia gets reset at the pragmatic level.

| | |
|---|---|
| boy | |
| ARGSTR = | ARG1 = **[z]human** |
| ... | |
| QUALIA= | ... |
| | WILD = [z]<u>thing</u> |

We could suggest that intransitive 'finish' be associated with a LSR which just means *finish*. Similarly predicational 'tall' could be associated with an LSR meaning, *tall by some criterion*. In almost all cases, however, the LSRs with these very weak meanings would be insufficiently informative and the use of these words would invariably trigger contextual narrowing via the insertion of wild cards. As such, these expressions would be 'presuppositional'. But the presupposition would turn on usage considerations.

Just as even non-context-dependent 'eat' can have a contextually restricted interpretation, so can it be bound into. For (18), the context could involve the boys having to eat some particularly horrible concoction tailor-made to their individual phobias in order to join a secret society. Asking how they performed on the task, we would understand (18) to mean not just that they ate something but that they ate their individual horror meal.

(18) Every boy ate before joining the others

This suggests that we need to posit a general mechanism for creating bindable expressions. When it comes to shifting a category A expression into a category $A^{NP}$ expression, an extra argument needs to be added. We can posit a lexical rule, **the D-rule**, which creates new lexical items from old with additions to the argument structure and the qualia structure. Two applications of this rule are required to interpret 'mistake' in (11). This is suggested below.

| mistake | ⇒ | $\text{mistake}_{dd}$ |
|---|---|---|
| ARGSTR = ARG1 = **[z]artefact** | | ARGSTR = |
| ... | | ARG1 = **[x]agent** |
| | | ARG2 = **[y]agent** |
| | | ARG3 = **[z]artefact** |
| | | ... |
| | | QUALIA = ... |
| | | WILD =R([x],[z]) |
| | | WILD = R([y],[z]) |

Note that applications of the D-rule would normally require the insertion of wild-cards for the bridge. [1] discusses other possible generative lexical constraints relevant to D-rule application. An interpretation for (11) involves multiple applications of the Jacobson's geach rule (see [4], [1]).

To sum up: It does not look as though bindability derives from hidden variables in syntactic, LF structure. DRT-based accounts place bindability at a post-linguistic level of presupposition binding-accommodation. But it seems as though presuppositionality and bindability are separate. In fact, it seems that any expression could be bindable. By marrying a variable-free approach to some idea of a dynamic lexicon, it is possible to separate out the mechanism which forms dependencies from the pragmatic level of accommodation and bridging.

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# How Does Focus Affect Logical Form?

**Ariel Cohen***

## 1 Focus and Logical Form

It is well known that focus can affect the truth conditions of some sentences—in this paper I will concentrate on adverbs of quantification (henceforth *Q-adverbs*). Hence, focus somehow affects logical form. But what does this mean, exactly? One possibility is that focus determines which elements in the sentence are mapped onto the nuclear scope, and which—onto the restrictor. A different view is that focus merely provide a set of alternatives, which is accommodated into the restrictor. The nuclear scope, according to this view, contains the whole sentence (minus the Q-adverb).

It is not often realized, but the two views are quite significantly different. Choosing one or the other has empirical as well as theoretical consequences. In this paper I am going to argue for the second view, and demonstrate how it can solve a new problem for theories of focus effects—*relative readings*.

## 2 Generosity vs. Stinginess

Consider the following sentence:

(1) A politician is often $[\text{crooked}]_F$.

What is its logical form?

There are two main possibilities, illustrated (in a simplified way) by (2). In (2.a) the whole sentence (minus the Q-adverb) is in the nuclear scope, and the alternatives induced by focus are accommodated into the restrictor (see, e.g., [13]). I will call this a *generous* nuclear scope. An alternative, (2.b), is that only the focus is mapped onto the nuclear scope, and everything else is in the restrictor (see, e.g. [2]). I will call this a *stingy* nuclear scope.

(2) a. **often(politician)(politician ∧ crooked)**
b. **often(politician)(crooked)**

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## 3 Problems with Both Approaches

The first question that comes to mind is, of course: does it matter which logical form we choose? I claim that it does. One consideration is theoretical: accepting a stingy logical scope implies that focus has two, unrelated roles: it introduces a set of alternatives, but also moves elements around the logical form.

Proponents of the stingy logical form could claim that focus has only a single role (introducing alternatives), and that it is topic that is responsible for moving elements out of the nuclear scope. But this is problematic, since *a politician*, being indefinite, is not specific, hence cannot be a topic. If forced to be a topic, the result is ungrammatical:

(3) *She said about a politician that he is often crooked.

In fact, the behavior of Q-adverbs can be contrasted with that of (unrestricted) generics, which do require topics. Hence, (4) is rather bad.

(4) ??A politician is crooked.

Putative cases of generics that do allow an indefinite in their restrictor are either restricted generics (as in (5.a)), or sentences expressing a rule or definition (as in (5.b)), rather than real generics [6].

(5) a. A politician is crooked when he or she is a member of party X.
b. A politician is a servant, not a master.

The view that logical form is generous also suffers from a problem: the *requantification problem* [14, 15]. While indefinites are supposed to be novel, the second occurrence of **politician** cannot be novel, since it must refer to the first occurrence. Krifka [12] proposes to solve this problem by developing a theory according to which only some indefinites must be novel.

## 4 A New Challenge for Generous Logical Forms

### 4.1 Conservativity

The logical form of (6) is clearly (2.a).

(6) A politician is often a $[\text{crooked}]_F$ politician.

Hence, (1) and (6) ought to be equivalent. This is not a problem if Q-adverbs are conservative; a quantifier $Q$ is conservative iff

$$Q(\psi, \phi) \equiv Q(\psi, \psi \wedge \phi)$$

Thus, for example, (7.a) is equivalent to (7.b).

(7) a. Most/all/no/some alligators like to sunbathe.
b. Most/all/no/some alligators are alligators that like to sunbathe.

However, it turns out there are non-conservative readings of Q-adverbs.

### 4.2 Relative Readings

Note that (1) is, in fact, ambiguous. One reading of (1) is that many politicians are crooked, i.e. a politician is likely to be crooked. Under this, which I call the *absolute* reading, (1) is (hopefully) false. And yet, one may hesitate before



declaring (1) unequivocally false, because there is another reading, under which the sentence is probably true. Under this, the *relative* reading, a politician is more likely to be crooked than an arbitrary person is. In other words, suppose we pick some person at random. There is some probability $p$ that this person is crooked; what (1) says is that if we pick a politician at random, the probability that he or she is crooked is higher than $p$.[1] Context and a fall-rise intonation (B-accent) are helpful in, perhaps necessary for, obtaining this reading.

(8) A: The main suspects are a politician, a physician, and a linguist. Who do you think did it?
B: Well, $[\text{a politician}]_B$ is often $[\text{crooked}]_F$.

This is a real ambiguity, and not merely a consequence of the vagueness of *often*. One argument is simple: as we have seen, (1) can be true under one reading and false under the other. For another argument, note that generics, which are not usually considered vague, also exhibit this ambiguity [3].

A stronger argument is based on the fact that the relative reading is not available when the adverb is fronted:

(9) Often, a politician is $[\text{crooked}]_F$.

Sentence (9) can only get the absolute reading, namely that many politicians are crooked, but not the relative reading. Fronting is known to eliminate ambiguities (e.g. some cases of scope ambiguity), but not to eliminate vagueness.

Perhaps the strongest argument, and the one most relevant for our purposes here, is the fact that the relative reading is not conservative. Sentence (6) is not equivalent to (1) and can, in fact, only get the absolute reading.

So, (1) and (6) are not equivalent; and since (6) must have a generous logical form, it would seem that (1) cannot.

## 5 Generous Logical Form And Relative Readings

### 5.1 Explanation

What is the explanation for these facts? Let us first make some (more or less) standard assumptions about generous logical forms, following [13]. A sentence $\phi$ has an ordinary semantic value—$[\![\phi]\!]^O$, as well as a focus semantic value—$[\![\phi]\!]^F$. The latter is a set derived from $\phi$ by replacing the focused constituent(s) with alternatives. The restrictor contains a variable, whose value is the disjunction of the focus semantic value.

Following [7] and a suggestion of Sigrid Beck (pc), the account of relative readings is as follows. B-accent is topiclike—sometimes called "contrastive topic"—but it is not really a topic, because it does not have to be specific.

1. Compare De Swart's [8] observation that (i.a) is ambiguous between (i.b) and (i.c).

(i) a. Paul often has a headache.
b. In many appropriate situations Paul has a headache.
c. Paul often than the average.

B-accent is not focus either, but it is focuslike [9, 10, 11], hence it induces alternatives. I will assume a B feature, leaving open its phonological realization. Correspondingly, I propose a B semantic value—$[\![\phi]\!]^B$—obtained by replacing the B-marked constituent(s) with alternatives. And, in addition, a semantic value which combines the two: contrast semantic value—$[\![\phi]\!]^{F+B}$—obtained by replacing focused and B-marked constituents with alternatives.

Q-adverbs have probabilistic truth conditions [4]. Specifically:

**Definition 1 (Often)** **often**$(C)(\phi)$ *is true iff* $P([\![\phi]\!]^O|C) > \rho$, *where:*

1. $\rho$ *is "large" (absolute reading), or*
2. $\rho = P(\bigvee [\![\phi]\!]^B | \bigvee [\![\phi]\!]^{F+B})$ *(relative reading).*[2]

Consider, for example, the interpretation of (10).

(10) [A politician]$_B$ is often [crooked]$_F$.

The derivation of the absolute reading is completely standard. The relative reading is derived in the following way. The logical form of (10) is

(11) **often**$(C)([\textbf{politician}]_B \wedge [\textbf{crooked}]_F)$

The ordinary semantic value of the nuclear scope is

$[\![\phi]\!]^O = \textbf{politician} \wedge \textbf{crooked}.$

The disjunction of the focus semantic value is accommodated into the restrictor:

$C = \bigvee [\![\phi]\!]^F = \textbf{politician}.$

The B semantic value is

$\bigvee [\![\phi]\!]^B = \textbf{crooked},$

and the contrast semantic value is

$\bigvee [\![\phi]\!]^{F+B} = \textbf{person}.$

Then, (11) is true iff

$P(\textbf{politician} \wedge \textbf{crooked}|\textbf{politician}) > P(\textbf{crooked}|\textbf{person}).$

This can be paraphrased as: A politician is more likely to be a crooked politician then an arbitrary person is likely to be crooked. This is the desired reading.

Crucially, the absolute and relative readings do not have different logical forms—both share the same logical form [5]. There are two arguments for this claim. One is parsimony: even if we did assume different logical forms for absolute and relative readings, this would still not give us the two interpretations; we would still need different evaluation procedures. Why, then, postulate an additional logical form, if it does not provide us with a different interpretation?

For the second argument, note that absolute and relative readings have the same main focus; when focus is on the subject, the meaning is different.

(12) ??[A politician]$_F$ is often crooked.

Sentence (12) is quite bad. Even if it were acceptable, it would not get the relative reading, but rather the interpretation where a crooked person is unlikely to be a politician. Assuming that, indeed, focus affects logical form, this is an indication that both readings have the same logical form.

2. $P(\alpha|\beta)$ is the conditional probability of $\alpha$ given $\beta$.



### 5.2 Conservativity Revisited

We can now explain why (10) is not equivalent to (13).

(13) [A politician]$_B$ is often a [crooked]$_F$ politician.

The respective logical forms of (10) and (13) are:

(14) a. **often**$(C)([\textbf{politician}]_B \wedge [\textbf{crooked}]_F)$

b. **often**$(C)([\textbf{politician}]_B \wedge \textbf{politician} \wedge [\textbf{crooked}]_F)$

Their ordinary semantic values are the same, but not the B and contrast semantic values. Consequently, while (14.a) has a relative reading, (14.b) does not, for the following reason. The ordinary semantic value is

$[\![\phi]\!]^O = \textbf{politician} \wedge \textbf{crooked}.$

The value accommodated into the restrictor is

$C = \bigvee [\![\phi]\!]^F = \textbf{politician}.$

Since only one occurrence of **politician** is B-marked, the B semantic value is

$\bigvee [\![\phi]\!]^B = \textbf{politician} \wedge \textbf{crooked},$

and the contrast semantic value is

$\bigvee [\![\phi]\!]^{F+B} = \textbf{politician}.$

Hence, (14.b) is true iff

$P(\textbf{politician} \wedge \textbf{crooked}|\textbf{politician}) > P(\textbf{politician} \wedge \textbf{crooked}|\textbf{politician}).$

Since a number is never strictly greater than itself, this is necessary false—certainly not the intended relative reading.

A similar account explains why (9) does not have a relative reading. Fronting the Q-adverb, I suggest, eliminates the B-marking of *a politician*. Thus, the B and contrast semantic values contain the predicate **politician**, and do not replace it with alternatives. This is different from the B and contrast semantic values of (10), which do contain alternatives to **politician**, allowing us to compare politicians with persons in general, resulting in the relative reading.

### 5.3 Other Q-adverbs

Not all Q-adverbs have relative readings. For example, (15) means that a politician is likely to be crooked. Regardless of context or intonation, it cannot mean that a politician is more likely to be crooked than an arbitrary person is.

(15) [A politician]$_B$ is usually [crooked]$_F$.

Can we, then, apply the results about the logical form of *often* (and *seldom*) to other Q-adverbs? Indeed, we can. Otherwise, we would be forced to the implausible conclusion that focus creates different logical forms depending on the specific Q-adverb involved. Hence, all Q-adverbs have the same—generous—logical form. Some Q-adverbs (*often* and *seldom*) are simply lexically ambiguous, others are not.

## 6 Conclusion

We conclude that Q-adverbs have a generous logical form. Hence, focus has one role only: it provides a set of alternatives, which is accommodated into the restrictor. B-marking also provides a set of alternatives; this does not go into the logical form, but plays a role in the evaluation of some Q-adverbs (*often* and *seldom*, and their synonyms), to generate their relative readings. The generous logical form provides the right truth conditions in all cases, including these non-conservative Q-adverbs. This is because the logical form does not determine truth conditions by itself: the B and contrast semantic values are also relevant.

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# On the Expressive Completeness of Underspecified Representations

**Christian Ebert***


**Abstract**
One property of underspecified representation formalisms is that of expressive completeness, i.e. the ability to provide representations for all possibly occuring sets of readings. In this paper a general and formal definition of completeness along the lines of [6] will be given. Several formalisms will then be compared concerning their expressive power and shown to be incomplete.


## 1 Introduction

In recent years, various proposals have dealt with the task of providing *underspecified representations* (*URs* for short in the following) to represent the different readings of scopally ambiguous sentences in a compact way. One of the main purposes of underspecification is the avoidance of the so-called *combinatorial explosion problem.* This term describes the simple mathematical fact that there are $n!$ possible orderings for $n$ items, which means that a sentence containing $n$ scope-taking elements can have $n!$ readings in the worst case. As the computation of all these $n!$ readings would be highly inefficient, it is desirable to work with a more compact UR instead and delay the computation of readings for as long as possible.

One important feature of URs is the ability to represent *partial disambiguations.* First, single sentences may not behave as badly as the worst case scenario above suggests. Quantifiers, for instance, are restricted in their scopal possibilities by scope islands and other facts (which are not fully explored yet). E.g. the sentence

(1) *Every linguist, who listened to more than three talks, gets a free drink.*

is only twofold ambiguous between a specific and a non-specific reading for *a drink*, although it contains three quantified noun phrases. The quantified NP *more than three talks* cannot contribute to the ambiguity of this sentence as it occurs in a scope island. Thus an UR representing this sentence has to underspecify only two readings instead of the full set of $3! = 6$ permutations.

Second, context is a major source of disambiguation. If (1) is followed by

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(2) *It will be a Mojito.*
it is disambiguated in favor of the specific reading of *a drink*. In general, if at some stage of discourse processing one has to deal with possibly available readings $P$ and the context is such that it gives reason to exclude $E$, then the UR representing this part of the discourse should underspecify exactly $P - E$.

The discussion above is held deliberately informal as to my knowledge there is currently no formally spelt out theory or approach to the underspecified processing of entire discourses. Its crucial point is that an adequate underspecified representation formalism must provide URs for all possibly occuring partial disambiguations, i.e. possibly occuring sets of available readings for single sentences as well as for discourses. If a formalism satisfies this requirement it is called *expressively complete*. Note that if we claim a formalism to be complete, which does not provide an UR for some set of readings $P$, we make the following strong claims:

1. There is no sentence in natural language, which is ambiguous between the readings in $P$.
2. Discourse cannot evolve in a way that yields an ambiguity between the readings in $P$.

Although the first claim may seem to be reasonable for certain sets of readings (given restrictions on quantifier scope in sentences), the second claim seems highly dubious as one can imagine that involved discourses may yield virtually any pattern of ambiguity. Just as (2) serves as a disambiguating context for (1) we can think of (possibly non-linguistic) contexts which disambiguate any sentence in any way. Exactly how this is done formally is a difficult question which needs further investigation. The crucial point is, that if the representation formalism is not expressive enough to even provide a representation for these disambiguations, one has lost already. In the following I will give a formal definition of completeness and apply it to several UR formalisms. Due to space restrictions this is done on a rather informal level, but the details will be made available in [3].

## 2 Expressive Completeness

The term *expressive completeness* was first used for UR formalisms in [6], where the authors argue as follows. Given a set of $n$ scope-taking elements, there are $n!$ permutations of these elements, which can be regarded as possible readings. Thus there are $2^{n!}$ possible subsets of permutations, which can be seen as possible partial disambiguations. An expressively complete formalism should then provide an UR for each of these $2^{n!}$ partial disambiguations. The formal definition below will run along these lines.

UR formalisms talk about expressions of an underlying formal language by taking them apart, enriching them with *meta-variables* and constraining the way those parts can be composed. In order to keep the definition generally



applicable we shall abstract over the particular underlying formal language and define completeness using *terms* over a *signature* instead.

A *signature* $\Sigma$ is a pair consisting of a set of functor symbols $F$ together with an associated arity function $\mathsf{a} : F \to \mathbb{N}$. A term is then either a constant $x$, where $\mathsf{a}(x) = 0$, or an expression of the form $ft_1 \dots t_n$, where $\mathsf{a}(f) = n$ and $t_1, \dots, t_n$ are terms. For every term there is a uniquely corresponding tree and we will make use of this correspondence by using 'tree' and 'term' synonymously in the following. Various relations can be defined on tree nodes, such as *immediate dominance* $\prec$ and its transitive and reflexive closure *dominance* $\preceq^*$. If there are no multiple occurences of functors in a tree, than each functor labels one unique node and we can define those relations on the functors directly. For instance, in the term $f(g(x), h(y))$ (where parentheses have been added for better readability) $g$ immediately dominates $x$ (i.e. $g \prec x$), and is immediately dominated by $f$ (i.e. $f \prec g$). Furthermore $h \prec y$, $f \prec h$ and $f \preceq^* f$, $f \preceq^* g$, $g \preceq^* g$, $g \preceq^* x$, $f \preceq^* x$, and so on.

As mentioned above, UR formalisms constrain the composition of parts of formal language expressions. We will view those parts as the elements of a signature $\Sigma$ and say that the formalism is *defined over* $\Sigma$. Then each UR $u$ of the formalism stands for a set of readings which are terms over $\Sigma$. In the following we write $\mathcal{L}(u)$ for this set and say that $u$ *licenses*[1] $\mathcal{L}(u)$.

So $\Sigma$ can be seen as the entire stock of scope-taking elements we can talk about. A *finite multiset* $\Gamma \subseteq \Sigma$ can then represent the collection of scope-taking elements (of which some can occur more than once) we have to deal with at some processing step, e.g. when we need to represent the scope ambiguity of a single sentence. If we define $[\Gamma]$ to be the set of terms which contain exactly the functors in $\Gamma$, then $[\Gamma]$ can be regarded as the worst case scenario, i.e. the set of all possible permutations of scope-taking elements in $\Gamma$. Hence partial disambiguations are subsets of $[\Gamma]$ and an UR formalism can be called complete, if it provides a representation for each of those.

**Definition 1.** An underspecified representation formalism over $\Sigma$ is *complete* iff for every finite multiset $\Gamma \subseteq \Sigma$ and every $P \subseteq [\Gamma]$ there is an UR $u$ such that $\mathcal{L}(u) = P$.

Furthermore we say that for two UR formalisms $U$ and $U'$ over the same signature, *$U$ is more expressive than $U'$* iff every $P$ that is licensed by some $u'$ of $U'$ has also a licenser $u$ of $U$.

## 3 Incompleteness Results

In this section I will state some results concerning the incompleteness and expressive power of some UR formalisms.

1. I avoid the term *denotes* here, as $\mathcal{L}(u)$ is defined purely syntactically and I don't want to suggest that it is associated with some semantics of URs in any way.

***Normal Dominance Constraints.*** In [4] and [5] the language of *Normal Dominance Constraints* (NDCs), a logical description language for trees, has been defined which is suited to serve as an UR formalism. I shall review some of the definitions briefly. A *Dominance Constraint* over $\Sigma$ is defined as a conjunction of *dominance literals*, *inequality literals*, and *labeling literals* (where $f \in \Sigma$ and $X, X_i$ and $Y$ are taken from a set of variables):

$$\varphi \quad ::= \quad X \triangleleft Y \mid X \neq Y \mid X : f(X_1, \ldots, X_{\mathsf{a}(f)}) \mid \varphi \wedge \varphi'$$

A tree $t$ is called a *solution* to a constraint $\varphi$ if there is a mapping from the variables in $\varphi$ to the nodes in $t$ such that all literals are satisfied. Concerning satisfaction, $\triangleleft$ stands for dominance, $\neq$ for distinctness of nodes, and the labeling literals make statements about the label and the daughters of a node. As every satisfiable constraint has an infinite number of solutions we restrict our attention to *constructive* solutions, which are solutions in which every node is denoted by some labeled variable.

A dominance constraint $\varphi$ is called *normal* if it fulfills certain additional requirements (cf. [5]) of which an important one is that of *overlap-freeness*. It requires distinct labeling literals to denote distinct nodes and therefore we know that every constructive solution of a NDC $\varphi$ contains exactly those functors occuring in the labeling literals of $\varphi$. If we let $\Gamma(\varphi)$ denote these functors, every constructive solution will be in $[\Gamma(\varphi)]$ and hence we can define licensing for NDCs as follows:

$$\mathcal{L}_{\text{NDC}}(\varphi) = \{t \mid t \text{ is a constructive solution of } \varphi\}$$

Now suppose that $\Gamma = \{f, g, h, x\}$ where $f, g, h$ are unary functors and $x$ is a constant and let $P = \{fghx, fhgx, hgfx, ghfx\} \subseteq [\Gamma]$. Then we claim that there is no normal dominance constraint $\varphi$ such that $\mathcal{L}_{\text{NDC}}(\varphi) = P$. Due to space restrictions we cannot give the proof here and have to simplify matters considerably. The intuitive idea however can be captured by closer inspection of the relations on the trees of $P$ (leaving out the pair brackets) as given in Table 1.

Now assume that $\varphi$ is a licenser of $P$. Then clearly every tree in $P$ fulfills each literal in $\varphi$. Now suppose for instance that $\varphi$ contains a literal making a statement about $f$ dominating $g$. Then e.g. *hgfx* would not satisfy it and hence $\varphi$ cannot contain such a literal. The same holds for statements about immediate dominance as the first four columns show. Thus we can find a counterexample in $P$ to every non-trivial literal which $\varphi$ could possibly contain. Eventually only trivial literals remain, i.e. literals which are satisfied by *any* tree in $[\Gamma]$ (such as statements about $f$ dominating $x$). Hence we can derive $\mathcal{L}_{\text{NDC}}(\varphi) = [\Gamma]$ from the assumption $\mathcal{L}_{\text{NDC}}(\varphi) = P$ which is a clear contradiction. Therefore $P$ has no licenser and constitutes a counterexample to completeness. Hence we get
**Theorem 2.** The language of Normal Dominance Constraints is incomplete.

***Hole Semantics.*** Hole Semantics has been defined in [1] as a general approach to underspecification. It shares with Dominance Constraints that it is



| $\prec_{fghx}$ | $\prec_{fhgx}$ | $\prec_{hgfx}$ | $\prec_{ghfx}$ | $\preceq^*_{fghx}$ | $\preceq^*_{fhgx}$ | $\preceq^*_{hgfx}$ | $\preceq^*_{ghfx}$ |
|---|---|---|---|---|---|---|---|
| $fg$ | | | | $fg$ | $fg$ | | |
| | $fh$ | | | $fh$ | $fh$ | | |
| | | $fx$ | $fx$ | $fx$ | $fx$ | $fx$ | $fx$ |
| | | $gf$ | | | | $gf$ | $gf$ |
| $gh$ | | | $gh$ | $gh$ | | | $gh$ |
| | $gx$ | | | $gx$ | $gx$ | $gx$ | $gx$ |
| | | | $hf$ | | | $hf$ | $hf$ |
| | $hg$ | $hg$ | | | $hg$ | $hg$ | |
| $hx$ | | | | $hx$ | $hx$ | $hx$ | $hx$ |

Table 1: Immediate Dominance and Dominance Relations in $P$

not committed to a particular underlying language and hence it can be easily defined over any signature. The 'parts' which this formalisms talks about have the exact form of labeling literals and there are only one constraints, which restrict the dominance relation $\preceq^*$. As all constraints are interpreted conjunctively we can show incompleteness by a proof very similar to the one sketched above. However, the set $Q = \{fghx, hgfx\}$ suffices as a counterexample to the completeness of Hole Semantics (cf. the 5th and 7th column of the table above).
**Theorem 3.** Hole Semantics is incomplete.

As Hole Semantics lacks inequality constraints it is not surprising that it is less expressive than Normal Dominance Constraints. $Q$ witnesses this as the following NDC licenses $Q$.

$$X : f(X') \wedge Y : g(Y') \wedge Z : h(Z') \wedge U : x \wedge Y' \neq U \wedge X' \neq Z \wedge Z' \neq X$$

Note that this constraint does indeed not contain any dominance literal but makes use of inequality literals only. Hence we get[2]
**Theorem 4.** The language of NDCs is more expressive than Hole Semantics.

***UDRT and Minimal Recursion Semantics.*** As already shown in [1] UDRT (as defined in [7]) can be formulated in Hole Semantics by using DRT as the underlying language. The important observation is that the constraints in UDRT are interpreted the same way as in Hole Semantics. Therefore UDRT is as expressive as Hole Semantics and therefore incomplete.

Concerning MRS (as defined in [2]), one can again get a proof of incompleteness similar to the one for Hole Semantics. One difference is MRS' subdivision of functors into *floating scopal* and *fixed scopal* ones, such that fixed scopal functors are not allowed to intervene the constraints (which are otherwise interpreted as dominance). This increases the expressive power w.r.t.

2. Note that this proves Theorem 4 in [5] wrong, which claims Hole Semantics and NDCs to be equivalent. According to Alexander Koller (p.c.), a slightly more restrictive definition of normality could save the equivalence result.

Hole Semantics as every Hole Semantics representation can be translated into an equivalent MRS (using only floating scopal functors). However, $\{fghx, hgfx\}$ cannot be licensed by any Hole Semantics representation but by an MRS and thus MRS is more expressive than Hole Semantics.

## 4 A Complete Formalism?

An obvious question is, what a complete formalism may look like. One crucial point in all the proofs is the conjunctive interpretation of the constraints. In every formalism *all* constraints must be fulfilled simultaneously by some solution and thus it was possible to derive restrictions on the form of those constraints via the relations on the solutions. So an obvious amendment seems to be to allow for disjunction (or negation). Such a formalism could be shown to be complete as one could have a disjunction of constraints, each of which has exactly one of the trees as its solution. However this approach seems to lead directly to another problem: As stated in [4], general dominance constraints already have NP-complete satisfiability problems, which is an extremely undesirable property for formalisms that are meant to allow for efficient processing. Hence the obvious question may be refined to: What does a complete formalism with good computational properties look like? At this stage, an answer to this question is left open for future work.

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# Parser Combinators for Extraction

**Jan van Eijck***


**Abstract**
Dislocation phenomena in natural language can be, and often are, thought of as the effects of movement transformations. We propose to handle these phenomena in terms of parser combinators [3, 8] that transform recursive descent parsers for a 'deep structure language' into parsers for a 'surface structure language'. This combinator approach to extraction keeps close to the 'movement' intuition and gives a computational account of the well known island constraints on extraction first proposed in [7].


## 1 Introduction

Left extraction in natural language occurs when a subconstituent of some constituent is missing, and some other constituent to the left of the incomplete constituent represents that missing constituent in some way. In the generative tradition, such dislocations used to be accounted for by means of transformations that *move* a constituent while leaving a trace. Computational and logic-oriented approaches to NL processing and understanding replace the transformational account with an *in situ* analysis, through gap threading (lexical functional grammar, categorial grammar, GPSG, HPSG), through extension of the context free rule format with wrapping operations (extraposition grammars, tuple-based and tree-based extensions of context free grammars), or through extension of context free rules with stacks of indices (indexed grammars). We propose an account in terms of pushdown parser combinators for recursive descent parsing. Our account allows us to remain close to the spirit of the original movement analysis.

## 2 Parser Combinators

Parser combinators are functions that transform parsers for a language into parsers for a different language [3]. We can think of a recursive descent parser for a fragment of natural language as a function of type

$$[Cat] \rightarrow [(Cat, [Cat])].$$

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The parser transforms a list of categories — type [*Cat*], with the square brackets indicating list formation — into a list of pairs (*Cat*, [*Cat*]), each consisting of a category and a list of remaining categories. Parsing with the rule $A \longrightarrow X_1 \cdots X_n$ gives the result:

$$[X_1, \ldots, X_n, X_{n+1}, \ldots, X_m] \Longrightarrow \begin{array}{c} \text{A} \\ | \\ X_1 \;\ldots\; X_n \end{array} \quad [X_{n+1}, \ldots, X_m].$$

Parsing the input list $[X_1, \ldots, X_m]$ with a set of rules may give a number of different results. Each successful parse of the input category-list will yield a pair consisting of (i) a recognized category for a prefix of the category list and (ii) the remainder of the category list. Parsing failures are indicated by return of the empty list, ambiguous parses by return of non-unit lists.

## 3 A Parser Combinator for Extraction

Relative clause formation in English is a simple example of left extraction. The structure of the relative clause in (1) is represented by the annotation that links a relative pronoun *that* to its trace $t_i$.

*I hated the man that*$_i$ *the woman sold the house to* $t_i$. (1)

Abbreviating the type of parsers as *Parser*, the parser combinator that instructs a parser to expect a DP gap — represented by a trace $t$ — has type *Parser* → *Parser*, and is given by the following definition by means of list comprehension:

```
expectDPgap :: Parser → Parser
expectDPgap  = λ parser λ xs.
               [(cat, zs) | ys ← randomInsert "t" xs,
                            (cat, zs) ← parser ys,
                            hasDPgap cat            ]
```

What this says is that the parser combinator *expectDPgap* takes a parser as a first argument and yields a function from input category lists to lists of output pairs consisting of categories and remainder category lists, i.e., a parser. The function call *randomInsert "t" xs* yields the list of all category lists that result from inserting trace *t* somewhere in the category list *xs*, so *ys* ranges over all such category lists, and (*cat*, *zs*) ranges over all pairs of categories and category lists that result from running the input parser on such *ys*. The function call *hasDPgap cat* is a Boolean check as to whether *cat* has an DP gap somewhere in it. Thus, if *expectDPgap* combines with a parser this yields a new parser that operates on an input category list *xs* by calling the input parser on category lists that differ from the input category list in the fact that the trace *t* occurs



in it somewhere, and that yields as output those pairs (*cat*, *zs*) in the yield of the input parser with *cat* having a DP gap.

Suppose that the trace introduced by *expectDPgap* is parsed as a DP gap, and assume that *parseSent* is a parser for sentences. Then

*expectDPgap parseSent*

is a parser for relative clauses. The combinator account of movement naturally accommodates the well known island constraint on extraction [7] that rules out configurations of the form

$$\ldots \text{that}_i \ldots [_{\text{DP}} \ldots [_{\text{REL}} \text{ that}_j \; [_{\text{S}} \ldots t_j \ldots t_i \ldots]]].$$

The island constraint is imposed to explain the ungrammaticality of examples like (2).

**I admired the woman that*$_i$ *you liked the man that*$_j$ [$t_j$ *sold it to* $t_i$]. (2)

This island constraint is captured in the *hasDPgap* check.

## 4 Pushdown Parsers

The parsing-as-deduction metaphor [6] assimilates parsing with CF rules to logical deduction. The goal is to prove the sentence symbol from a list of premisses corresponding to the categories of the input word list, with the CF rule $A \longrightarrow X_1 \cdots X_n$ read as $X_1 \cdots X_n \vdash A$.

In this perspective, parsing with a dislocated constituent can be seen as parsing with a hypothesis to be discharged at the point where the corresponding gap is encountered. Parsing with CF rules relates to parsing with CF rules allowing hypothetical reasoning in roughly the same way as basic categorial grammar relates to Lambek style categorial grammar, but for the fact that in the case of categorial grammar hypothetical reasoning does not increase (weak) expressive power [5], while in the case of CF grammar it does (see below).

The appropriate function for 'parsing with hypotheses' is a pushdown parser that collects the list of undischarged hypotheses on a stack. A *PdParser* is a function of the following type:

$$[Cat] \rightarrow [Cat] \rightarrow [(Cat, [Cat], [Cat])].$$

Such a function takes a list of undischarged hypotheses and a list of unparsed categories, and it produces a list of triples consisting of a category, a list of remaining hypotheses, and a list of remaining categories.

If a displaced constituent is encountered, a gap category is pushed onto the stack of hypotheses. If, during the parse, a corresponding category is expected but not found in the input category list, a hypothesis may be discharged.

Suppose the parser expects a DP. If a gap of type DP is on top of the stack, then it is possible to parse the DP as this gap, and it is also possible to parse the DP using a DP rule, and carry the gap along. Discharging the gap is done by using the *pop* parser combinator:

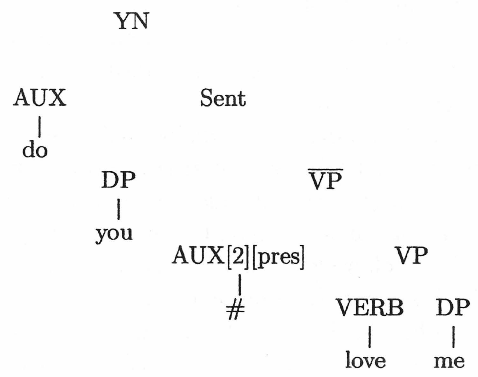
$$\begin{aligned} \mathit{pop} &:: \mathit{CatLabel} \rightarrow \mathit{PdParser} \\ \mathit{pop}\ l\ (h : \mathit{hs})\ \mathit{xs} &= [\ (h, \mathit{hs}, \mathit{xs}) \mid \mathit{catLabel}\ h = l\ ] \end{aligned}$$

The following function propagates a hypothesis through a pushdown parser:

$$\begin{aligned} \mathit{propagate} &:: \mathit{CatLabel} \rightarrow \mathit{Cat} \rightarrow \mathit{PdParser} \rightarrow \mathit{PdParser} \\ \mathit{propagate}\ l\ h\ p &= \lambda \mathit{hs}\ \lambda \mathit{xs}. \\ &\quad [\ (\mathit{cat}, h : \mathit{is}, \mathit{ys}) \mid (\mathit{cat}, \mathit{is}, \mathit{ys}) \leftarrow p\ \mathit{hs}\ \mathit{xs}, \mathit{catLabel}\ h = l\ ] \end{aligned}$$

This choice between pop and propagation ensures that the island constraint is met: the pending hypothesis cannot be discharged inside a category with the same label. (In the other case, i.e., if the label of the pending hypothesis is different from the label of the expected category, the hypothesis can be used inside.)

Yes/no questions can be thought of as the result of extracting an auxiliary from a sentence, e.g.:




A Wh-question is the result of extracting a Wh-phrase (either a DP or a PP) from a YN-question, so parsing a Wh-question is just a matter of first finding a Wh-phrase and next letting a parser for YN-questions look for a matching Wh-phrase gap. Figure 1 gives a structure tree for *What did they break it with?* Similarly, we get a parse for *With what did they break it?* by pushing a PP gap onto the hypotheses stack.



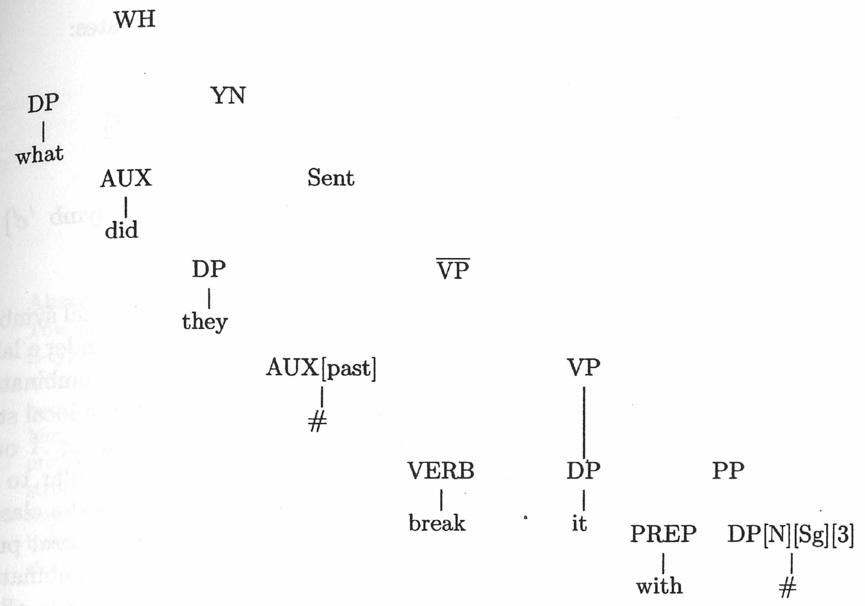



Figure 1: Parse tree for *What did they break it with?*

## 5 Semantics

For generation of logical forms, replace each category by a pair of the type (*Cat, LF*), and modify the push function as follows:

$$\begin{aligned} \mathit{push} &:: (\mathit{Cat},\mathit{LF}) \rightarrow \mathit{PdParser} \\ \mathit{push}\ (\mathit{gap},v)\ f\ \mathit{hs}\ \mathit{xs} &= [\ ((c, \lambda v.\mathit{lf}), \mathit{is}, \mathit{ys}) \mid ((c, \mathit{lf}), \mathit{is}, \mathit{ys}) \leftarrow f\ (\mathit{gap},v){:}\mathit{hs}\ \mathit{xs}\ ] \end{aligned}$$

Suppose the gap variable has type $\alpha$ and the LF component of the output of parser $f$ has type $\beta$. Then the LF component of the output of the parser

*push (gap, v) f*

has type $\alpha \rightarrow \beta$. This makes storage of a gap category (introduction of a hypothesis) correspond to lambda abstraction over a variable that interprets the gap, as it should.

## 6 Recognizing Power

Starting out from a set of combinators for CF parsing, the addition of the pushdown stack of hypotheses allows for the parsing of non-CF languages, as the following example of a parser for the language $a^n b^n c^n$ illustrates:

$$\begin{aligned} parseS, parseZ &:: PdParser \\ parseS &= parsesAs\ 'S'\ [symb\ 'a', push\ 'X'\ parseS] \\ &\oplus\ parseZ \\ parseZ &= parsesAs\ 'Z'\ [symb\ 'b', pop\ 'X'\ parseZ, symb\ 'c'] \\ &\oplus\ eps \end{aligned}$$

This uses only the CF combinators (*symb* for recognition of individual symbols, $\oplus$ for choice, *parseAs* for sequential composition of a list of parsers under a label, and *eps* for recognizing the empty string), plus the *push* and *pop* combinators.

A pushdown parser for recognizing a category $A$ comes with a local stack of undischarged hypotheses that can be used either in recognizing $A$ or in recognizing categories further on in the parse process. This is similar to the nested stack automata from [2], the machine model that matches the class of indexed languages [1]. We conjecture that parsing with recursive descent pushdown parsers, using only parser combinators for the context free combinators, plus the combinators for storage (push) and retrieval (pop) of hypotheses, allows for the recognition of all indexed languages.

Pushdown parser combinators have been implemented in the lazy functional programming language Haskell [4], yielding promising parsers for interesting NL fragments.

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# Indistinguishable Participants

**Paul Elbourne***


**Abstract**
This paper addresses the 'problem of indistinguishable participants' posed for E-type analyses of donkey anaphora by Kamp. Sentences like *If a bishop meets a bishop, he blesses him* seem to be impossible to analyze in an E-type theory, because there are no definite descriptions that can serve as denotations for *he* and *him*, since the participants introduced are indistinguishable. The E-type analysis proposed here differentiates the two participants by making reference to the structure of the situations in which they are embedded. Meanwhile, previously neglected data show that dynamic semantics theories encounter problems with indistinguishable participant sentences, meaning that the E-type analysis with situation semantics is empirically superior to dynamic theories in this area.


## 1 A problem for the E-type analysis

Hans Kamp, reported in [1], has claimed that sentences like (1) constitute an objection to the E-type analysis of donkey anaphora [1–3] as opposed to the dynamic semantics analysis [4–7].

(1) If a bishop meets a bishop, he blesses him.

If we try to analyze this example using situation semantics and E-type pronouns, as suggested by Heim [1], the objection goes, we cannot interpret the pronouns *he* and *him*. Let us use the situation variable $s$ for the situations specified by the antecedent, and $s'$ for the extended situations specified by the consequent. If we try to interpret either pronoun as a definite description whose descriptive content is 'bishop in $s$' or 'bishop who meets a bishop in $s$', we do not achieve the right results; since meeting is necessarily a symmetrical relation, in any situation in which a bishop meets a bishop there are *two* bishops who meet a bishop, and the uniqueness needed by definite descriptions is not achieved. While the E-type approach seems to founder on these examples, dynamic theories have no trouble. They obtain truth conditions for (1) equivalent to, 'For all $x$, for all $y$, if $x$ is a bishop and $y$ is a bishop and $x$ meets $y$, then $x$ blesses $y$.'

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## 2 Previous E-type solutions

The literature contains E-type analyses by Heim, Neale and Ludlow that address this problem [1,8,9]. Heim's solution has been criticized by its author [1].

According to Neale's solution [8], the definite descriptions contributed by E-type pronouns are numberless. So (1) would mean something like (2).

(2) If a bishop meets a bishop, the bishop or bishops who meet a bishop bless the bishop or bishops who meet a bishop.

This produces the right truth conditions. But it seems to be doing violence to the fact that the pronouns in question do have number features, whose intuitive content we recognize quite plainly. Furthermore, we might ask how number features are assigned to E-type pronouns in this system. It cannot be by a semantic process, since semantically the pronouns are numberless. So presumably it must be by syntactic agreement with the antecedent. But that predicts that (3a) will be grammatical.

(3) a. * If a bishop meets more than one parishioner at once, he blesses him.

b. If a bishop meets more than one parishioner at once, he blesses them.

We cannot, then, be satisfied with this solution. See [10] for further discussion.

Ludlow [9] suggests that the participants in (1) can be distinguished because they are assigned different thematic roles. He claims that no two arguments of the same event can have the same thematic role. For the antecedent of a sentence like (1), there will be two distinct thematic roles $\theta 1$ and $\theta 2$, such that the semantics is something like (4).

(4) There is an event $e$ such that there is an individual $x$ such that $x$ is a bishop and there is an individual $y$ such that $y$ is a bishop and $y$ is not identical to $x$, such that $e$ is an event of meeting and $\theta 1(e,x)$ and $\theta 2(e,y)$.

Then the *he* of the consequent can be analyzed as a definite description involving $\theta 1$, say, and the *him* as a definite description involving $\theta 2$.

It seems, however, that this proposal begs the question. No specific suggestions are made concerning the identity of the distinct thematic roles $\theta 1$ and $\theta 2$; and no reasons are given to make the existence of such roles seem necessary on a *priori* or methodological grounds. Indeed, it is *prima facie* plausible to say that symmetrical relations do by definition constitute eventualities whose arguments have identical thematic roles, if we are to maintain any relationship between thematic roles and discernible differences in the properties of entities in extralinguistic reality.



## 3 A problem for dynamic semantics

There is a problem, then, for the E-type analysis. But previously neglected data show that dynamic theories too have trouble in this area. Consider the contrast between (1) and (5).

(5) * If a bishop and a bishop meet, he blesses him.

In the case of (5), one does indeed have the intuition that the sentence is bad because there is no way to resolve the anaphora and satisfy the uniqueness presuppositions of *he* and *him*, as the E-type analysis would predict. Now let us work out what prediction dynamic theories make about (5), by examining the data in (6).

(6) a. If a bishop meets a nun, he blesses her.

b. If a bishop and a nun meet, he blesses her.

It is characteristic of dynamic theories, as opposed to E-type theories, that they do not make use of any descriptive content in resolving donkey anaphora; for the donkey pronouns in (6b) to be interpreted, it must be necessary that a conjunction of two indefinites as subject of the antecedent of a conditional can establish discourse markers that can be used for the interpretation of pronouns in the consequent. But then it is evident that dynamic theories predict (5) to be grammatical too, since precisely the same configuration is involved. We must conclude, then, that dynamic theories too face a problem of indistinguishable participants.

## 4 A new E-type solution

### 4.1 Situation semantics

As shown by Heim [1], the E-type analysis can profitably be combined with situation semantics. I will assume the lexical entries in (7).

(7)
$[\![\text{bishop}]\!]^g = \lambda u_{\langle s,e\rangle}.\, \lambda s.\, u(s)$ is a bishop in $s$
$[\![\text{blesses}]\!]^g = \lambda u_{\langle s,e\rangle}.\, \lambda v_{\langle s,e\rangle}.\, \lambda s.\, v(s)$ blesses $u(s)$ in $s$
$[\![\text{meets}]\!]^g = \lambda u_{\langle s,e\rangle}.\, \lambda v_{\langle s,e\rangle}.\, \lambda s.\, v(s)$ meets $u(s)$ in $s$
$[\![\text{a}]\!]^g = \lambda f_{\langle\langle s,e\rangle,\langle s,t\rangle\rangle}.\, \lambda g_{\langle\langle s,e\rangle,\langle s,t\rangle\rangle}.\, \lambda s.$ there is an individual $x$ and a situation $s'$ such that $s'$ is a minimal situation such that $s' \leq s$ and $f(\lambda s.x)(s') = 1$, such that there is a situation $s''$ such that $s'' \leq s$ and $s''$ is a minimal situation such that $s' \leq s''$ and $g(\lambda s.x)(s'') = 1$

### 4.2 The transitive cases

(8), from the antecedent in (1), has an LF essentially isomorphic to (9) [11].

(8) a bishop meets a bishop

(9) [[a bishop] [$\lambda_6$ [[a bishop][$\lambda_2$[$t_6$ meets $t_2$]]]]]

The above semantics yields the denotation (10) for (9). The situation structure is shown in (11).

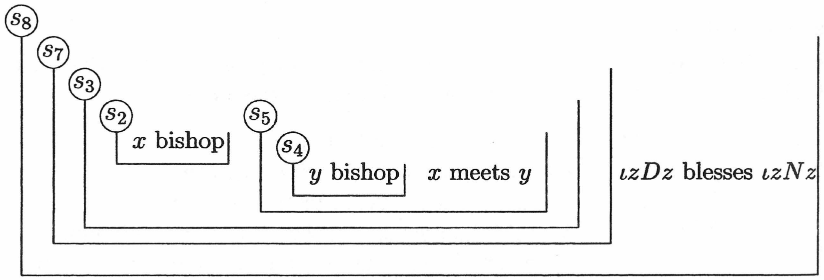
(10) $\lambda s_1$. there is an individual $x$ and a situation $s_2$ such that $s_2$ is a minimal situation such that $s_2 \leq s_1$ and $x$ is a bishop in $s_2$, such that there is a situation $s_3$ such that $s_3 \leq s_1$ and $s_3$ is a minimal situation such that $s_2 \leq s_3$ and: there is an individual $y$ and a situation $s_4$, such that $s_4$ is a minimal situation such that $s_4 \leq s_3$ and $y$ is a bishop in $s_4$, such that there is a situation $s_5$ such that $s_5 \leq s_3$ and $s_5$ is a minimal situation such that $s_4 \leq s_5$ and $x$ meets $y$ in $s_5$.

(11) $[_{s_1}\ [_{s_3} [_{s_2}\ x$ bishop$]\ [_{s_5} [_{s_4}\ y$ bishop$]\ x$ meets $y]]\ ]$

From (11) it is evident that (10) treats $x$ and $y$ differently. For example, $x$ but not $y$ is part of the situation $s_2$. This opens the way, then, for an explanation of the differentiation of the bishops that is necessary for the E-type strategy to analyze this kind of example. For any situation containing two situations $s_2$ and $s_5$, defined as above, call the bishop that appears in $s_2$ the *distinguished* bishop. Suppose that the descriptive content of E-type pronouns can be any property or relation recoverable from the context. Then we can give (1) the semantics in (12). The structure of the situations is in (13).

(12) $\lambda s_6$. for every minimal situation $s_7$ such that $s_7 \leq s_6$ and $[(10)](s_7) = 1$, there is a situation $s_8$ such that $s_8 \leq s_6$ and $s_8$ is a minimal situation such that $s_7 \leq s_8$ and the distinguished bishop in $s_8$ blesses in $s_8$ the non-distinguished bishop in $s_8$.

(13)




Given any actual pair of bishops meeting, there will be two ways of dividing up the relevant individuals, properties and relations into structures like those in $s_7$ in (13): one way will have one bishop in $s_2$, and hence distinguished, and the other will have the other bishop in $s_2$. The truth conditions say that for each situation like $s_7$ the distinguished bishop has to bless the non-distinguished bishop; they correctly predict, then, that when two bishops meet, each will have to bless the other. So E-type theories can handle sentences like (1).



### 4.3 The intransitive cases

This leaves only (5). Since intransitive *meet* must take (functions from situations to) plural individuals [12] as its sole arguments, *and* in (6b) and (5) must mean something like (15), which is an intensionalized version of (14).

(14) $\lambda f_{\langle et,t\rangle}.\lambda g_{\langle et,t\rangle}.\lambda P_{\langle e,t\rangle}.\ \exists x\,(\ f(\lambda y.y \leq_i x) = 1\ \&\ g(\lambda y.y \leq_i x) = 1\ \&\ Px\ )$

(15) $\lambda \mathcal{F}_{\langle\langle se,st\rangle,\langle s,t\rangle\rangle}.\ \lambda \mathcal{G}_{\langle\langle se,st\rangle,\langle s,t\rangle\rangle}.\ \lambda \mathcal{P}_{\langle se,st\rangle}.\ \lambda s.$ there is an individual $x$ and a situation $s'$ such that $s'$ is a minimal situation such that $s' \leq s$ and $\mathcal{F}(\lambda u_{\langle s,e\rangle}.\lambda s'''.\ u(s''') \leq_i x$ in $s''')(s') = 1$ and $\mathcal{G}(\lambda u_{\langle s,e\rangle}.\lambda s'''.\ u(s''') \leq_i x$ in $s''')(s') = 1$, such that there is a situation $s''$ such that $s'' \leq s$ and $s''$ is a minimal situation such that $s' \leq s''$ and $\mathcal{P}(\lambda s'''.x)(s'') = 1$

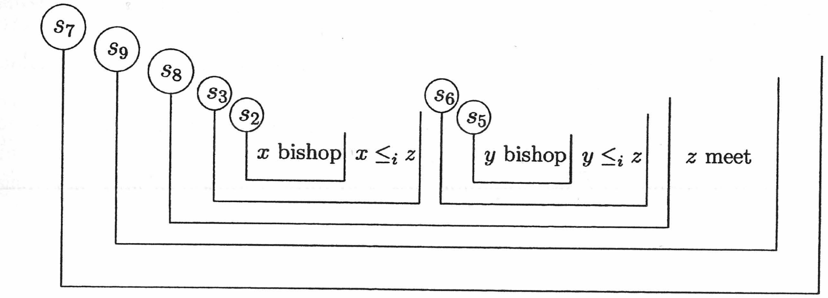
This *and* treats its QP arguments symmetrically, in terms of the situation structure: both merely give information about the makeup of the plural individual, in parallel subsituations of the situation $s'$. The denotation of (16), the antecedent of (5), is (17).

(16) A bishop and a bishop meet.

(17) $\lambda s_7$. there is an individual $z$ and a situation $s_8$ such that $s_8$ is a minimal situation such that $s_8 \leq s_7$ and [there is an individual $x$ and a situation $s_2$ such that $s_2$ is a minimal situation such that $s_2 \leq s_8$ and $x$ is a bishop in $s_2$, such that there is a situation $s_3$ such that $s_3 \leq s_8$ and $s_3$ is a minimal situation such that $s_2 \leq s_3$ and $x \leq_i z$ in $s_3$] and [there is an individual $y$ and a situation $s_5$ such that $s_5$ is a minimal situation such that $s_5 \leq s_8$ and $y$ is a bishop in $s_5$, such that there is a situation $s_6$ such that $s_6 \leq s_8$ and $s_6$ is a minimal situation such that $s_5 \leq s_6$ and $y \leq_i z$ in $s_6$], such that there is a situation $s_9$ such that $s_9 \leq s_7$ and $s_9$ is a minimal situation such that $s_8 \leq s_9$ and $z$ meet in $s_9$

The symmetrical structure of the situations in (17) is shown in (18).

(18)




So the bishops introduced cannot be distinguished, and the E-type analysis correctly predicts that (5) will be ungrammatical.

## 5 Conclusion

We see that the indistinguishable participant data constitute an argument that the E-type analysis of donkey anaphora is empirically superior to the dynamic semantics analysis.

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# Causation and Inertia over Strings

**Tim Fernando***


**Abstract**

Notions of causation and inertia in lexical and temporal semantics are studied relative to a conception of events as strings of observations (e.g. movies). Causation is defined in a temporalized forcing framework, with worlds constructed from generic sets against an inertial background of superposed strings.


## 1 Introduction

Causation and inertia commonly come up in studies of change (e.g. [8], [2], [10]). Typically, change is linked to some cause or other, in the absence of which inertia prevails. The present work analyzes change over finite sequences of observations, formulated as strings. A finite set $\Phi$ of formulae called *fluents* ([8]) is fixed, and strings formed from the alphabet $\mathsf{Pow}(\Phi)$ of sets of fluents. A string $\alpha_1 \cdots \alpha_n \in \mathsf{Pow}(\Phi)^*$ is treated as a movie (or comic strip) that begins with the still (snapshot) $\alpha_1$, followed by $\alpha_2$, and so on, ending with $\alpha_n$. Each fluent in $\alpha_i$ is interpreted to hold at the $i$th observation moment, motivating a *subsumption* relation $\trianglerighteq$ between strings in $\mathsf{Pow}(\Phi)^*$ of equal length given by componentwise containment $\supseteq$

$$\alpha_1 \cdots \alpha_n \trianglerighteq \alpha'_1 \cdots \alpha'_k \quad \text{iff} \quad k = n \text{ and for } 1 \leq i \leq n,\ \alpha_i \supseteq \alpha'_i \ .$$

For variation in lengths as well as observations, we step from strings up to sets of strings — i.e. languages — and extend $\trianglerighteq$ to languages $L, L' \subseteq \mathsf{Pow}(\Phi)^*$, construing the strings in a language as disjunctive possibilities (complementing the conjunction within a still)

$$L \trianglerighteq L' \quad \text{iff} \quad (\forall \mathsf{s} \in L)(\exists \mathsf{s}' \in L')\ \mathsf{s} \trianglerighteq \mathsf{s}' \ .$$

While $\trianglerighteq$ on strings agrees with $\trianglerighteq$ on languages (i.e. $\mathsf{s} \trianglerighteq \mathsf{s}'$ iff $\{\mathsf{s}\} \trianglerighteq \{\mathsf{s}'\}$), there is a danger of confusing symbols with languages and strings that we can reduce by drawing boxes around stills. In particular, let us write $\Box$ for the empty set understood as a still, as opposed to the empty language $\emptyset$ or the null string $\epsilon$. For more complicated languages, let & be the binary operation on languages $L, L' \subseteq \mathsf{Pow}(\Phi)^*$ that *superposes* strings from $L$ and $L'$ of equal length

$$L \& L' \;=\; \bigcup_{n \geq 1} \{(\alpha_1 \cup \alpha'_1) \cdots (\alpha_n \cup \alpha'_n) \mid \alpha_1 \cdots \alpha_n \in L \text{ and } \alpha'_1 \cdots \alpha'_n \in L'\} \ .$$

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The aforementioned disjunctive construal of languages yields

$$L \trianglerighteq L' \quad \text{iff} \quad L \subseteq L\&L' \ .$$

A notion of componentwise consistency is provided by restricting the alphabet to a proper subfamily $\Sigma \subset \mathsf{Pow}(\Phi)$ of *legal stills* such that for every $\alpha \subseteq \Phi$,

$$\alpha \in \Sigma \quad \text{iff} \quad \mathsf{Pow}(\alpha) \subseteq \Sigma$$

and for *no* $\varphi \in \Phi$ does $\boxed{\varphi, \sim\varphi}$ belong to $\Sigma$, where $\sim$ is negation on fluents ([3]).

## 2 Inertia with forces as strings

A fluent $\varphi$ can be described as inertial if whenever it occurs in a string, it persists into the future and back from the past unless some force acts on it. Collecting such forces in a language $F \subseteq \mathsf{Pow}(\Phi)^+$, let us say *$F$ accounts for $\varphi$ in $\alpha_1 \cdots \alpha_n$* if for all $i \in \{1, \ldots, n\}$ such that $\varphi \in \alpha_i$ (i.e. $\alpha_1 \cdots \alpha_n \trianglerighteq \Box^{i-1}\boxed{\varphi}\Box^*$),

(i) if not $\alpha_i \cdots \alpha_n \trianglerighteq \boxed{\varphi}^*$ then for some $\beta_1 \cdots \beta_k \in F$ and $l < i$,

$$\alpha_1 \cdots \alpha_n \trianglerighteq \Box^l \beta_1 \cdots \beta_k \Box^* \quad \text{and} \quad \beta_{i-l} \cdots \beta_k \trianglerighteq \boxed{\varphi}\Box^*\boxed{\sim\varphi}$$

(ii) if not $\alpha_1 \cdots \alpha_i \trianglerighteq \boxed{\varphi}^*$ then for some $\beta_1 \cdots \beta_k \in F$ and $l < i$,

$$\alpha_1 \cdots \alpha_n \trianglerighteq \Box^l \beta_1 \cdots \beta_k \Box^* \quad \text{and} \quad \beta_1 \cdots \beta_{i-l} \trianglerighteq \boxed{\sim\varphi}\Box^*\boxed{\varphi} \ .$$

Given a set $\mathsf{Inr} \subseteq \Phi$ specifying *inertial* fluents, a string $\mathsf{s} \in \mathsf{Pow}(\Phi)^*$, and a language $L \subseteq \mathsf{Pow}(\Phi)^*$, let us write $\mathsf{Inr}(\mathsf{s})$ for the set of inertial fluents occurring in $\mathsf{s}$

$$\mathsf{Inr}(\mathsf{s}) \quad = \quad \{\varphi \in \mathsf{Inr} \mid \mathsf{s} \trianglerighteq \Box^*\boxed{\varphi}\Box^*\}$$

and $\mathsf{Ac}(L, \mathsf{Inr}, F)$ for the set of $(\mathsf{Inr}, F)$-accountable strings in $L$

$$\mathsf{Ac}(L, \mathsf{Inr}, F) \quad = \quad \{\mathsf{s} \in L \mid (\forall \varphi \in \mathsf{Inr}(\mathsf{s}))\ F \text{ accounts for } \varphi \text{ in } \mathsf{s}\} \ .$$

Inertia can be regarded not only as a system of constraints reducing a language $L$ to a fragment $\mathsf{Ac}(L, \mathsf{Inr}, F) \subseteq L$, but also as a generative mechanism. Putting $F$ aside in favor of a notion $\Sigma \subseteq \mathsf{Pow}(\Phi)$ of legal still, inertia builds $L$ up to its closure $i(L; \mathsf{Inr}, \Sigma) \supseteq L$ under the rules

$$\frac{\mathsf{s}\alpha\alpha'\mathsf{s}'}{\mathsf{s}\alpha(\alpha' \cup \boxed{\varphi})\mathsf{s}'}\ \varphi \in \alpha \cap \mathsf{Inr},\ \alpha' \cup \boxed{\varphi} \in \Sigma \qquad \frac{\mathsf{s}\alpha\alpha'\mathsf{s}'}{\mathsf{s}(\alpha \cup \boxed{\varphi})\alpha'\mathsf{s}'}\ \varphi \in \alpha' \cap \mathsf{Inr},\ \alpha \cup \boxed{\varphi} \in \Sigma \ .$$

Now, an example is provided by the Reichenbachian analysis of the perfect ([9]), under a finite-state formulation illustrated by (1),(2).



(1) Pat arrive in Dublin [un-inflected: no tense nor aspect]
$E = \boxed{\sim\text{in}(p,d)}\boxed{\text{arrive}(p,d),\ \text{in}(p,d)}$

(2) PERFECT(Pat arrive in Dublin)

a. $\boxed{\sim\text{in}(p,d)}\boxed{\text{arrive}(p,d),\ \text{in}(p,d)}\Box^*\boxed{R}$

b. $\boxed{\sim\text{in}(p,d)}\boxed{\text{arrive}(p,d),\ \text{in}(p,d)}\boxed{\text{in}(p,d)}^*\boxed{\text{in}(p,d),\ R}$

The idea (developed at length in [5]) is to treat Reichenbach's reference time $R$ as a non-inertial fluent, and to boost the event time $E$ to a language (written as a string in (1), following the common practice of regular expressions). The condition that $E$ precede $R$ for the perfect then becomes

$$\mathsf{Perf}(E, R) \quad = \quad E\Box^*\boxed{R} \ .$$

This corresponds to the existential perfect, as shown in (2a). The resultative perfect, illustrated by (2b), is given by

$$\mathsf{Perf}_{\mathsf{Inr}}(E, R) \quad = \quad \{\alpha_1 \cdots \alpha_k \theta^n (\theta \cup \boxed{R}) \mid \alpha_1 \cdots \alpha_k \in E,\ \theta = \alpha_k \cap \mathsf{Inr},\ n \geq 0\}$$

for a suitable choice of $\mathsf{Inr}$. Clearly, $\mathsf{Perf}_{\emptyset}(E, R) \doteq \mathsf{Perf}(E, R)$. Moreover, suppose we agree to call $L$ $\mathsf{Inr}$-*full* if for all $\mathsf{s} \in L$ and $\varphi \in \mathsf{Inr}(\mathsf{s})$, $\mathsf{s}$ decides $\varphi$ throughout in that

$$\mathsf{s} \trianglerighteq (\boxed{\varphi} + \boxed{\sim\varphi})^*$$

where $+$ is non-deterministic choice. Then

$$\mathsf{Perf}_{\mathsf{Inr}}(E, R) \quad = \quad \mathsf{Ac}(i(\mathsf{Perf}(E, R), \mathsf{Inr}, \Sigma), \mathsf{Inr}, E)$$

assuming $E$ is $\mathsf{Inr}$-full, $R \notin \mathsf{Inr}$, and for all $\alpha \subseteq \Phi - \{R\}$, $\alpha \in \Sigma$ iff $\alpha \cup \boxed{R} \in \Sigma$.

A different example is given by temporal interval modification, illustrated by (3)-(5).

(3) Pat sleep $\Box^*\boxed{\text{sleep}(p)}\Box^*$

(4) two hours $\boxed{0(\tau)}\Box^+\boxed{\text{2hours}(\tau)}$

(5) Pat sleep for two hours

a. $\Box^*\boxed{\text{sleep}(p)}\Box^* \ \& \ \boxed{0(\tau)}\Box^+\boxed{\text{2hours}(\tau)}$

b. $\boxed{0(\tau),\ \text{sleep}(p)}\boxed{\text{sleep}(p)}^+\boxed{\text{2hours}(\tau),\ \text{sleep}(p)}$

The fluent sleep$(p)$ is coerced to the language $\Box^*\boxed{\text{sleep}(p)}\Box^*$ in (3) before it is &-conjoined with the language in (4) for "two hours." Applying inertia to the result (5a) gives (5b), provided sleep$(p) \in \mathsf{Inr}$ and the initial and final stills in (5b) belong to $\Sigma$. More generally, for $\varphi \in \mathsf{Inr}$ and a language $I$ for a temporal interval, we can expect

$$\mathsf{Ac}(i(\Box^*\boxed{\varphi}\Box^* \ \&I, \mathsf{Inr}, \Sigma), \mathsf{Inr}, \emptyset) \quad = \quad \boxed{\varphi}^+ \ \&I \ .$$

This accords with the account of "for"-modification in [4], where a language $L$ coerces to the terminal still

$$\omega_L \quad = \quad \boxed{\varphi \in \Phi \mid L \trianglerighteq \Box^*\boxed{\varphi}} \ .$$

## 3 Implicit information and causation

Next, we fix a set $\mathrm{T{\scriptstyle I}}$ of times, and consider relations $p \subseteq \mathrm{T{\scriptstyle I}} \times \Phi$ with the intuition that

$$p(t, \varphi) \quad \text{iff} \quad \varphi \text{ holds at } t, \text{ says } p\ .$$

Beyond such explicit information, we may distribute implicit information in a background $\mathsf{P} \subseteq \mathsf{Pow}(\mathrm{T{\scriptstyle I}} \times \Phi)$ as follows. Let $\Vdash_{\mathsf{P}}$ be a *forcing relation* with domain $\subseteq \mathsf{P}$,

$$\begin{aligned} p \Vdash_{\mathsf{P}} t, \varphi \quad &\text{iff} \quad p(t,\varphi) \\ p \Vdash_{\mathsf{P}} \neg A \quad &\text{iff} \quad \text{not } (\exists p' \supseteq_{\mathsf{P}} p)\ p' \Vdash_{\mathsf{P}} A \end{aligned}$$

where $\supseteq_{\mathsf{P}}$ is the restriction of $\supseteq$ to $\mathsf{P}$. Leaving open exactly what formulae may occur to the right of $\Vdash_{\mathsf{P}}$, we negate twice to define satisfaction $\models_{\mathsf{P}}$

$$\begin{aligned} p \models_{\mathsf{P}} A \quad &\text{iff} \quad p \Vdash_{\mathsf{P}} \neg\neg A \\ &\text{iff} \quad (\forall p' \supseteq_{\mathsf{P}} p)(\exists p'' \supseteq_{\mathsf{P}} p')\ p'' \Vdash_{\mathsf{P}} A\ . \end{aligned}$$

For properly defined $\Vdash_{\mathsf{P}}$, we can characterize $\models_{\mathsf{P}}$ in terms of certain subsets of $\mathsf{P}$ that are analogous to worlds. A set $\mathsf{G} \subseteq \mathsf{P}$ is $\mathsf{P}$-*generic* if

(i) for all $p \in \mathsf{G}$ and $p' \subseteq_{\mathsf{P}} p$, $p' \in \mathsf{G}$
(ii) for every $A$, there is a $p \in \mathsf{G}$ such that $p \Vdash_{\mathsf{P}} A$ or $p \Vdash_{\mathsf{P}} \neg A$, and
(iii) for all $p, p' \in \mathsf{G}$, $p \frown_{\mathsf{G}} p'$

where we write $p \frown_{\mathsf{G}} p'$ (pronounced: $p$ and $p'$ are $\mathsf{G}$-compatible) to mean that there exists $p'' \in \mathsf{G}$ such that $p'' \supseteq p \cup p'$. A $\mathsf{P}$-generic set $\mathsf{G} \subseteq \mathsf{P}$ induces a model $M[\mathsf{G}]$ such that

$$\begin{aligned} M[\mathsf{G}] \models A \quad &\text{iff} \quad (\exists p \in \mathsf{G})\ p \Vdash_{\mathsf{P}} A \\ p \models_{\mathsf{P}} A \quad &\text{iff} \quad (\forall\ \mathsf{P}\text{-generic } \mathsf{G} \ni p)\ M[\mathsf{G}] \models A \end{aligned}$$

assuming suitable clauses for $\Vdash_{\mathsf{P}}$ (e.g. [6]).

Now, for causation, let us fix also a binary relation $\mathsf{succ}$ on $\mathrm{T{\scriptstyle I}}$, the transitive closure $\mathsf{succ}^+$ of which is irreflexive. Given $p \subseteq \mathrm{T{\scriptstyle I}} \times \Phi$, let $\mathsf{ch}(\mathsf{succ}, p)$ be the set of all finite non-empty sequences $t_1 \cdots t_n$ such that $\mathsf{succ}(t_i, t_{i+1})$ for $1 \le i < n$ and

$$\{t_1, t_n\} \subseteq \mathsf{domain}(p) \subseteq \{t_1, \ldots, t_n\}\ .$$

We call $p$ a *strip* if $\mathsf{ch}(\mathsf{succ}, p) \neq \emptyset$, and write $\mathsf{first}(p)$ for $t_1$ and $\mathsf{last}(p)$ for $t_n$ (which are well-defined since $\mathsf{succ}^+$ is irreflexive). For $t \in \mathrm{T{\scriptstyle I}}$, let $p|t$ be the restriction of $p$ to $t$ and times succ-before it

$$p|t \quad = \quad \{(t', \varphi) \in p \mid t' = t \text{ or } \mathsf{succ}^+(t', t)\}\ .$$

Given a family $\mathsf{P}$ of strips, we say $p$ *causes* $\varphi$ *at* $t$ *against the background* $\mathsf{P}$ if

(i) $p \in \mathsf{P}$ and $\mathsf{succ}^+(\mathsf{first}(p), t)$



(ii) $p \models_{\mathsf{P}} t, \varphi$
(iii) for some $p' \in \mathsf{P}$, $p' \not\models_{\mathsf{P}} t, \varphi$
(iv) for *all* $p' \in \mathsf{P}$, $p \frown_{\mathsf{P}} p'|\mathsf{first}(p)$.

The point behind (iv) is to preclude $p$ from having any effect on $\mathsf{P}$ before $\mathsf{first}(p)$.

## 4 From strips and fluents to strings and languages

Let us fix succ as in the previous section. For $L \subseteq \mathsf{Pow}(\Phi)^*$, a strip $p$ is an *event of type* $L$ — which we write $p : L$ — if $p$ forms a string in $L$ in that

$$\boxed{\varphi \in \Phi \mid p(t_1, \varphi)} \cdots \boxed{\varphi \in \Phi \mid p(t_n, \varphi)} \quad \in \quad L$$

for some $t_1 \cdots t_n \in \mathsf{ch}(\mathsf{succ}, p)$. We say $L$ *causes* $\varphi$ *at* $t$ *against the background* $\mathsf{P}$ if every $p \in \mathsf{P}$ that is an event of type $L$ does. Next, we replace the fluent $\varphi$ by a language $L$. Towards that end, let us fix a function cb that maps $(p, t) \in \mathsf{Pow}(\mathrm{T{\scriptstyle I}} \times \Phi) \times \mathrm{T{\scriptstyle I}}$ to a set $\mathsf{cb}(p, t) \subseteq \mathsf{Pow}(\mathrm{T{\scriptstyle I}} \times \Phi)$ of *t-continuation branches of* $p$, and then relativize $:$ to cb by existential quantification

$$p :_{\mathsf{cb}} L, t \quad \text{iff} \quad p(t, R) \text{ and } (\exists p' \in \mathsf{cb}(p,t))\ p' : L$$

(recalling that $R \in \Phi - \mathsf{Inr}$ is Reichenbach's reference time). The term "continuation branch" is borrowed from [7], and the function cb adapted from the modal base function [1] applies for a temporal interpretation of might, with strips in place of worlds. As in [1], we build *historical necessity* ([11]) into the continuation branches, requiring that every element of $\mathsf{cb}(p, t)$ agree with $p$ at $t$ and times succ-before $t$ —

(c1) for all $p' \in \mathsf{cb}(p, t)$, $p|t = p'|t$.

A second condition, (c2), says $p$ may continue —

(c2) $p \in \mathsf{cb}(p, t)$.

Now, instead of $p \Vdash_{\mathsf{P}} t, \varphi$ from the previous section, we set

$$p \Vdash_{\mathsf{P}} t, L \quad \text{iff} \quad (\exists p' \subseteq p)\ p' :_{\mathsf{cb}} L, t$$

so that we can define $L'$ *causes* $L$ *at* $t$ *against the background* $\mathsf{P}$ by putting $L$ in place of $\varphi$ in "$L'$ causes $\varphi$ at $t$ against the background $\mathsf{P}$."

Let us close by turning our attention to backgrounds $\mathsf{P}$ for causation. We might construct $\mathsf{P}$ inertially from a set $\mathcal{L}$ of languages over the alphabet $\mathsf{Pow}(\Phi)$ as follows. Let

$$L_{\mathcal{L}} \quad = \quad \bigcup \{ \bigwedge \mathbf{L} \mid \mathbf{L} \text{ is a non-repeating string over the alphabet } \mathcal{L} \}$$

where $\bigwedge$ is a function from strings $\mathbf{L}$ of languages defined inductively by

$$\begin{aligned} \bigwedge \epsilon \quad &= \quad \Box^+ \\ \bigwedge (\mathbf{L} L) \quad &= \quad (\bigwedge \mathbf{L})\ \&\ \Box^* L \Box^*\ . \end{aligned}$$

We then form P from events of type

$$\{s \mid (\exists s' \in \mathsf{Ac}(i(L_{\mathcal{L}}; \mathsf{Inr}, \Sigma), \mathsf{Inr}, \bigcup \mathcal{L}))\ s' \trianglerighteq s\}$$

(as defined in section 2). We may assume that $\Phi$ contains finitely many formulae $\mathsf{time}(t)$ with $t \in \mathrm{T}_{\mathrm{I}}$, and require that for all $p \in \mathsf{P}$ and $t, t' \in \mathrm{T}_{\mathrm{I}}$,

$$p(t, \mathsf{time}(t')) \quad \text{implies} \quad t = t'$$

— a constraint that invites us to regard strips as particular strings over the alphabet $\mathsf{Pow}(\Phi \cup \{\mathsf{time}(t) \mid t \in \mathrm{T}_{\mathrm{I}}\})$.

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# EVEN and negative bias in questions revisited

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**Abstract**

This paper discusses three Greek lexical items meaning EVEN in polar questions, focusing on the issue of negative bias. It is shown that negative bias does not arise with positive EVEN (a fact undermining the viability of proposals that rely on this option), or NPI EVEN, but only with what is identified as *flexible-scale* EVEN. The discussion has two implications. First, it provides an argument for lexical ambiguity of *even*. Second, it offers a novel way to reconcile the fact that strong polarity items (PIs) create negative bias, but *any* doesn't, by arguing that only strong PIs contain the flexible-scale EVEN.


## 1 The problems: *even* and polarity items in questions

It is well-known that PIs of various kinds appear in questions:

(1) a Does Beatrix speak any foreign language?
b Did Beatrix lift a finger to help?

(2) Beatrix didn't lift a finger to help.

PIs like *any* are known as *weak* because they appear widely in downward entailing and (possibly upward entailing or non-monotone) nonveridical contexts; minimizers are *strong* PIs, licensed only in a proper subset of *any* contexts— typically with negation (2). Polar questions are not negative in any obvious way, but the difference between weak and strong PIs surfaces as a contrast in what counts as expected answer: (1a) is a neutral question having as its answer set A ={Beatrix speaks a foreign language, Beatrix doesn't speak a foreign language}; but (1b) exhibits negative bias: the negative proposition in A is strongly expected. The bias is a conversational implicature: we can still answer (1b) as *Well, in fact she did.* This 'negativity' accompanies minimizers in other polarity contexts, e.g. conditionals: *If you say a word, I'll kill you;* and it is a corsslinguistic fact (see Vallduvi 1994 for Spanish and Catalan, Giannakidou 1997, 1999 for Greek), though minimizers in these languages have a much narrower distribution than in English (see section 2).

*Even* is also known to exhibit negative bias in questions (Karttunen and Peters (K&P) 1979, Ladusaw 1980, Wilkinson 1996, Guerzoni 2002):

(3) Have you talked to him even once?

The expected answer here is negative. The parallel between *even* and (1b) inspired the claim (Linebarger 1980, Heim 1984) that PIs that produce negative bias, do so because they contain a silent *even*. (Thus *any* does not contain *even*, *pace* Lee and

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Horn 1994 who argue that it does). The idea is supported by the fact that crosslinguistically, an overt *even* may occur with minimizers, e.g. in Catalan, Spanish (Vallduvi 1994; Herburger 2003), or Greek:

| | | | | |
|---|---|---|---|---|
| (4) | a | No va dir | *(**ni**) paraula en tota la tarda. | Catalan |
| | b | No dijo | (**ni**) palabra en toda la tarde. | Spanish |
| | | He did not say | even a word all evening | |
| | c | Ipe | (**esto ke**) mia leksi oli nixta? | Greek |
| | | Did he say | (even) one word all night? | |

Note that EVEN is obligatory in Catalan, but optional in Greek/Spanish. This set of data support a link between *even* and minimizers; but there are two problems with this connection. First, it is not obvious how the negative bias follows from the ordinary contribution of *even* in the absence of overt negation.

(5) The Dean invited **even** Bill.

(6) i. $\exists x\ [x \neq \text{Bill} \wedge C(x) \wedge \text{invited (Dean, x)}]$, and
ii. $\forall x[x \neq \text{Bill} \rightarrow \text{likelihood (D. inviting x)} > \text{likelihood (D. inviting B.)}]$

The sentence asserts that the Dean invited Bill. *Even* introduces a set of focus alternatives, and a scalar presupposition: that the value of *even* is at the bottom of a likelihood scale (K&P; likelihood is a Horn possibility scale). As Ladusaw 1980 and Wilkinson 1996 admit, this presupposition alone cannot predict negativity.

Second, languages that allow their EVEN to appear in minimizers contain at least two EVEN-items, one of which is used in positive sentences like (5), and the other behaves itself as a PI: Spanish and Catalan *ni*, e.g., is a negative PI (NPI) (Herburger 2003), and as we see below, Greek *esto* is a PI too (albeit of the weaker type). This fact supports Rooth's (1985) ambiguity analysis of *even*.

## 2 Greek EVEN

At this point, it will be useful to consider Greek, which distinguishes three EVENs:

| | | | | | |
|---|---|---|---|---|---|
| (7) | a | I Maria efaje | **akomi ke** | to pagoto. | (positive EVEN) |
| | b | *I Maria efaje | **oute (kan)** | to pagoto. | (NPI-EVEN) |
| | c | ??I Maria efaje | **esto (ke)** to pagoto. | | (*other* EVEN) |
| | | the Maria ate.3sg | even (and) | the ice cream | |

*Oute (kan)* and *esto* are bad in positive sentences; they are thus PIs. (The optionally appearing *kan* is also a PI; Giannakidou 2003). Recall that it is *esto* that appears with minimizers in questions (4b) yielding bias. With negation, *oute* is good, but *esto* remains awkward (for reasons discussed in Giannakidou 2003, carrying over to *akomi ke* which can also be odd with negation). *Esto* improves in other nonveridical environments: e.g. questions, imperatives, conditionals, and with modal verbs (see Giannakidou 2003 for details).



| | | | | |
|---|---|---|---|---|
| (8) | a | ??I Maria dhen efaje | **esto (ke)** to pagoto. | |
| | b | I Maria dhen efaje | **oute (kan)** | to pagoto. |
| | | the Maria didn't eat.3sg | even | the ice cream |

*Oute* is thus an NPI proper. Following the pattern of other Greek NPIs, *oute* is only admitted in negative contexts (negation and *without*; see Giannakidou 1997, 2003 for discussion), and only then can it combine with minimizers:

| | | |
|---|---|---|
| (9) | Dhen ipe | **oute mia** leksi. |
| | He didn't say | even one word. |

Comparable items, as I mentioned earlier, are the Spanish/Catalan *ni, ni siquiera* which are also typically licensed with negation; recall (4a,b). Crucially, the scope theory (K&P, Wilkinson 1996, Guerzoni 2002) would have to move these EVENs, and *even* in (9) above, over negation— conflicting thereby with the standard position that the minimizer scopes *inside* the scope of negation.

Without negation, e.g. in positive questions, *ni* and *oute* are out:

| | | | | |
|---|---|---|---|---|
| (10) | a | *Ipe | **oute mia** leksi? | (Greek) |
| | | Did he say | even one word? | |
| | b | *Va dir | **ni** paraula en tota la tarda? | (Catalan) |
| | c | *Dijo | (**ni**) palabra en toda la tarde? | (Spanish) |

The ungrammaticality follows from the fact that *oute* and *ni* are NPIs proper.

I propose the following meanings for the positive and NPI EVEN:

(11) $[\![$ **akomi ke** $]\!]$: $\lambda x\ \lambda P$: $\exists y\ [y \neq x \wedge C(y) \wedge P(y)] \wedge \forall y\ [y \neq x \rightarrow \text{likelihood (P(y))} > \text{likelihood (P(x))}].\ P(x)$ (positive EVEN)

(12) $[\![$ **oute (kan)** $]\!]$ = $\lambda x\ \lambda P$: $\exists y\ [y \neq x \wedge C(y) \wedge \neg P(y)] \wedge \forall y\ [y \neq x\ (\text{likelihood (P (x))} > \text{likelihood (P(y))}].\ P(x)$ (NPI-EVEN)

These reflect the analyses of K&P, and Rooth's for NPI-*even*: NPI-*even* has a negative existential presupposition and associates with the most likely element. *Esto*, on the other hand, does not come with a fixed scale but depends on the context to provide it. Apart from this difference, the ordering imposed is that of positive EVEN, and *esto* associates with the low endpoint:

(13) $[\![$ **esto** $]\!]$ = $\lambda x\ \lambda P$: $\exists y\ [y \neq x \wedge C(y) \wedge \neg P(y)] \wedge \exists \mathbf{Q}_{scalar}\ [C(\mathbf{Q}) \wedge \forall y\ [y \neq x \rightarrow \mathbf{Q}(y) > \mathbf{Q}(x)]].\ P(x)$ (*flexible scale* EVEN)

*Esto* combines the negative existential presupposition of NPI-*even* with the low scalar one of positive *akomi ke* on a variable scale. This is the key to understanding its behavior in questions. Greek appears to be uncommon among the languages that have polarity EVENs (Dutch, German, Spanish, Catalan) in allowing this item.

### 3 Negative bias in questions explained

Consider first the presuppositions of *akomi ke* and *esto* in a nonveridical sentence:

(14) a Na lisis **esto to provlima 1.** (Pr. 1 is the easiest)
b Na lisis **akomi ke to Provlima 1.** (Pr. 1 is the hardest)
(Please) solve even Problem 1.

(15) $\exists$x [x $\neq$ Problem 1 $\wedge$ C (x) $\wedge$ $\neg$ (you solve x)] $\wedge$ $\forall$x [x $\neq$ Problem 1 $\rightarrow$ **difficult** (x) > **difficult** (Problem 1)] (*esto*)

Here *esto* ranks alternatives on a difficulty scale. The sentence presupposes a context in which the speaker considers Problem 1 to be the least difficult one. Of course, the least difficult problem is the easiest one, hence the flavor of easiness that Problem 1 acquires. *Akomi ke,* on the other hand, produces the opposite effect: now Problem 1 seems to be the hardest.

(16) $\exists$x [x $\neq$ Problem 1 $\wedge$ C(x) $\wedge$solve (you, x)] $\wedge$ $\forall$x [x $\neq$Problem 1$\rightarrow$ **likelihood** (you solving x) > **likelihood** (you solving Problem 1)

Here, we have excess of problem solving: *in-addition-to* other problems, the addressee is asked to solve *also* the least likely problem, which normally is the most difficult one. Hence, the contrast with *esto* in terms of the status of Problem 1 is due to the fact that likelihood and difficulty have reverse entailments.

In polarity contexts, then, *esto* and *akomi ke* exhibit these distinct readings, which also produce different interpretations in questions:

(17) a Tu exis milisi **esto ke mia** fora?
b * Tu exis milisi **oute kan mia** fora?
c ??Tu exis milisi **akomi ke mia** fora?
Have you talked to him even once? Expected biased answer: No.

NPI *oute* is out because there is no negation to license it. Interestingly, *akomi ke* is also out with low-frequency *once*— an expected fact in our account: the low likelihood of *akomi ke* conflicts with the high likelihood of ONE, since ONE is the weakest, hence the most likely predicate (it is entailed by any other cardinality):

(18) $\exists$n [n $\neq$ **once** $\wedge$ C(n) $\wedge$ you talked to him (n)] $\wedge$ $\forall$n [n $\neq$ **once** $\rightarrow$ likelihood (talking to him n times)) > likelihood (talking to him **once**)]

Generally, then, the combination of positive EVEN with inherently high likelihood items is predicted to be problematic.

(19) ?? Boris na prosthesis **akomi ke 1 + 1**? 'Can you add even 1+1?'
(This addition is the easiest one to do, hence the MOST likely).



But *esto* is fine high likelihood, as long as it scores low on the context scale, e.g. frequency in the case of (17a):

(20) $\exists$n [C(n) $\wedge$ n $\neq$ **once** $\wedge\neg$ (you talked to him n times)] $\wedge$ $\forall$n [ n $\neq$ **once** $\rightarrow$ **frequent** (n-times) > **frequent** (once)]

(21) Boris na prosthesis **esto 1 + 1**? 'Can you add even 1+1?'
(This addition is the least difficult one to do).

Note the contrast in (21) and (19) with *akomi ke*, which was bad. Here 1+1 is the least difficult addition, and *esto* is fully compatible with it, conveying negative bias.

With predicates of variable likelihood, both *esto* and *akomi ke* are fine:

(22) a Elises **esto to Provlima 1**? (Problem 1 is the easiest)
Did you solve even (at least) Problem 1?
b Elises **akomi ke to Provlima 1**?(Problem 1 is the hardest)
Did you solve even (in addition to) Problem 1?

*Akomi ke* in (22b) has only the expected *in-addition-to* reading:

(23) $\exists$x [x $\neq$ **Problem 1** $\wedge$ you solved x] $\wedge$ $\forall$x [x $\neq$ **Problem 1** $\rightarrow$ **likelihood** (you solve x) > **likelihood** (you solve Problem 1)]
= Problem 1 is the least likely one to solve, hence the most difficult one.

This presupposition does not create negative bias: the speaker assumes that other problems were solved. Additionally, because *akomi ke* must pick out the least likely element, Problem 1 must be the hardest one. This describes correctly the conditions under which a polar question with *akomi ke* can be used. In (22a) with *esto*, on the other hand, we have the following presupposition:

(24) $\exists$x [ x $\neq$ **Problem 1** $\wedge$ $\neg$ (you solved x)] $\wedge$
$\forall$x [x $\neq$ **Problem 1** $\rightarrow$ **difficult** (x) > **difficult** (Problem 1)] (*esto*)

This presupposition creates negative bias: the speaker assumes that there are other problems besides Problem 1 that were not solved; and if Problem 1 is the least difficult one, then the question is about whether *at least* the least difficult problem is solved, hence the bias. So, Guerzoni's 2002 criticism— "the choice of PI-even [...] does not predict the affirmative answers to be infelicitous"— is in fact exactly what our account predicts: affirmative answers should be infelicitous (though not impossible) with the presupposition of *esto*.

### 4 Conclusion

The behavior of EVEN-items in questions was shown to support lexical ambiguity for English *even* between *esto* (at least) and *akomi ke* (in addition to). It is hard to see how the scope theory would cope with these data: if we tried to make positive and NPI-*even* equivalent in questions (as in Guerzoni 2002) we would be off the point, because NPI-EVEN is ungrammatical in questions; and we would still have not eliminated the possibility that negative bias yielding *even* is *esto*, which indeed seems to be the case. What consequences does this have for the analysis of strong PIs that have been argued to contain *even*? The obvious conclusion seems to be that the relevant *even* can only have the presuppositions of *esto*. Hence we can recast the idea that *any* is an indefinite plus *even* (Lee and Horn 1994) as a claim that *any* doesn't contain *esto*, since it does not license negative bias, but it does contain another *even*. Could that be the NPI-EVEN? Most probably not, because NPI-EVEN, as we saw, is not licensed in questions. Can it be the positive one? The answer could be yes, but then we need to address the issue of negation because, as I mentioned, positive *even*, unlike *any*, can be odd with negation.

**Acknowledgement**
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# Modal Scorekeeping and 'Might'-counterfactuals

**Anthony S. Gillies***

## 1 Two Little Puzzles about Counterfactuals

You are watching Euro 2004. The Dutch side needs a win on its final day of group play to advance. It is the 90th minute. Just then Davids plays a brilliant ball through the defense to a streaking Kluivert. The keeper is badly out of position, and the crowd roars. But, sadly, Kluivert is held by a defender (though the officials miss this obvious infraction) and the ball rolls harmlessly over the end line. The match ends a second later in a draw, and the Dutch are eliminated. The following fairly characterizes the views of the Dutch fans:

(1) If Kluivert had not been held, then the Dutch would have won the match.

And, to my ears, this sounds like as clear an example of a contingently true, flat-footed, counterfactual as there can be.[1] But, a bothersome English fan speaks up:

(2) If Kluivert had not been held, then he *might* have misplayed it and shot well wide of the mark.

We devoted Dutch fans may protest at this point, insisting that Kluivert misplays very few breakaway chances (these days at least). But our English fan has a ready reply: she is not asking us to agree that had Kluivert not been held he would *not* have scored; she is asking us to agree that had Kluivert not been held he *might* not have scored. Kluivert's goal-scoring prowess notwithstanding, it seems a little much to deny our English fan on this point. Danger lurks nearby, for if we grant that, then it looks inescapabale that we must also grant that

(3) If Kluivert had not been held, then the Dutch (still) might have lost.

And, given this admission, our commitment to (1) starts to look pretty bad since

(4) If Kluivert had not been held, then the Dutch (still) might have lost the match; but nevertheless, if Kluivert had not been held, then the Dutch would have won the match.

sounds like a flat contradiction. So we have the option of hedging our commitment to (1), denying (3), or denying that (4) really is as bad as it sounds. This is the first little puzzle.[2]

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1. A non-flat-footed counterfactual has a hedge, typically a probabilitistic or quasi-probabilistic hedge, as part of the content of the conditional's consequent, as in "If $\phi$ had been the case, $\psi$ would likely (probably, etc.) have been the case". Flat-footed counterfactuals are just those are not non-flat-footed.

2. See [1].

The second little puzzle is more programmatic. Suppose you are moved by the simple elegance of the Update Semantics (US) [10] account of epistemic modals like **might**, according to which updating a state (a set of possible worlds) with **might** $\phi$ returns either all or none of the input state: all if $\phi$ is not already ruled out in the input, and none if it is. It is this test behavior of the modalities that makes this simple semantics dynamic: it makes for a non-distributive interpretation function over the set of information states.

We can tell a similar "test-like" story for (simple, non-nested) counterfactual conditionals. The basic idea is easy enough: the update of a state with a counterfactual **If had been** $\phi$**, then would have been** $\psi$ returns either all or none of the input state: all if the input minimally changed to support $\phi$ also supports $\psi$, none if it doesn't. Similarly for the dual, 'might'-counterfactual **If had been** $\phi$**, then might have been** $\psi$. Just as in the case with **might**, there is no tolerance for test failure. Call such tests which are unforgiving in this way *non-accommodating tests.* This picture of counterfactuals might then be called a Non-Accommodating Ramsey Test analysis.

But for all of its intuitiveness, elegance, and squaring with linguistic data, the non-accommodating test thesis about modals (and so about modalized conditionals) is also at odds with the cardinal rule of competent linguistic interpretation: interpret what is said so that it makes sense to have said it. For if we suppose, following Lewis [7], that successful utterances of relative modality claims—in particular, the existential modals—come ready-made with a rule of accommodation which shifts the boundary between the relevant and the irrelevant possibilities in order to make such utterances acceptable, then any non-accommodating test behavior of those modals is ruled out immediately. There is something semantically distinctive about discourses like

(5) a. If John had come to the party last night, he would have had fun;
b. but, of course, if John had come to the party last night, he might have had a massive coronary in which case he would not have had fun.

But this distinctiveness is not of the $p \wedge \neg p$ variety. In the case of (5), hearers naturally accommodate upon interpreting the consequent of the second conditional, shifting the boundary outward on what worlds are relevant so that it makes sense to have said what was said. So the second little puzzle is this: how can we make accommodation fit together—both in the case of unary modalities and in the case of counterfactuals—in a more or less seamless way with a US picture of the semantics of modals?

## 2 Plan

The plan is to attack these puzzles in reverse order, hopefully ending up with something like a start to a unified solution. The basic strategy I want to pursue is this: incorporate a rule of accommodation for relative modality statements—in particular, for the counterfactual or subjunctive or metaphysical unary modalities—into an update semantics and to exploit the resulting analysis in shedding some light on the behavior of 'might'-counterfactuals.

For the point I want to make here, virtually any vaguely Ramsey-inspired account of counterfactuals will do as a starting point, since I want to emphasize how modifying the story just a bit to allow for Accommodating Tests affects the status of our little puzzles about counterfactuals. One natural idea is very Kratzer-esque: **If** $\phi$



**had been the case,** $\psi$ **might have been the case** is a bare sort of conditional constuction with modalized elements in both the antecedent and consequent. The antecedent tests the modal horizon to make sure it is possible, and then we hypothetically restrict the horizon (thus shifted, if need be) to the antecedent worlds. Then we perform an accommodating test on the **might have been** ... in the conditional's consequent. If the test is successful (as it is almost always bound to be), we collect up the worlds in the modal horizon thus changed as the output state.

The first step in the plan will be to get clear on accommodating tests in the unary case. This will prove to be enough trouble that we will at best only get to see a parting gesture at how the story with them can be naturally extended to fulfill the promises of this sketch.[3] I should disclose at the outset that this really is meant to be merely a sketch of a larger project: I am here interested in the interaction between one particular parameter of conversational score—roughly, what von Fintel [2] calls the *modal horizon*—and subjunctive modalities. So I will largely be suppressing and ignoring other issues.

## 3 Accommodating Tests

Where $\phi$ is a formula of propositional logic (PL), let $\Diamond\phi$ formalize **It might have been that** $\phi$, where this 'might have been' is understood in its non-epistemic sense (i.e., the sense according to which it is fully compatible with $\neg\phi$). I don't really want to label this an expression of *metaphysical* possibility, since we tend to think of what is metaphysically possible as a rather fixed and broad category. I would prefer to say that it is an expression of of what might be the case in virtue of what is true at the worlds in $X$, where: (1) the worlds compatible with what is known are included in $X$, (2) there is no presumption that this inclusion is not proper, and (3) the context restricts $X$ in determinate ways from there. The broad notion of metaphysical possibility would then be a special case. Similarly, $\Box\phi$ will formalize the slightly less natural **It would have been** .... In the conditional constructions to be considered, $\Box\!\!\rightarrow$ and $\Diamond\!\!\rightarrow$ will be the 'would'-counterfactual and the 'might'-counterfactual, respectively. Officially: let $\mathcal{L}$ be the minimal set including PL such that if $\phi \in$ PL, then $\Diamond\phi, \neg\Diamond\phi \in$ PL. $\Box\phi$ can then be introduced in the usual way.

Meanings of formulas in $\mathcal{L}$ will be functions from information states to information states. The basic idea is that information states carry modal as well as factual information. Some of the modal information is *ordering information* and some of the modal information is *relevance information.* We can represent it thusly. Fix a (finite) space of worlds $W$. An agent's information state $\sigma$ encodes her factual information in a set of worlds not yet ruled out by those plain facts. This is the *factual background* $s$ in $\sigma$. $\sigma$ also encodes a boundary—the line between the worlds relevant for the evaluation of the modal claim, and those which are not. Formally, this is just a subset $m$ of $W$ which includes $s$. This is the *modal horizon* of a state $\sigma$. Finally, there is the ordering information. There is an interplay between factual backgrounds and ordering information which I will assume, but not explore further: the facts an agent has determines, at least in part, an ordering of relative proximity centered around those facts. Rather than say how this goes, we can just acknowledge the dependence by putting restrictions on how the ordering information must relate to the background. As follows: For each $\sigma$ with factual background $s$ and horizon $m$ we assume a system of spheres $\mathfrak{S}_s$ centered on $s$ such that (1) $\mathfrak{S}_s$ is a

3. The sketch will not be unlike a kripkean outline.

set of $\subseteq$-nested subsets of $W$, (2) $s$ and $W$ are the smallest and largest such sets, respectively, (3) $m \in \mathfrak{S}_s$, and (4) for any $\phi$ there is a smallest $\phi$-permitting set. Such systems of spheres are a generalization of the Lewisian sort.

The key to accommodating tests is that upon interpretation, the modal horizon flexes outward if need be to make it sensible to say the relevant modal. And it is with respect to the modal horizon thus shifted that the formula is then evaluated. But, of course, such outward flexing is only going to help in the case of existential modals, not universals. And such outward shifts should be sensibly constrained. Before defining the update function on the positive modalities (i.e., formulas in the modal fragment with no leading negations), we need one auxiliary definition. We will need another intermediate step when we turn to interpreting formulas with leading negations in the modal fragment. The first is just a way of constraining the shifts. The second is a way of recovering a non-accommodating test profile for the purposes of negation. The idea being that, although it is almost always acceptable to say something of the form It might have been that $\phi$, that by itself does not make it hard to say its negation.

**Definition 1.** Consider a state $\sigma$ with ordering $\mathfrak{S}_s$ and modal horizon $m$. For any $\phi \in$ PL, define:

1. $m\langle\phi\rangle$ is the smallest set $X$ in $\mathfrak{S}_s$ such that $m \subseteq X$ and $X \cap [\![\phi]\!] \neq \emptyset$.
2. $m[\Diamond\phi] = \{w \in m\langle\phi\rangle : m\langle\phi\rangle \cap [\![\phi]\!] \neq \emptyset\}$.

So updating the horizon with $\Diamond\phi$ tests the horizon for some $\phi$-worlds; but if that test were bound to fail, then it tests not the input horizon $m$ but the horizon $m\langle\phi\rangle$. As a result, if $[\![\phi]\!] \neq \emptyset$ then $m[\Diamond\phi] \neq \emptyset$. And this goes some way in explaining the intuition that it is surprisingly difficult to say something of the form It might have been that $\phi$ which isn't bound to be felicitous.

Negation should not be as permissive as this, though. So I want negation to act as a barrier to accommodating test failure in the modal fragment.

**Definition 2.** Call a formula *positive* iff it has no leading negations. Consider a state $\sigma$ with modal horizon $m$. Given any positive $\phi \in \mathcal{L}$ let $m[\phi] = m'$. Let $x \subseteq W$, and define:

$$\downarrow_x(m[\phi]) = \{w \in m' \cap x : (m' \cap x)[\phi] = m' \cap x\}.$$

As a special case, $\downarrow_m(m[\phi]) = \{w \in m' \cap m : (m' \cap m)[\phi] = m' \cap m\}$.

The effect of $\downarrow_m$ on a state $m[\phi]$ is to retrieve the non-accommodating update profile of $[\phi]$. If $m \subseteq m'$ (as, e.g., when $\phi = \Diamond p$), then this construction reduces further still: $\downarrow_m(m[\phi]) = \{w \in m : m[\phi] = m\}$. We are now in a position to define the update behavior of negation: it is just going to be set subtraction, except that it is the non-accommodating profile which gets involved.

**Definition 3.** Consider a state $\sigma$ with ordering $\mathfrak{S}_s$ and modal horizon $m$. For any positive $\phi \in \mathcal{L}$, define:

$$m[\neg\phi] = m \setminus \downarrow_m(m[\phi]).$$

It is then easy to see that $\Box\phi$, introduced as an abbreviation for $\neg\Diamond\neg\phi$, has just the update profile that it would normally have in an US:

**Proposition 1.** *For any modal horizon m and any $\phi \in$ PL:*

$$m[\Box\phi] = \{w \in m : m \cap [\![\phi]\!] = m\}.$$



## 4 Basic Properties of Accommodating Tests

Before gesturing at how such accommodating tests for the non-epistemic modals might be put to work in the case of counterfactuals, we first need to explore some of their basic properties, and see their associated concepts of support, entailment, and the like.

It turns out that $[\Diamond\phi]$ is equivalent to a particular kind of contraction operation in belief dynamics.

**Definition 4.** Given a set $K \subseteq$ PL such that $K = \text{Cn}(K)$, let $\leq$ be a transitive ordering of over the language PL such that:

1. If $\psi \in \text{Cn}(\{\phi\})$, then $\phi \leq \psi$.
2. $\phi \leq \phi \wedge \psi$ or $\psi \leq \phi \wedge \psi$.
3. If $K \neq$ PL, then $\phi \leq \psi$ for every $\psi \in$ PL iff $\phi \notin K$.
4. If $\phi \leq \psi$ for every $\psi \in$ PL, then $\phi \in \text{Cn}(\emptyset)$.

Such an ordering is an ordering of *entrenchment.* If $\leq$ is faithful to $\mathfrak{S}_s$ (i.e., if $\phi \leq \psi$ iff the the innermost $\phi$-permitting sphere contains the innermost $\psi$-permitting sphere), then $\leq$ is *based on* $\mathfrak{S}_s$. The *severe withdrawal* of $\phi \in$ PL from $K$ is defined as follows, where we assume $[\![\phi]\!] \neq \emptyset$:

$$K \sim \phi = \begin{cases} K \cap \{\psi \in \text{PL} : \phi < \psi\} & \text{if } \phi \in K \\ K & \text{otherwise.} \end{cases}$$

**Proposition 2.** *Consider a state $\sigma$ with ordering information $\mathfrak{S}_s$ and horizon m. Let* $\text{Th}(m) = \{\phi \in \text{PL} : m \subseteq [\![\phi]\!]\}$. *Then:*

1. $m[\Diamond\phi] \subseteq [\![\psi]\!]$ *iff, for $\leq$ based on $\mathfrak{S}_s$, $\psi \in (\text{Th}(m) \sim \neg\phi)$.*
2. $[\Diamond\phi]$ *is revision equivalent to an AGM contraction function—i.e.,* $m[\Diamond\phi] \cap [\![\phi]\!] = (m \ominus \phi) \cap [\![\phi]\!]$, *where $\ominus$ is a sphere-based transitively relational contraction function for m based on $\mathfrak{S}_s$.*

Support (or, if you prefer, truth-with-respect-to-a-horizon) is defined as a fixed-point, and entailment as an update-to-test consequence relation. In order to ensure definedness, we need to stipulate that for a formula $\phi \in$ PL and any horizon $m$, $m[\phi] = m \cap [\![\phi]\!]$.

**Definition 5.** Let $\sigma$ be any information state with ordering $\mathfrak{S}_s$ and modal horizon $m$, and consider any $\phi, \psi \in \mathcal{L}$.

1. $m \models \phi$ iff $m[\phi] = m$.
2. $\phi \models \psi$ iff for any $m$: $m[\phi] \models \psi$.

Sequences of formulas—in particular, sequences of *modal* formulas—can also be the bearer interesting semantic properties. Of particular interest to me is that we can naturally locate three grades of semantic markedness along the modal horizon:

**Definition 6.** Let $\phi; \psi$ be a sequence of modal formulas of $\mathcal{L}$.

1. $\phi; \psi$ is *consistent* iff there is a horizon $m \neq \emptyset$ such that $m[\phi][\psi] \neq \emptyset$.
2. $\phi; \psi$ is *coherent* iff there is a horizon $m \neq \emptyset$ such that $\emptyset \neq m[\phi][\psi] \subseteq m$.
3. $\phi; \psi$ is *cohesive* iff there is a horizon $m \neq \emptyset$ such that $m[\phi][\psi] = m$.

**Proposition 3.** *$\phi; \psi$ is cohesive only if coherent only if consistent.*

## 5 A Glimpse at Counterfactuals

I find the sketch above for turning our story about accommodating tests into a story about the update profiles of counterfactuals to be rather intuitive. But extending the story as we have told it up to now does require a bit of care, formally speaking.

But the kernel of the story is already present in what we have before us, and I suggest that that may be useful enough to say, at least in a preliminary fashion, what is going on with our first little puzzle.

Suppose (1) is accepted in a particular information state. Updating that state with the counterfactual produces no change in the modal horizon. So, intuitively speaking, the Kluivert is not held-worlds in that horizon are also a fixed-point of an update with It would have been that the Dutch won. Equivalently: all of the Kluivert is not held-worlds in that horizon are included in the Dutch win-worlds. Now, when we update with (2), a funny thing happens: when we test the horizon restricted to the Kluivert is not held-worlds with Kluivert might have misplayed it and shot wide, this modal buried in the consequent requires accommodating. And once we shift the horizon in this way (3) is supported. (4) sounds bad because it is an inconsistent sequence. (2) entails (3), so given (2), commitment to (1) is not an option. But, and this is the important point, this does not jeopardize (1) in the context as it was when we accepted it. The sequence (1);(2) is coherent, so (2) doesn't contradict (1). But it is not a cohesive sequence, and one cannot accept both conditionals in a single state of mind. Much more needs saying, of course, before this is really anything like a solution to our puzzle. But the beginnings are here.

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# Plural Quantifiers Inversely Linked

**Martin Hackl***


**Abstract**

Inverse Linking constructions display an asymmetric requirement of "number concord" that can be summarized as follows: if the inversely linked quantifier is plural the host NP has to be plural as well. This paper argues that under suitable assumptions Beck's proposal in [2] for definite plural DP-arguments of nouns can be extended to quantificational plural DPs in Inverse Linking constructions. The paper argues furthermore that a number of apparent exceptions to the generalizations can be explained through independently motivated constraints on movement and pluralization.


## 1 Introduction

Inverse Linking constructions such as the ones in (1) from [8] are complex DPs, where a quantificational DP (the inversely linked QP or $QP_{IL}$) is embedded inside at least one other DP (the host DP or $DP_H$), while taking semantic scope over $DP_H$ and potentially binding a bound variable pronoun in the matrix.

(1) a. Some people from every walk of life like jazz.
 b. Some houses near all of the nuclear power plants in New Mexico will be contaminated within five minutes of meltdown.
 c. Somebody from every city despises it.

The literature on Inverse Linking focuses primarily on two closely related questions: 1. How can the apparent conflict between surface scope and semantic scope be resolved within a general theory of quantifier scope ([8], [9], [6], [4], [1], etc.)? 2. How can we allow for variable binding while maintaining the basic tenets of Binding Theory ([10], [3], etc.)? Pivotal in these debates is whether $QP_{IL}$ is allowed to vacate $QP_H$ with the trading off exceptional movement and variable binding against standard denotations for $QP_{IL}$. This paper aims to contribute to this debate by examining little studied interactions between the determiners of $DP_H$ and $QP_{IL}$ as they reveal themselves through a phenomenon that will be called "number concord."

## 2 Asymmetric Number Concord in Inverse Linking

The data in (1)a and b from [8] indicate implicitly an unexpected interaction between the number marking of $QP_{IL}$ and $DP_H$ that can be summarized as in (2).

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(2) Asymmetric Number Concord in IL
For any $DP_H$ containing a quantifier $QP_{IL}$, if $QP_{IL}$ is plural marked inverse scope over $DP_H$ is possible for $QP_{IL}$ only if the $DP_H$ is plural as well.

The data in (3), (4) and (5) provide initial support for the generalization in (2).[1] All the examples involve a definite $DP_H$ *the mayor(s) of* with either a morphologically singular $QP_{IL}$ or its plural counterpart. The a- and the c-examples receive standard IL interpretations, the b-examples, where a plural quantifier is embedded in a singular host DP, are, instead, pragmatically awkward: they suggest that there is a unique individual that is the mayor of all/at least two/no cities that were hit by the wildfires. This indicates that the IL interpretation for $QP_{IL}$ is not available.

(3) a. The mayor of every city that was hit by wildfires asked for assistance.
b. #The mayor of all the cities that were hit by wildfires asked for assistance.
c. The mayors of all the cities that were hit by wildfires asked for assistance.

(4) a. The mayor of more than one city that was hit by wildfires asked for assistance.
b. #The mayor of at least two cities that were hit by wildfires asked for assistance.
c. The mayors of at least two cities that were hit by wildfires asked for assistance.

(5) a. The mayor of no city that was hit by wildfires asked for assistance.
b. #The mayor of no cities that were hit by wildfires asked for assistance.
c. The mayors of no cities that were hit by wildfires asked for assistance.

This contrast can be replicated with a singular indefinite $DP_H$ versus a bare plural $DP_H$ as the triplets in (6), (7) and (8) show.[2]

(6) a. A representative of every city that was hit by wildfires asked for assistance.
b. #A representative of all the cities that were hit by wildfires asked for assistance.
c. Representatives of all the cities that were hit by wildfires asked for assistance.

(7) a. A representative of more than one city hit by wildfires asked for assistance.
b. #A representative of at least two cities hit by wildfires asked for assistance.
c. Representatives of at least two cities hit by wildfires asked for assistance.

(8) a. A representative of no city that was hit by wildfires asked for assistance.
b. #A representative of no cities that were hit by wildfires asked for assistance.
c. (?) Representatives of no cities that were hit by wildfires asked for assistance.

[1] Because of space limitations the paper focuses almost exclusively on IL-constructions with $QP_{IL}$ being the internal argument of the noun of $DP_H$. Cases where $QP_{IL}$ is inside a PP modifier of $DP_H$ are neglected. While the data are for the most part comparable, it does seem to be the case that $QP_{IL}$s inside PP-adjuncts are subject to somewhat weaker constraints, which make them in general more natural but also less reliable as the sharpness of contrasts fades more quickly. Quite generally, it appears that the sensitivity of native speakers for the relevant contrasts discussed in this paper fades relatively quickly not unlike in the case of WCO - this parallelism suggests a connection that will have to be left for further research.

[2] (8)a is marginal to begin with, however the added awkwardness in b is still clearly felt.



Interestingly the effect of number concord goes only in one direction. If $DP_H$ is plural, there is no general requirement for $QP_{IL}$ to be plural as well. Incidentally, plural marking on $DP_H$ affects the interpretation of the IL-construction so that it is implicated (possibly even presupposed) that the cities under consideration have a plurality of representatives/mayors. This is different from the cases where $QP_{IL}$ is plural as well.

(9) a. (The) representatives of every city that was hit by wildfires asked for assistance.
b. (The) representatives of more than one city hit by wildfires asked for assistance.
c. (The) representatives of no city that was hit by wildfires asked for assistance.
d.#The mayors of every/more than one/no city hit by wildfires asked for assistance.

## 3. Extending Beck's Account to IL

[2] provides an analysis of closely related constructions such as in (11), where a definite plural DP (or proper name conjunction) occupies the internal argument position of a relational noun. This noun, in turn, is the argument of the **-operator, defined in (10) (cf. [5], [15], [11], [2]). This operator pluralizes the relation described by *daughter of* to yield appropriately weak truth-conditions involving at least one daughter per defense player, but no daughter that is a daughter of all the defense players, a reading which is excluded for pragmatic reasons.

(10) For any function R of type ⟨e,et⟩ and individuals x, y in D,
$$**R(x)(y)=1 \text{ iff } R(x)(y)=1 \text{ or } \exists x_1,x_2,y_1,y_2\ [x_1+x_2=x\ \&\ y_1+y_2=y\ \&\ **R(x_1)(y_1)=1\ \&\ **R(x_2)(y_2)=1$$

(11)a. Reinier compared the daughters of the defense players (Greg and Norm).
b.*Reinier compared the daughter of the baseball players (Greg and Norm).

Together with the stipulation that nominal predicates and relations need to be morphologically plural to be able to range over/relate pluralities, [2] derives the fact that *daughter of* needs to be plural marked in cases like (11).

This account can be extended to plural $QP_{IL}$s, under the assumption that plural QPs quantify over pluralities. The most transparent execution of this extension assumes that a plural $QP_{IL}$ vacates its base position to resolve the type mismatch generated by a QP in object position, takes scope over $DP_H$ and leaves behind a trace that is interpreted as variable ranging over pluralities (similar to definite plural DPs).[3]

(12)a. [[All the cities x] [the **mayors of the cities $x]_{DP}]_{DP}$ asked for assistance.

[3] (12) assumes that $QP_{IL}$ is adjoined to $DP_H$ along the lines of [9], [6] and [4] which requires a higher type for $QP_{IL}$ namely ⟨ee,ett⟩ as sketched in **Error! Reference source not found.**b or ⟨⟨e,ett⟩,ett⟩. Cf. [3] for a variant of this proposal in which the compositional machinery is enriched to be able to deal with QPs that are adjoined to DPs or QPs and [1] for more radical revision of the compositional machinery to allow for $QP_{IL}$ to stay inside $DP_H$.

b. [[all the cities]]($f_{ee}$)($g_{et}$) = 1 iff for all cities x, g(f(x)) = 1

### 3.1 Bare Numeral and Quantificational $DP_H$s and *Every*

The proposal sketched above predicts that any plural $DP_H$ should be able to host any plural $QP_{IL}$ while a singular $DP_H$ shouldn't. This expectation is not borne out as the data in (13) to (15) show.[4,5]

(13)a. Four residents of three cities hit by wildfires lost their houses.
b.#Four residents of exactly/more than/at least three cities lost their houses.
c.#Four residents of (almost) all the cities hit by wildfires lost their houses.[6]
d. Four residents of (almost) every city hit by wildfires lost their houses.

(14)a. Exactly/at least/more than four residents of three cities lost their houses.
b.#Exactly/at least/more than four residents of exactly/more than/at least three cities lost their houses.
c.#Exactly/at least/more than four residents of (almost) all the cities that were hit by wildfires lost their houses.
d. Exactly/at least/more than four residents of (almost) every city that was hit by wildfires lost their houses.

(15)a. Every resident of three cities hit by wildfires lost his house.
b. Every resident of exactly/more than/at least three cities lost his house.
c. Every resident of (almost) all the cities hit by wildfires lost his house.
d. Every resident of (almost) every city hit by wildfires lost his house.

These data suggest that there are unexpected gaps in the availability of IL with plural quantifiers. More specifically, modified numeral $QP_{IL}$ and *all the* $QP_{IL}$ seem to not be able to take inverse scope over bare numeral or plural quantificational DP while bare numeral $QP_{IL}$s can. Secondly, *every* QPs seem to be exceptionally tolerant in both positions: they can take inverse scope over any $QP_H$ as well as host any $QP_{IL}$. The facts above together with the data in (3) to (9) suggest that definite, indefinite determiners and *every* form a natural class modulo number concord wrt. Inverse Linking. This is not expected under the proposal developed above.

### 3.2 Inverse Linking as Adjunction to NP

In this section a modification of the previous proposal is sketched that is in the spirit of proposals in [12] [16] and [7']. It is assumed that definite and indefinite determiners as well as bare numerals can be analyzed as NP modifiers in conjunction with choice function analysis of quantificational force in these constructions cf. [16]. With this much in place, Inverse Linking can be re-analyzed as NP-adjunction rather than DP-adjunction as sketched below.

(16)a. $\exists f$ CH(f) & [$f$ [All the cities x]$_{DP}$ [the **mayors of the cities x]$_{NP}$]$_{DP}$ asked for assistance.
b. [[all the cities]]($f_{eet}$) = $\lambda$y. for all cities x, f(x)(y) = 1
c. [[the mayors of the cities x]] = $\lambda$y. y = max z st.**mayor of (the cities x)(z) =1

Note that the definite plural determiner is treated as NP modifier that makes sure that *the mayors of the cities x* denotes a singleton set containing the biggest plurality of individuals that stands in the cumulative *mayor of* relation with *the cities x*. This extension is passed on by the inversely linked quantifier *all the cities* so that leaving the existentially closed choice function only one choice: the biggest plurality y such that for all cities x there is a mayor in y. The indefinite cases can be treated analogously however there is no uniqueness condition on the extension of *representative of the cities x*.

Assuming that true quantificational determiners like *modified numerals* project a DP layer on top of the NP more or less in the traditional sense following again [16] an explanation for the data in (13) to (15) can be given in terms of a constraint on movement while maintaining the basic insight in [2] that cumulation plays an essential role. Since it is natural to assume that $QP_{IL}$ cannot be moved out of a DP – independent support for this assumption comes from the so called specificity constraint on extraction out of NP – $QP_{IL}$ cannot take scope over quantificational determiners.

An account of the tolerance of *every* in Inverse Linking constructions within this set of ideas would have to analyze *every* as NP modifier as well so that $QP_{IL}$ can take inverse scope. Interestingly a recent proposal in [12] decomposes *every* into a definite determiner and a "part-quantifier." Future work has to reveal whether this proposal can be suitably adopted to fit the proposal sketched here.

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[4] Since the **-operator is independently motivated in the derivation of cumulative readings [13], [5],[15], etc. a more cautious expectation would be that the availability of IL between a plural $QP_{IL}$ inside a quantificational host DP correlates with the availability of a cumulative reading between the two quantifiers. However even this more restrictive prediction is not borne out in general.

[5] Proportional quantifiers in IL like *most residents of most cities* give rise to a number of intricate complications and will be left for future research.

[6] Almost prevents a collective reading that is at least marginally available for *all the MLB teams*.

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# A Focus Semantics for Interrogatives

**Andreas Haida***

## 1 The Empirical Domain

The (semantic) singularity of the *which*-phrase in an interrogative such as (1a) has often been recognized[1] as leading to a *uniqueness* presupposition for a felicitious answer, accompanied by an *existential* one (the occurence of both is referred to as $\exists_1$-presupposition in the following). There are, however, contexts capable of bleeding the $\exists_1$-presupposition, in which case a different requirement comes to the fore: In the context specified and reinforced by the contrast expressed, the *which*-question in (1b) is a request for a *complete* specification of the domain of the *which*-phrase (hereafter designated as $\forall$-requirement), namely with regard to whether the respective email has been retrieved or not.

(1) a. [Which$_F$ novel]$_F$ have you read?
 b. {As for the emails in the infolder, tell me ...}
  which email has $[\emptyset_{\lambda p.p}]_F$ been retrieved (and which one not$_F$)

The interaction of both conditions can be observed in (2a).[2] That is, there is a $\forall$-requirement for the subject *which*-phrase and an $\exists_1$-presupposition for the object *which*-phrase, giving rise to the presupposition that every student has read one and only one novel. In specific contexts, however, the $\forall$-requirement is superimposed by an $\exists_1$-presupposition for the subject *which*-phrase also, the result of which is a single-pair reading of a double *which*-question, as is the case in (2b).

(2) a. Which student has read [which$_F$ novel]$_F$?
 b. {A: This student has read this novel.}
  B: [Which$_F$ student]$_F$ has read [which$_F$ novel]$_F$?

In the following, it will be demonstrated that the answerhood conditions of the interrogatives in (1) and (2) are a superposition of their semantics proper with the interpretation of their F-structures (as indicated in each of the examples above).

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1. Cf., among others, [6] and [3].
2. Cf. [3] and also [6] for an even stronger condition, namely bijectivity.

## 2 The Focus Semantics

My analysis is doubly based on the semantics of questions and answers of [4]/[5]. Firstly, this framework provides the interrogative semantics of my analysis and, beyond that, it is the conceptual basis of the focus semantics I am proposing – a reinterpretation of interrogative semantics as focus semantics.

### 2.1 Overview

Along the lines of the focus theory of [7], I assume that the interpretation of the F-structure of a clause provides a question $Q_p$ and a proposition $J$, where:

- $Q_p$ – termed the ***backgrounded question*** – is the interpretation of the non-F-marked portion of the clause.
- $J$ – designated as the ***focus answer*** – results from interpreting the F-marked portion (the focus) of the clause as a constituent answer to the backgrounded question.

In terms of the above notions, the contribution of the F-structure of an interrogative to its answerhood conditions can be described[3] as follows:

- A pragmatic answer to an interrogative with semantic interpretation $Q$ is not an answer to $Q$ alone, but an answer to the intersection of $Q$ with the backgrounded question $Q_p$ of the interrogative.
- A pragmatic answer furthermore has to be compatible with the focus answer $J$ of the interrogative.

### 2.2 The F-abstract

In the G&S-framework, question formation proceeds recursively starting from a sentential structure, the so-called zero-place abstract. Accordingly, the formation of the backgrounded question of a clause requires a sentential base, termed the (zero-place) ***F-abstract***. As for an interrogative clause, I assume that the F-abstract – being derived from a question – reflects the semantics of interrogativity in that it is index-dependent on *two* indices. Furthermore, I assume that in the formation of an F-abstract an F-marked constituent $\beta$ translates as a variable that is of the same type as the categorematic interpretation of $\beta$. In focus semantics, an F-marked *which*-phrase is thereby interpreted categorematically, namely as a restrictor-less existential GQ (the restrictive clause being a conjunct of the zero-place abstract of the underlying question).

These assumptions are exemplified with (3a) and (b), which are the F-abstracts of (1a) and (2a) respectively.

(3) a. $\mathcal{P}(i)(\lambda i \lambda x.\psi/i,x/) \leftrightarrow \mathcal{P}(j)(\lambda i \lambda x.\psi/i,x/)$
where $\psi/\imath,x/ = (\text{novel}(\imath)(x) \wedge \text{read}(\imath)(\text{you},x))$

b. $\lambda x\lceil\text{student}(i)\rceil\mathcal{P}(i)(\lambda i\lambda y(\text{novel}(i)(y) \wedge \text{read}(i)(x,y))) =$
$\lambda x\lceil\text{student}(j)\rceil\mathcal{P}(j)(\lambda i\lambda y(\text{novel}(i)(y) \wedge \text{read}(i)(x,y)))$

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3. More precisely, a proposition $P$ is a complete pragmatic answer iff $P \cap J \in J/(Q \cap Q_p)$, where $Q \cap Q'$ is the question such that $I/(Q \cap Q') = I/Q \cap I/Q'$. Cf. Def. 20-1, p. 22 in [5].



### 2.3 The backgrounded question of an interrogative

The challenge for a focus semantics for interrogatives is the twofold index dependency of the sentential base, one of which has to be "neutralized" compositionally. This is the function of the partiality operator $\partial\imath$ (where $\imath$ is an index) introduced in the definition below.

**Definition 1 (Backgrounded question[4])** If $\alpha$ is an interrogative with F-abstract $\alpha'/\xi/$, the categorial and propositional interpretation, respectively, of the backgrounded question of $\alpha$ is $\alpha'_c$ and $\alpha'_p$ below.

$$\alpha'_c = \lambda\xi\lceil C\rceil\partial k([\lambda j.\alpha'/\xi/](k))$$
$$\alpha'_p = \lambda j(\alpha'_c = [\lambda i.\alpha'_c](j))$$

where $C$ is a certain restriction[5] on $\xi$.

The model theory of the formalism of semantic representation is so defined that $\partial\imath$ has the following properties:

(I) $\partial\imath$ operates on the truth value of the maximal subformula(e) in its scope index-dependent on only index $\imath$.

(II) With respect to such a formula $\varphi/\imath/$, $\partial\imath$ expresses – via partiality – that $\varphi/\imath/$ is presupposed to be true. In particular:
$[\![\partial\imath.\varphi/\imath/]\!] = [\![\partial\varphi/\imath/]\!] = \partial[\![\varphi/\imath/]\!]$, where the sentence operator/truth function $\partial$ is given by the rightmost truth-table in (5b).[6]

To give an idea of what is achieved through this: For the backgrounded question of (1a) (i.e, $\alpha'_p$ based on (3a)),[7] the first (meta-language) equation in (4) is valid by property (I) of $\partial\imath$.

(4) $$[\![\lambda j(\lambda\xi\lceil C\rceil\partial k(\varphi/i,\xi/ \leftrightarrow \varphi/k,\xi/) = \lambda\xi\lceil C\rceil\partial k(\varphi/j,\xi/ \leftrightarrow \varphi/k,\xi/))]\!]$$
$$= [\![\lambda j(\lambda\xi\lceil C\rceil(\varphi/i,\xi/ \leftrightarrow \partial k.\varphi/k,\xi/) = \lambda\xi\lceil C\rceil(\varphi/j,\xi/ \leftrightarrow \partial k.\varphi/k,\xi/))]\!]$$
where $\varphi/\imath,\xi/$ is a formula that is index-dependent on only index $\imath$
$$= [\![\underbrace{\lambda j(\lambda\xi\lceil C\rceil\varphi/i,\xi/ = \lambda\xi\lceil C\rceil\varphi/j,\xi/)}_{\Phi}]\!]$$

Furthermore, the second equation in (4) holds, if '↔' is defined in conformity with (5a)[8] – a condition the truth function '≡' given[9] by the leftmost truth table in (5b) obviously conforms to.[10]

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4. Cf. Regel 1 and Regel 2 in [5], p. 12f for the corresponding definitions in interrogative semantics.
5. for the time being, to be specified in an ad hoc manner
6. This operator is a four-valued version of the well-known Beaver-operator.
7. i.e., in (4) $\varphi/\imath,\xi/ = \mathcal{P}(\imath)(\lambda i\lambda x.\psi/i,x/)$, where $\xi = \mathcal{P}$ and $\psi/i,x/$ is as given in (3a)
8. There is no useful three-valued truth function that fulfills the condition in (5a). A four-valued logic has therefore to be employed.
9. '≡' can be defined in the usual way from '⊓' and '−' given in (5b).
10. The definition of the valuation function therefore contains the following stipulation: $[\![\varphi \leftrightarrow \psi]\!] = [\![\varphi]\!] \equiv [\![\psi]\!]$.

(5) a. $[\![\varphi_1 \leftrightarrow \psi]\!] = [\![\varphi_2 \leftrightarrow \psi]\!]$ iff $[\![\varphi_1]\!] = [\![\varphi_2]\!]$

b.

| $\equiv$ | 1 | 0 | $n$ | $u$ |
|---|---|---|---|---|
| 1 | 1 | 0 | $n$ | $u$ |
| 0 | 0 | 1 | $u$ | $n$ |
| $n$ | $n$ | $u$ | 1 | 0 |
| $u$ | $u$ | $n$ | 0 | 1 |

| $\cap$ | 1 | 0 | $n$ | $u$ |
|---|---|---|---|---|
| 1 | 1 | 0 | $n$ | $u$ |
| 0 | 0 | 0 | 0 | 0 |
| $n$ | $n$ | 0 | $n$ | 0 |
| $u$ | $u$ | 0 | 0 | $u$ |

| $-$ | |
|---|---|
| 1 | 0 |
| 0 | 1 |
| $n$ | $u$ |
| $u$ | $n$ |

| $\partial$ | |
|---|---|
| 1 | 1 |
| 0 | $n$ |
| $n$ | $n$ |
| $u$ | $u$ |

Finally, the equation in (6) is valid, if $C$ requires a GQ to be extensional.[11]

(6) $$[\![\lambda \jmath(\lambda \mathcal{P}[C]\mathcal{P}(\imath)(\lambda i \lambda x.\psi/i,x/) = \lambda \mathcal{P}[C]\mathcal{P}(\jmath)(\lambda i \lambda x.\psi/i,x/))]\!]$$
$$= [\![\lambda \jmath(\lambda x.\psi/\imath,x/ = \lambda x.\psi/\jmath,x/)]\!]$$

Since the term on the left-hand side of the (meta-language) equation in (6) is of the form of $\Phi$ in (4) and the right-hand side of (6) is identical to the question that (1a) expresses semantically, the backgrounded question of (1a) is identical to its semantic question.

More generally, the backgrounded question of the *which*-questions under discussion is either identical to or less fine-grained than their respective semantic question. That is, in these cases the backgrounded question does not alter the answerhood conditions directly,[12] but only via the focus answer defined below.

## 2.4 The focus answer of an interrogative

In accordance with [5], interpreting the focus as a constituent answer to the backgrounded question involves the categorial interpretation of the backgrounded question and the exhaustivization of the focus:

**Definition 2 (Focus answer[13])** If $\alpha$ is an interrogative and $\alpha'_c$ is the categorial interpretation of the backgrounded question of $\alpha$, the focus answer of $\alpha$ provided by its F-marked constituent $\beta$ is the proposition below.

$$\lambda i(\alpha'_c(\lambda i.\text{EXH}(i)(\beta')))$$

where $\beta'$ is the categorematic interpretation of $\beta$ and EXH is defined[14] as follows:

$$\text{EXH} = \lambda i \lambda \mathcal{Q} \lambda P(\mathcal{Q}(i)(P) \wedge \neg\exists P'(\mathcal{Q}(i)(P') \wedge$$
$$\wedge P'(i) \neq P(i) \wedge \forall x(P'(i)(x) \rightarrow P(i)(x))))$$

11. i.e., $[\![C(\mathcal{Q})]\!] = 1$ iff there is a function $f$ with domain $\mathcal{D}_{\langle\langle e,t\rangle,t\rangle}$ such that $\forall P, i: \mathcal{Q}(i)(P) = f(P(i))$

12. In contrast to this, the backgrounded question of yes/no questions, in particular of so-called alternative questions, is *more* fine-grained than their semantic question:

(i) Did you invite [John or Mary]$_F$?

The backgrounded question of the alternative question in (i) is *Who did you invite?* and its focus answer can be paraphrased as *that you invited either John or Mary, provided that, in fact, you invited either John or Mary*. Cf. [1] for a comparable analysis of alternative questions.



As for the GQ denoted by an F-marked *which*-phrase, EXH($\imath$) yields the set of properties that are singletons in $\imath$ (abbreviated as $\lambda P.\exists_1 x.P(\imath)(x)$; more generally, if $\beta'$ is a GQ then EXH($\imath$)($\lambda i.\beta'$) is designated as $\beta'_E/\imath/$).

The equations in (7) can then be shown to be valid for the focus answer of (1a).[15] In (7), the first and seconf equation hold by $\lambda$-conversion and the last by property (I) and (II) of $\partial\imath$.

(7) $$[\![\lambda i([\lambda \mathcal{P}[C]\partial k(\mathcal{P}(i)(\lambda i \lambda x.\psi/i,x/) \leftrightarrow \mathcal{P}(k)(\lambda i \lambda x.\psi/i,x/))](\lambda i.\beta'_E/i/))]\!]$$
$$= [\![\lambda i \partial k(\beta'_E/i/(\lambda i \lambda x.\psi/i,x/) \leftrightarrow \beta'_E/k/(\lambda i \lambda x.\psi/i,x/))]\!]$$
$$= [\![\lambda i \partial k(\exists_1 x.\psi/i,x/ \leftrightarrow \exists_1 x.\psi/k,x/)]\!]$$
$$= [\![\lambda i(\exists_1 x.\psi/i,x/ \leftrightarrow \partial\exists_1 x.\psi/k,x/)]\!]$$

If $k$ is taken to be the actual world, the focus answer of (1a) can therefore be paraphrased as follows.

(8) that you have read one and only one novel,
provided that, in fact, you have read one and only one novel

As a restriction on the answer space of (1a), this gives the correct reading.

# 3 Deriving the Empirical Findings

For reasons of space, only the focus answers of the interrogatives in (1) and (2) will be discussed in the remainder of this abstract. In each of the relevant cases,[16] the focus answer provides a restriction on the answer space that accounts for the correct reading of the respective interrogative.

## 3.1 One-focus interrogatives

The focus answer of (1a) has been discussed in the preceding section.

As for (2a), the focus answer (based on the F-abstract in (3b)) is given in (9a) and paraphrased in (9b).

(9) a. $\lambda i.\partial k(\lambda x[\text{student}(i)](\exists_1 y(\text{novel}(i)(y) \wedge \text{read}(i)(x,y))) =$
$\lambda x[\text{student}(k)](\exists_1 y(\text{novel}(k)(y) \wedge \text{read}(k)(x,y))))$

b. that every student has read one and only one novel
provided that, in fact, every student has read one and only one novel

The adequacy of the paraphrase in (9b) can be shown as follows: The proposition in (9a) is identical to the one in (10) (by property (I) and (II) of $\partial\imath$).

(10) $$\lambda i(\lambda x[\text{student}(i)](\exists_1 y(\text{novel}(i)(y) \wedge \text{read}(i)(x,y))) =$$
$$\lambda x[\text{student}(k)]\partial(\exists_1 y(\text{novel}(k)(y) \wedge \text{read}(k)(x,y))))$$

13. Cf. Regel 3 in [5], p. 34 for the corresponding definition in interrogative semantics.
14. Cf. Def. 33 in [5], p. 35 for the corresponding extensional representation.
15. i.e., $\beta'_E/i/ = \lambda P.\exists_1 x.P(i)(x)$ and $\psi/i,x/$ is as given in (3a)
16. i.e., in the cases in which the F-structure contributes to the answerhood conditions

On the (standard) assumption that all atomic formulae are classically valued (cf. [2]), the left-hand term of the equation in (10) denotes a function in $\{0,1\}$. In contrast to this, the right-hand term denotes a function in $\{0,1\}$ iff $\forall x \in [\![\text{student}(k)]\!] : [\![\exists_1 y(\text{novel}(k)(y) \wedge \text{read}(k)(x,y)))]\!] = 1$.

### 3.2 Multiple-focus interrogatives

In multiple-focus constructions, the F-marked constituents are interpreted as a *sequence of terms*.[17] That is, the F-abstract of the interrogative in (2b) is the sentence in (11a). This gives the focus answer specified in (11b-i) (and paraphrased in (b-ii)), whereby '$\exists_1\langle x,y\rangle \ldots$' abbreviates the result of exhaustivization of the two-membered sequence of *which*-phrases[18] that make up the focus.

(11) a. $\mathcal{R}(i)(\lambda i\lambda x\lambda y.\psi/i,x,y/) = \mathcal{R}(j)(\lambda i\lambda x\lambda y.\psi/i,x,y/)$

b. (i) $\lambda i\partial k(\exists_1\langle x,y\rangle.\psi/i,x,y/ \leftrightarrow \exists_1\langle x,y\rangle.\psi/k,x,y/)$

(ii) One and only one student has read one and only one novel provided that, in fact, one and only one student has read one and only one novel

where $\psi/\imath,x,y/ = (\text{student}(\imath)(x) \wedge \text{novel}(\imath)(y) \wedge \text{read}(\imath)(x,y))$

### 3.3 Zero-focus interrogatives

As for the interrogatives in (1b), it can be observed that the F-markings are interpreted as contrastive foci, i.e., with respect to one another. This indicates that the F-structure of the interrogatives in (1b) is *not* interpreted as a contribution to the answerhood conditions of the respective interrogative. Therefore, the unaltered G&S-semantics comes to the fore in (1b).

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17. in the sense of Regel 4 in [5], p. 36
18. achieved by $\text{EXH}^2$; cf. Def. 34 in [5], p.37



# Uptake by Conditional Obligations

**Joris Hulstijn* and Nicolas Maudet†**

## 1 Introduction

Dialogues are generated in a joint process of offering and accepting moves. Depending on the dialogue genre, there is usually one participant who takes the initiative; other participants respond to the initiative. In this paper, we further investigate the process of *uptake* [1, 4]. Essentially, an initiative is ambivalent. The way in which an initiative is 'taken up', allows the responder to modify the course of a dialogue. In section 2 we introduce dialogue games. Section 3 analyzes the uptake mechanism as a negotiation of the dialogue game at a meta-level. Section 4 provides a formalization of dialogue games, that can be translated into rules for the individual participants [5]. To deal with possible conflicts, we express such rules as conditional obligations in the BOID cognitive agent architecture [2]. Section 5 shows how the uptake mechanism can be expressed in this framework.

## 2 Dialogue Games

By engaging in dialogue, participants execute some social activity. Often the linguistic realization of such social activities is conventionalized, and turned into a genre like information exchange or negotiation. The conventions of a genre may be expressed as dialogue game rules. This approach has been applied in linguistics, argumentation theory, and multi-agent communication [3, 7, 9]. Typically, a dialogue game consists of rules to express the entry conditions, the moves that participants are allowed to make in a dialogue context, the way participants should update their apparent information states upon uttering or receiving a move, the order in which moves should follow one another and the termination conditions. The dialogue context contains general information about the setting, the participants and their roles in the social activity, as well as a record of the previous moves.

Here we consider dialogue games that contain exchanges consisting of an initiative, followed by a response and possibly an evaluation remark. For example, a question is an initiative which expects relevant information as a response;


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an inform act is an initiative, that expects an acknowledgement. Such basic exchanges can in turn be combined, e.g. by embedding, merging or sequential composition. To form a coherent dialogue, there are two constraints. Within an exchange, a response to an initiative must be appropriate in the current dialogue context. And each initiative to start an exchange, must contribute to the apparent overall purpose of the dialogue. Dialogue game rules have been proposed for several genres, such as information exchange, inquiry, persuasion and negotiation [12]. In this paper we assume the existence of a library with definitions of the relevant dialogue game rules.

What is the status of a dialogue game rule? Dialogue games are conventions, which are both descriptive and prescriptive. On the one hand they explain the reoccurring patterns found in naturally occurring dialogue. Therefore, an initiative may lead to expectations about the continuation of the dialogue. On the other hand, they constitute a norm to respond [7]. Nevertheless, participants are autonomous, and can choose to ignore or violate the norm. In our view, the norm should be fairly general. Specific linguistic information is encoded in an *appropriateness* constraint, that indicates for each game what counts as an appropriate response to some initiative, and a *projection* function, that specifies which dialogue games are likely to follow a sequence of dialogue moves. Projection will typically use different sources of information available in the context, either static (e.g. agent profiles) or dynamic (e.g. current dialogue context).

## 3 Uptake

Following [6], we suggest the following analysis of the uptake mechanism. Apart from the regular meaning, at a meta-level an initiative can be seen as a *bid* to open a dialogue game of a particular type. For example, a question initiates an information seeking game. By responding in an appropriate way the responder also indicates to accept the bid. Once committed to a game, the participants are obliged to play by its rules.

Because an initiative is often ambivalent as to which game it starts, the responder has a large influence on the way the dialogue develops. The way the responder 'takes up' the initiative, reflects a possible interpretation that further constrains the dialogue context. For example, a request to shut the window, as in (1), may be taken as a request, permission or command [1], revealing the social relation between $A$ and $B$.

| | | | |
|---|---|---|---|
| (1) | A: | Shut it. | |
| | B: | Sure | (grant request) |
| | B: | Thanks. | (acknowledge permission) |
| | B: | OK. | (accept command) |

Indirect speech acts are similarly ambivalent. Sometimes the responder will instead postpone the acceptation of a bid in order to 'prepare' another dialogue game, thus using the compositional aspect of dialogue games. Imagine a second



hand market with buyer $B$ and seller $S$. A question by $B$ about the price of a product initiates a plain information seeking game (2). But the responder may choose to postpone the acceptance of this bid, because he is willing, say, to enter a negotiation to buy the product (3).

| | | | |
|---|---|---|---|
| (2) | B: | How much for that jacket? | |
| | S: | 25 euros. | (accept information seeking). |
| (3) | B: | How much for that jacket? | |
| | S: | How much would you offer? | (propose negotiation) |
| | B: | 10 euros. | (accept negotiation) |
| | S: | You must be kidding! I propose 20 euros. | |

The examples above are constructed, but examples can be found in naturally occurring dialogues too. Because each dialogue will continue in one particular direction, examples of genuine ambiguity are difficult to find.

The following example shows part of dialogue DIS150JU130 from the MICASE corpus [10]. The dialogue takes place at a visit of physics undergraduates to the planetarium. $S1$ is a graduate student, who is the guide on this tour.

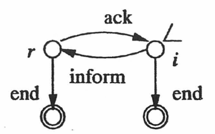
| | | |
|---|---|---|
| (4) | S1: | okay um, this is the planetarium and (i'm trying to get this to work here...) this is the evening sky in Ann Arbor as it will look tonight at about, seven P-M. [...] so this is actual north if you've got a good sense of, geography if you go outside the building and look in that direction that's north. *this point, directly above my head, what do i call that if i'm an astronomer?* |
| | Ss: | the zenith |
| | S1: | the zenith. okay? and we've got a line that runs, from north to south, passing through the zenith what do we call that? |
| | Ss: | meridian |
| | S1: | the meridian, and ... |

After a long explanation, $S1$ changes the dialogue game. She starts to test the knowledge of the students. As is clear from the answers, the students 'take up' this change remarkably well. Note that $S1$ is not much older, and has no formal teaching position. Nevertheless, she adopts a teaching role and the students accept this.

These examples show an ambivalent and negotiable dialogue context, for example with respect to the social setting or intentions of the participants. Such indeterminism does not have to be a bad thing. Selecting a particular response further constrains the dialogue context. In this respect, the uptake mechanism is similar to presupposition accommodation.

## 4 Conditional Obligations

Because dialogue games describe simple patterns, the order in which moves must be made can be given a straightforward logical representation [5]. Figure 1 shows an example of a very simple protocol, with rules distributed among an initiator $i$ and a responder $r$. However, an interpretation of dialogue rules as hard constraints can not deal with possible conflicts between several applicable



$$
\begin{array}{ll}
i & \mathbf{start}(T) \rightarrow \mathrm{inform}(i,r,\varphi)(T{+}1) \\
 & \mathrm{ack}(r,i,\varphi)(T) \rightarrow \mathrm{inform}(i,r,\varphi')(T{+}1) \vee \mathrm{end}(i,T{+}1) \\
r & \mathrm{inform}(i,r,\varphi)(T) \rightarrow \mathrm{ack}(r,i,\varphi)(T{+}1) \vee \mathrm{end}(r,T{+}1) \\
r,i & \mathrm{end}(x,T) \rightarrow \mathbf{stop}(T{+}1)
\end{array}
$$

Figure 1: Continuous update protocol [5]

rules and prevents so called contrary-to-duty reasoning. Therefore, we need an explicit way to represent obligations, that can distinguish between violations and inconsistencies, and can resolve conflicts by means of a priority order. In this paper we will use the BOID cognitive agent architecture [2].

The BOID defines the goal generation process of an intelligent agent in terms of components for belief B, obligation O, intention I and desire D [2]. Components are sets of prioritized default rules $\varphi \xrightarrow{B} \psi$, $\varphi \xrightarrow{O} \psi$, etc. Rules are applied iteratively, to form an extension: a maximally consistent set of literals. Rules are only applicable, in case the antecedent is contained in the extension and the consequent is consistent with it, and is not already contained in it. An extension is interpreted as the goal set for an agent, which may serve as input to a planning procedure to realize the goals. A priority order is used to solve conflicts: if several rules are applicable, the rule with the highest priority is selected. If the priority order respects the boundaries between components, it may characterize an *agent type*. For example, selfish agents generally give priority to desires over obligations; social agents value obligations over desires and realistic agents only generate goals which are compatible with their belief rules. The BOID architecture has been implemented, and has been used to analyze benchmark examples of conflicts between mental attitudes[1].

## 5 Uptake Norms

Dialogue game rules are represented as a protocol [5], but now using conditional obligations from the BOID. Given some protocol definition $P$, $P_j(T)$ is a dialogue move just received, and each $P_i(T{+}1)$ is a legal continuation at time $T{+}1$. Secondary meanings of moves can be inferred by defeasible B-rules.

(5) $P_j(T) \xrightarrow{O} \bigvee_i P_i(T{+}1) \qquad P_j(T) \xrightarrow{B} P_j'(T)$

Note that we do not make any claim about the cognitive validity of our model. Several researchers [4] have convincingly argued against the fact that there exist such things as primary and secondary moves in human processing of dialogue. Our use of the term should be taken in a technical sense.

We formalize the examples by the following rules, shared among initiator $i$ and responder $r$. $G$ can be any game and $\mu, \nu$ can be any move. The predicate

1. See http://boid.info/.



'project' determines possible dialogue games $G$ initiated by a sequence of moves $\mu;\nu;\ldots$ The most expected projection is given by default, but may be overridden; 'appr' indicates that a response is appropriate for a given game; 'comm' means that the agent is committed to the game, which can not be overridden.

$$
\begin{array}{llcl}
(6) & 1.\ \mathrm{init}(i,r,\mu)(T) \wedge \mathrm{project}(\mu,G) & \xrightarrow{B} & \mathrm{bid}(i,r,G)(T) \\
 & 2.\ \mathrm{bid}(i,r,G)(T) & \xrightarrow{O} & \mathrm{accept}(r,i,G)(T{+}1) \vee \mathrm{reject}(r,i,G)(T{+}1) \\
 & 3.\ \mathrm{accept}(r,i,G)(T) & \xrightarrow{B} & \mathrm{resp}(r,i,\nu)(T) \wedge \mathrm{appr}(\mu,\nu,G) \wedge \mathrm{project}(\mu;\nu,G) \\
 & 4.\ \mathrm{reject}(r,i,G)(T) & \xrightarrow{B} & \neg(\mathrm{resp}(r,i,\nu)(T) \wedge \mathrm{appr}(\mu,\nu)) \wedge \mathrm{project}(\mu,G) \\
 & 5.\ \mathrm{comm}(r,i,G)(T) \wedge \mathrm{init}(i,r,\mu)(T) & \xrightarrow{O} & \mathrm{resp}(r,i,\nu)(T{+}1) \wedge \mathrm{appr}(\mu,\nu,G) \\
 & 6.\ \mathrm{comm}(i,r,G)(T) \wedge \mathrm{resp}(r,i,\mu)(T) & \xrightarrow{O} & \mathrm{resp}(i,r,\nu)(T{+}1) \wedge \mathrm{appr}(\mu,\nu,G) \\
 & 7.\ \mathrm{accept}(r,i,G)(T) & \rightarrow & \mathrm{comm}(r,i,G)(T'),\ T \le T' \\
 & 8.\ \mathrm{bid}(i,r,G)(T) \wedge \mathrm{comm}(r,i,G)(T') & \rightarrow & \mathrm{comm}(i,r,G)(T''),\ T \le T' \le T''
\end{array}
$$

A dialogue game is of the form *game*$(i,r,topic)$, where *topic* refers to the object or issue the game is about, $?x.P(x)$ expresses an issue like "What is $P$?" and $\mathrm{p}(j,x)$ represents "the price of the jacket is $x$". Suppose agent $s$ is cooperative, which triggers a goal to accept the information seeking bid. Then the following derivation produces the dialogue in example (2).

$$
\begin{array}{lll}
(7) & \mathrm{init}(b,s,?x.\mathrm{p}(j,x))(t_1), \mathrm{project}(?x.\mathrm{p}(j,x), \mathrm{info}(b,s,j)) & \\
 & \mathrm{bid}(b,s,\mathrm{info}(b,s,j))(t_1) & \text{(B-rule 1)} \\
 & \mathrm{accept}(s,b,\mathrm{info}(b,s,j))(t_2) \vee \mathrm{reject}(s,b,\mathrm{info}(b,s,j))(t_2) & \text{(O-rule 2)} \\
 & \mathrm{accept}(s,b,\mathrm{info}(b,s,j))(t_2) & \text{(cooperative)} \\
 & \mathrm{resp}(s,b,\mathrm{p}(j,25))(t_2), \mathrm{appr}(?x.\mathrm{p}(j,x), \mathrm{p}(j,25), \mathrm{info}(b,s,j)) & \text{(B-rule 3)}
\end{array}
$$

A similar derivation can be constructed for example (3). Now the seller is asking $?y.\mathrm{p}(b,j,y)$: what price the buyer is prepared to pay. This initiates an embedded information seeking game. Because of the entry conditions of an information seeking game, this only makes sense if the seller has not fixed a price. This suggests a negotiation game. The buyer is cooperative, and also competitive, i.e. wants the best price. The buyer's reply, "10 euros", is an appropriate response, both w.r.t. information seeking and negotiation. The seller's rejection and counterproposal are appropriate in the context of a negotiation. The counterproposal is also a postponed response to the buyer's initial question. So in this case, a negotiation subsumes two information exchanges, about what each would offer.

$$
\begin{array}{lll}
(8) & [\ldots] \text{ as in (7) line 1-3} & \\
 & \mathrm{init}(s,b,?y.\mathrm{p}(b,j,y))(t_2),\ \mathrm{project}(?y.\mathrm{p}(b,j,y), \mathrm{info}(s,b,\mathrm{p}(b,j))), & \\
 & \qquad \mathrm{project}(?y.\mathrm{p}(b,j,y), \mathrm{nego}(s,b,\mathrm{p}(j))) & \\
 & \mathrm{bid}(s,b,\mathrm{info}(s,b,\mathrm{p}(b,j)))(t_2), \mathrm{bid}(s,b,\mathrm{nego}(s,b,\mathrm{p}(j)))(t_2) & \text{(B-1)} \\
 & \mathrm{accept}(b,s,\mathrm{info}(s,b,\mathrm{p}(b,j)))(t_3) \vee \mathrm{reject}(b,s,\mathrm{info}(s,b,\mathrm{p}(b,j)))(t_3), & \\
 & \mathrm{accept}(b,s,\mathrm{nego}(s,b,\mathrm{p}(j)))(t_3) \vee \mathrm{reject}(b,s,\mathrm{nego}(s,b,\mathrm{p}(j)))(t_3) & \text{(O-2)} \\
 & \mathrm{accept}(b,s,\mathrm{info}(s,b,\mathrm{p}(b,j)))(t_3) & \text{(coop.)} \\
 & \mathrm{resp}(b,s,\mathrm{p}(b,j,10))(t_3), \mathrm{appr}(?y.\mathrm{p}(b,j,y), \mathrm{p}(b,j,10), \mathrm{info}(s,b,\mathrm{p}(b,j))) & \text{(O-3)} \\
 & \mathrm{accept}(b,s,\mathrm{nego}(s,b,\mathrm{p}(j)))(t_3) & \text{(comp.)} \\
 & \mathrm{resp}(b,s,\mathrm{p}(b,j,10))(t_3), \mathrm{appr}(?y.\mathrm{p}(b,j,y), \mathrm{p}(b,j,10), \mathrm{nego}(s,b,\mathrm{p}(j))) & \text{(7,O-5)} \\
 & \mathrm{resp}(s,b,\mathrm{p}(s,j,20))(t_4), \mathrm{appr}(\mathrm{p}(b,j,10), \mathrm{p}(s,j,20), \mathrm{nego}(s,b,\mathrm{p}(j))) & \text{(7,O-6)} \\
 & \mathrm{resp}(s,b,\mathrm{p}(s,j,20))(t_4), \mathrm{appr}(?x.\mathrm{p}(j,x), \mathrm{p}(s,j,20), \mathrm{info}(b,s,j)) & \text{(7,O-5)}
\end{array}
$$

## 6 Related Work and Conclusions

Using obligations to encode the prescriptive nature of dialogue moves has first been proposed by [11]. These authors however did not explicitly consider dialogue game structures, only focusing on the obligation put on the responder. Using initiatives as an offer at a meta-level has recently been proposed in [6], where it is claimed that the acceptance of a game bid also expresses 'the intention to participate in a joint action'. This meta-level has also been put forward in the context of agent communication [9, 8], because it may be used as a way to make interaction more flexible by letting agents freely compose dialogue games in a joint negotiation process. A topic for further research is abduction. Note that in a goal generation context, rule 3 and 4 may reason from goal to action. For interpretation such rules would run the other way around: an appropriate response 'counts as' an acceptance. We need both styles of reasoning.

We investigated the uptake process, by which a responder may influence the course of a dialogue, and proposed a preliminary formal account. Dialogue game rules are expressed as defeasible obligation rules in the BOID architecture. Secondary meanings of moves, as bids for a game, are expressed as defeasible belief rules. The approach allows ambiguity in dialogue game bids, and explains more generally how dialogues can be generated in a joint process.

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# On the Semantics of Branching Quantifier Sentences

**Theo M.V. Janssen** *


**Abstract**

An example of a branching quantifier sentence is

(1) Some friend of each townsman and some neighbor of each villager envy each other

The intended reading of such sentences [3] is that the choice of the friend should be made independent of the choice of the neighbor. There has been discussion whether such sentences are grammatical and/or have the meaning attributed to them (e.g. [1]), but we will accept both points. Our aim is to investigate the formal analysis given to such sentences and argue that they do not formalize the intended reading: the desired independence is not captured. As for an application of branching quantifiers in physics, the same will be argued.


## 1 Introduction

The classical representation for (1) is given in (2) using self explaining predicates. The first block of quantifiers is a so called 'branching quantifier'; its interpretation is expressed in the Skolem form (3).

(2) $\begin{pmatrix} \forall x & \exists u \\ \forall y & \exists v \end{pmatrix} [T(x) \wedge V(y) \rightarrow [F(u,x) \wedge N(v,y) \wedge E(u,v)]]$

(3) $\exists f \exists g \forall x \forall y [T(x) \wedge V(y) \rightarrow [F(f(x),x) \wedge N(g(y),y) \wedge E(f(x),g(y))]]$

Normally the Skolem functions would have both $x$ and $y$ as argument, but the fact that $g$ is independent of $x$ is reflected by the fact that only has $y$ as argument. The same for $f$. In the sequel we will not use branching quantifiers, but Skolem forms.

The aim of this paper is to consider some examples where branching quantifiers are claimed to arise, and to investigate whether the analysis formalizes the desired meaning , e.g. whether (3) formalizes the meaning of (1). First we will present the examples (Section 2), thereafter they are discussed (Section 3).

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## 2 Applications

### Numbers

Whether the original example (1) is true depends on the actual situation concerning townsman and villagers. Instead we first will discuss variants where the situation is well known: sentences about natural numbers. Consider:

(4) For every $n$ and $m$, a number $p$ can be chosen independent of $m$ such that $n > p$ and a number $q$ can be chosen independent of $n$ and $p$ such that $q > m$.

This sentence is of course true.

In the formal representation using Skolem functions one sees the connection with (3).

(5) $\exists f \exists g \forall n \forall m[f(n) > n \wedge g(m) > m]$

X. But consider now the following variant (6), with Skolem form (7).

(6) For every number $n$ and $m$, a $p$ can be chosen independent of $m$ such that $n > p$ and a $q$ can be chosen independent of $n$ and $p$ such that $q > m$ and such that $p + q$ is even.

(7) $\exists f \exists g \forall n \forall m[f(n) > n \wedge g(m) > m \wedge Even(f(n) + g(m))]$

Intuitively sentence (6) is not true: if $q$ is to be chosen without knowledge about the choice of $n$ and $p$, then it cannot be chosen in such a way that $p+q$ is even. Whether (7) formalizes the meaning of (6) will be discussed below.

### Physics

Hintikka argues that a fundamental distinction between classical physics and quantum mechanics can be characterized by means of the distinction independence /dependence. In classical mechanics the position and impulse of an object can be measured independently of each other. In quantum mechanics (which involves subatomair particles) this is not possible because a measurement of the position disturbs the particle with as a consequence that we are not sure about its pulse (and vice versa). If we determine the one rather precisely, the other becomes unspecific; the relation between the two measurements is expressed by Heisenberg's uncertainty relation.

Hintikka [4][p. 76] describes the difference using his special independence friendly logic, we mimic this with Skolem functions. Let $f$ be a Skolem function which describes the measurement of the position, and $g$ the measurement of the pulse. Let $S$ be some statement about the object/ particle, for instance a description of its total energy (to which speed and position both contribute). The classical situation is claimed to be described by (8) and the quantum mechanical one by (9).

(8) $\exists f \exists g \forall x \forall y \; S(f(x), g(y))$

(9) $\exists f \exists g \forall x \forall y \; S(f(x), g(y, f(x))$



## 3 Analysis

### Numbers

Sentence (6) intuitively does not hold, because $p$ and $q$ cannot be independent and at the same time sum up to even. So (7) should come out false. But it is true. Take for instance for $p$ the least odd number that is greater than $n$, and for $q$ the least odd number that is greater than $m$. So their sum is even. These two choices are tuned: one may replace in both 'odd' by 'even', but not in only one of them. We see that the required independency of the choice of $m$ from the choice of $n$, not is captured by the formalization. The Skolem form formalizes only independence between the values of $p$ and $q$. But as the example illustrates, the intuitions concerning independence include that the strategies for $p$ and $q$ should be independent as well.

### Friends and neighbors

It is known [6], [2] that in order (3) to be true, there has to be a group of friends and a group of neighbors such that each friend and each neighbor envy each other. Furthermore each townsman should have a friend in the group, and each villager a neighbor.

Consider now the following situation. Among the friends of the townsmen two groups are distinguished, viz. male and female ones, and the same among the neighbors of the villagers. Assume now that envying is a relation between all pairs of male friends and male neighbors, and also between female friends and female neighbors, but not between friends and neighbors of different sexes. In this situation the choices for friends of townsmen and neighbors of villagers have to correspond: in both cases male ones, or female ones. So in this situation (1) is not true because one cannot make the choices independent. However, (3) comes out true: coordinate the Skolem functions and take e.g. for $f$ and $g$ functions yielding male friends and neighbors respectively. Again we see that the Skolem representation formalizes independence of values, but not of strategies. So the required independence is not captured by the formalizations (in 3).

### Physics

Heisenberg's uncertainty relations says $\Delta a \Delta p = \frac{h}{2*\pi}$, where $\Delta a$ is the uncertainty in position, $\Delta p$ in pulse, and $h$ Planck's constant. This formula does not express that the pulse depends on the position (as (9) says), but only that the accuracy of position and pulse measurement are related. If $f$, the measurement of the position, is a very accurate function, then $g$, the measurement of the pulse, has to be a less accurate one. As we have seen in the previous paragraphs, such a tuning is possible with Skolem functions. So (8), intended for classical mechanics, is the one that holds for quantum mechanics, and the one intended for classical mechanics has nothing to do with the uncertainty relation. So Hintikka's formalization is incorrect.

### Alternative

We have seen that the examples in natural language of the so called branching quantifier sentences require that the involved strategies are independent. But their formalization with branching quantifiers in logic, as well as their Skolem form, as well Hintikka's independence friendly logic describe only independence of values. An alternative is proposed in [5]. There it is argued that a strategy $f$ to be independent of $x$ means that the strategy is the best possible one whatever the value of $x$ is; more technically speaking: if the formula can be made true, it is done by $f$. For details see that quoted paper.

## 4 Conclusion

The applications of branching quantifiers which we have considered turned out to be incorrect. Such quantifiers formalize only independence of values, but not of strategies, and the latter is required in these applications.

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# *Any* and Eventualities

**Jacques Jayez*and Lucia Tovena†**

## 1 Introduction

The fact that *any* has both a Free Choice (FC) and a Polarity Sensitive (PS) profile has been the source of many controversies (see [4],[5] for recent inventories). If one assumes, following in particular [1], [3], [6], [9], that FC items in general avoid reference to particular individuals involved in episodic predications, the examples in (1) are problematic, since all these sentences are episodic and refer to particular individuals (books, students, girls). One might dispute the relevance of (1a) by insisting that PS *any* is different. However (1b,c) are traditionally considered as FC uses. Must we create a third non–PS and non–FC *any* for such cases? In this paper, by postulating different modes of free choiceness, we show that the different behaviors of *any* represent different grammaticalized 'answers' (i.e. constraints) to the same problem.

(1) a. Mary didn't read any book of the list
    b. Any student *(who had cheated) was suspended
    c. Mary performed better than any other girl in her class

## 2 Intuitive description

We propose a unified analysis of *any* as an 'arbitrary' item and account for both its PS and FC properties. Arbitrariness (Fine) means that all individual differences can be neglected. More precisely, if we evaluate a sentence of the form [*any*] [*P*] [*Q*], every *P*–individual which satisfies *Q* in some situation *s* can be replaced by every other *P*–individual in *s*, or, equivalently, all individuals are on a par. This is called *Non Individuation* (NI) in [6]. NI can be satisfied in different ways, which represent as many versions of *any*. This accounts for the persistent conflicting impressions that *any* is one (its uses are not unrelated) and multiform (its uses cannot be derived from a common semantic core).

❶ The clearest manifestation of NI is known as *variation* in the literature on FC items (see e.g. [2], [3], [10]). Variation works well when we have several possible

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worlds, as, for instance, in the Vendlerian imperative *Pick any apple!*. We can imagine than any apple picked in a continuation could be replaced by another apple of the initial set of apples. So, the individual properties of the apples do not determine in advance which apple is to be picked or not to be picked.

❷ With episodic sentences, the situation is as follows. Assertions like (1d) are out because the books that are read are determined in the current situation.

(1) d. Mary read *any book on the list

However, why is (1a) normal? Since Mary did not read any book on the list, the books that are not read are determined (they are all the books on the list). We distinguish between two scenarios of NI. The first is uniformity: all individuals must be able to satisfy or not satisfy the same properties, as illustrated by the case of variation (❶). The second involves reference: even when uniformity is respected, FC items avoid reference to particular individuals. E.g. (1d) is excluded although it may be interpreted as 'Mary read every book on the list' because it entails that particular books were read. Referential properties depend on different factors, among which the nature of eventualities. *Any* 'considers' objects participating in a particular, spatio–temporally situated, eventuality as individuated. PS environments do not refer to positive eventualities: there is no proper positive event of Mary 'not reading' a book because there is no spatio–temporal location at which the event would develop.[1] Similarly, in a question like *Did Mary read any book?*, there is no mention of a reading event. PS environments simply do not give rise to the kind of individuation that *any* can detect, namely one which is grounded in positive eventualities. The exclusion of positive eventualities accounts immediately for the fact that sentences that entail (1a) are anomalous if they mention genuine positive eventualities (1e).

(1) e. Mary successively *refused to read any book on the list

The idea that *any* forbids positive events raises the following problem. Suppose that a certain apple cannot be picked in any follow–up to a Vendlerian imperative *Pick any apple!*.[2] If the speaker is aware of that and wants to include this apple in the set of possible choices, *any* is infelicitous. Yet, not picking the apple does not count as a positive event and does not individuate the fruit. But, to be excluded in advance, the fruit has to be characterized by properties which distinguish a subset of the set of apples. This configuration is incompatible with NI, which prescribes uniformity.

❸ Since (1b,c) refer to particular events, they should sound strange. (1b) illustrates *subtrigging* ([7]), that is, the fact that an otherwise anomalous *any*–

1. Of course, the fact that not reading a book does not count as an event spatio-temporally does not prevent it from counting as an event in other respects. The literature on so–called 'negative events' often mentions examples of the form *And what happened? Mary did not read my novel!*, see [8].

2. The apple might be rotten, for instance.



sentence is redeemed by adjoining an appropriate modifier, here a relative clause. Clearly, there is a conditional relation between the VP content and that of the modified noun in such cases. This makes the identity of the students irrelevant (arbitrariness): students are suspended *qua* cheaters and not *qua* particular students.

❹ As for (1c), the crucial observation is that we cannot refer explicitly to a set of particular events (2).

(2) On Monday, Mary beat *any other girl in the class

This indicates that (1c) refers to such events only indirectly. As in the case of subtrigging, individuation by events is possible. Suppose that the girls in Mary's class were engaged in a chess tournament. The fact that Mary beat Sally certainly depends on their respective individual strategies. But (1c) actually means that Mary reached the highest performance level when compared to the other girls. The exact way in which this is achieved, that is the order and content of the particular confrontation events, is irrelevant. Let $\{e_i : i \in I\}$ be the set of particular confrontation events. Mary's performance corresponds to the set of results $\{r_M(e_i)\}$. The fact that this set is 'superior', with respect to some measure operator $\mu$ to another set (that is, $\mu(\{r_M(e_i)\}) > \mu(\{r_x(e_i)\})$ for every other girl $x$) is not related to any particular $e_i$ in $\{e_i : i \in I\}$. The same configuration obtains if the competition is not a set of confrontations but a comparison of individual performances (for example a competition between athletes). If Mary jumps higher than Sally, there is (at least) two ways of applying an event–based ontology. First, we can say that there is an event of Mary jumping higher than Sally, which takes place at some particular spatio–temporal location. Second we can focus on the relation (comparison) between the events of Mary jumping and Sally jumping. The possibility of (1c) suggests that *any* does not pick up particular events in which Mary and the other girls would participate, but a more abstract relation between events or sets of events.

❺ Finally, note that we do not want to rephrase *any* as a garden–variety indefinite (like *a*) combined with the NI requirement. For instance, (3a) and (3b) are not equivalent, since only (3a) gives one the right to consult an unlimited number of files. This is why we represent *any* as an existential quantifier on sets rather than on individuals in (4.1) below.

(3) a. You may consult any file
    b. You may consult a file, any file

## 3 Calibrating *any*

❶ $\mathcal{E}^+$ denotes the set of positive eventualities. We adopt a Davidsonian notation for eventualities.

(4) A sentence with a tripartite structure $M([any]\ [P]\ [Q])$, where $M$ is a (possibly null) modal operator,
1. asserts $M(\exists X(X \subseteq [\![P]\!]\ \&\ X \subseteq [\![Q]\!]))$,
2. implies that there is no $a \in [\![P]\!]$ such that either:
a. $\exists e, \exists e' \in \mathcal{E}^+(P(a,e)\ \&\ Q(a,e'))$ if $M$ is null, or
b. $\Box\exists e, e'(P(a,e)\ \&\ Q(a,e'))$ or
$\Box\neg\exists e, e'(P(a,e)\ \&\ Q(a,e'))$.

(4.2) distinguishes two cases. For simple assertions, no positive eventualities must be involved. For modal sentences, no individual in the restriction $P$ can be imposed or excluded as a satisfier of the scope $Q$. Clearly, (4.2a) is too strong because it predicts that subtrigging is impossible. In (1b), there are positive events of suspension.

❷ We replace (4.2a) by (4.2a').

(4) 2a'. $\exists e, \exists e' \in \mathcal{E}^+(P(a,e)\ \&\ Q(a,e'))$ if $M$ is null
unless $\Box[\forall x \forall e(P(x,e) \Rightarrow \exists e' \in \mathcal{E}^+(Q(x,e')))]$ holds.

(4.2a') suspends the prohibition on positive eventualities whenever there is a necessary implication between being a $P$–object and being a $Q$–object. In this case, the positive eventualities can be interpreted as the manifestations of a general constraint, which does not take into account the identity of the individuals involved (arbitrariness).

❸ For comparatives, the intuition is that there is no genuine positive eventuality. However, as for subtrigging, condition (4.2a) is too strong and so is condition (4.2a'). The problem comes from the fact that we cannot deny the status of eventuality to did–better–than(Mary, $x$). So (1c) can be translated as:
$\forall x((\text{in–Mary's–class}(x)\ \&\ x \neq \text{Mary}) \Rightarrow \exists e\ \text{did–better–than}(\text{Mary}, x, e))$.
Since the sentence presupposes that there are girls in Mary's class, it implies that there are positive eventualities of Mary doing better than other girls. We saw in section 2.❹ that, in such cases, *any* selects the relations between events. So we rephrase (4.2a') as (4.2a").

(4) 2a". $\exists e, \exists e' \in \mathcal{E}^+(P(a,e)\ \&\ Q(a,e'))$ if $M$ is null, unless
(i) $\Box[\forall x \forall e(P(x,e) \Rightarrow \exists e' \in \mathcal{E}^+(Q(x,e')))]$ holds, or
(ii) for every $e' \in \mathcal{E}^+$ such that $\exists e(P(a,e)\ \&\ Q(a,e'))$, $Q(a,e')$ is equivalent to $\phi(a)$ for some non–Davidsonian (possibly complex) expression $\phi$

(4.2a") adds the idea that there is a non–Davidsonian property $\phi$ which replaces the Davidsonian $Q$. Suppose that (1c) refers to a chess tournament in which each girl must play against each other girl, and that the players are ranked by number of victories. Let $v(x,n)$ mean that $x$ won $n$ times. (1c) implies:
$\exists x, e, e'(\text{in–Mary's–class}(x,e)\ \&\ x \neq \text{Mary}\ \&\ \text{did–better–than}(\text{Mary}, x, e'))$.
This form violates (4.2a"). The following form does not.



(5) $\exists x, e(\text{in–Mary's–class}(x,e)\ \&\ x \neq \text{Mary}\ \&\ \exists n, n'(v(\text{Mary}, n)\ \&\ v(x,n')\ \&\ n > n'))$.

## 4 Remaining issues

Summarizing, we connect the PS uses of *any* with a sensitivity to positive eventualities, the apparent exceptions (subtrigging and comparatives) with the fact that regularities or relations are fore–grounded, leaving eventualities in the background, and the modal uses with the variation requirement (uniformity). Several problems remain.

❶ How does all this interact with NI? Uniformity and subtrigging clearly put all individuals on a par. Comparatives and downward entailing sentences constrain the reference to events. Comparatives do not forbid positive events that involve particular individuals but they also refer to comparisons between events. Consider two girls $a$ and $b$ in Mary's class. If they each confront Mary, this gives rise to two distinct events. If their performances are compared to that of Mary, it is more difficult to say that we have events 'of comparison'. One might object that the outcomes of the comparisons may be distinct and help to individuate $a$ and $b$. The point is that, in a sense, the outcomes are reduced to the minimal information that Mary did better than $a$ and $b$.[3] So, the relations between Mary and $a$ and Mary and $b$ cannot be distinguished. The difference with (2) is that, in that case, we may associate $a$ and $b$ with different events $e_a$ and $e_b$, whereas, with (1c), $a$ and $b$ participate in the same relation to Mary. Finally, downward entailing sentences do not mention positive eventualities. Therefore, it is impossible to distinguish individuals on the basis of their participations in eventualities. We conclude that, in spite of their differences, all these cases make the pairing of individuals with eventualities impossible or irrelevant.

❷ Uniformity, subtrigging and compatibility with comparatives can be observed with FC items in French and in Greek (see [6] for *n'importe quel* and *tout*, and [3] for *opjosdhipote*). Since there is no morphological relation between these items and *any*, it is unlikely that the sensitivity of *any* to eventualities is parochial. Rather, eventualities constitute an important resource for individuation, and forbidding these resources or making them inefficient is a standard strategy for ensuring NI. PS behavior is not observed with the items mentioned above. Lack of space precludes a discussion of the possible accounts one can propose for this difference.

❸ It is well–known that *any* oscillates between an existential and a universal interpretation. It has been proposed that FC items tend to be indefinites and that their universal interpretation comes from the interchangeability of individuals across worlds (uniformity), see [3] in particular. How this derives the $\forall$

3. Note that, in (5), the outcomes $n$ and $n'$ are bound by $\exists$ and thus convey no specific information.

behavior observed in subtrigged sentences and comparatives is not quite clear, however.

## 5 Conclusion

In this paper, we have proposed that the different uses of *any* are manifestations of the general constraint NI. All the cases we have reviewed concern the way in which *any* links individuation and eventualities. As noted in [11], the French item *le moindre*, whose scalar origin is clear, has a very similar distribution. Future work will have to say whether scalarity plays a central role for *any*, as advocated in [5], and, more generally, for items which have both a PS and a FC sensitivity.

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# Computing Word Meanings by Interpolation


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**Abstract**
I outline a natural algorithm for solving a central problem in the task of learning word-to-meaning mappings, as formulated by Siskind (1996, 2000) and extended to the typed lambda calculus setting by Kanazawa (2001). The algorithm is based on a new syntactical method for proving the Interpolation Theorem for the implicational fragment of intuitionistic propositional logic.


A central problem in the task of learning word-to-meaning mappings, as formulated by Siskind (1996, 2000), can be illustrated by the following example. The learner knows from the outset that the meaning of each word is represented by some first-order term with zero or more free variables, and the sentence meaning is composed from the meanings of the component words by performing a sequence of substitutions in a suitable order. Suppose that the learner has already inferred from evidence presented so far that the meaning of *lifted*, whatever it is, is built up from three symbols CAUSE, GO, and UP, together with some number of variables. Suppose that the learner is now given the information that the meaning of *John lifted Mary* is represented by the first-order term

$$\mathrm{CAUSE}(\mathbf{John}, \mathrm{GO}(\mathbf{Mary}, \mathrm{UP})).$$

The available evidence suffices to uniquely pin down the meaning of *lifted* to

$$\mathrm{CAUSE}(x, \mathrm{GO}(y, \mathrm{UP})),$$

which can be computed by a simple algorithm, even if the meanings of *John* and *Mary* may still be indeterminate.

Following Kanazawa (2001), I generalize this problem to the typed lambda calculus setting as follows. The meaning of each word is represented by a closed $\lambda I$-term (with one or more constant symbols). The meaning of a sentence is obtained by plugging the meanings of the words in a suitable *meaning recipe*, represented by a *linear* (or *BCI*) $\lambda$-term (containing one free variable for each of the words) of type $t$ and then computing the $\beta$-normal form of the resulting $\lambda$-term. The central problem now becomes:

**Mapping Problem.** Given a closed $\lambda I$-term $N$ of type $t$ in $\beta$-normal form containing constant symbols $c_1^{A_1}, \ldots, c_m^{A_m}, d_1^{B_1}, \ldots, d_n^{B_n}$ ($m \geq 1, n \geq 0$), find a closed $\lambda I$-term $M$ (of type $E$) satisfying the following conditions:

- The constant symbols appearing in $M$ are $c_1^{A_1}, \ldots, c_m^{A_m}$;

- There is a $\lambda I$-term $P[z^E]$ of type $t$ with $z^E$ as its only free variable such that $P[M] \twoheadrightarrow_\beta N$.

In the above formulation, $N$ is the meaning of a sentence, $\{c_1^{A_1}, \ldots, c_m^{A_m}\}$ is the set of constant symbols that are in one of the words in the sentence, and $P[z^E]$ is supposed to be the result of combining the meaning recipe for the sentence (a $\lambda I$-term) and the meanings of the remaining words (linear $\lambda$-terms). ($P[z^E]$ is not just any $\lambda I$-term—for example, it must be a linear $\lambda$-term in case $n = 0$, but this point will be ignored.)

An instance of the Mapping Problem may be given by the $\lambda I$-term

$$\forall(\lambda x^e.{\rightarrow}(\mathbf{thing}\ x)(\mathbf{give}\ \mathbf{Bill}\ x\ \mathbf{John})) \tag{1}$$

with its set of constants divided into $\{\forall, \rightarrow, \mathbf{thing}\}$ and $\{\mathbf{give}, \mathbf{Bill}, \mathbf{John}\}$. (Here, $\forall$, $\rightarrow$, **thing**, **give**, **Bill**, and **John** are constants of type $(e \to t) \to t$, $t \to t \to t$, $e \to e \to e \to t$, $e$, and $e$, respectively.) The above $\lambda$-term is supposed to represent the meaning of *John gave Bill everything*, and the problem is to build a correct meaning for *everything* out of $\forall, \rightarrow, \mathbf{thing}$.

Unlike in the first-order case of Siskind, the Mapping Problem in the general higher-order setting has many solutions of varying strengths. The following are some of the solutions, along with their types, to the above instance of the Mapping Problem:

$$\begin{aligned} &\lambda w^{((e\to e\to t)\to t)\to(t\to t\to t)\to(e\to t)\to t}.w\,(\lambda u^{e\to e\to t}.\forall(\lambda x^e.uxx)) \rightarrow \mathbf{thing} \\ &\quad : (((e \to t) \to t) \to (t \to t \to t) \to (e \to t) \to t) \to t \end{aligned} \tag{2}$$

$$\lambda u^{e\to t}.\forall(\lambda x^e.{\rightarrow}(\mathbf{thing}\ x)(ux)) : (e \to t) \to t \tag{3}$$

$$\lambda v^{e\to e\to t} y^e.\forall(\lambda x^e.{\rightarrow}(\mathbf{thing}\ x)(vxy)) : (e \to e \to t) \to e \to t \tag{4}$$

$$\lambda w^{e\to e\to e\to t} z^e y^e.\forall(\lambda x^e.{\rightarrow}(\mathbf{thing}\ x)(wzxy)) : (e \to e \to e \to t) \to e \to e \to t \tag{5}$$

The solutions (2)–(5) are linearly ordered in terms of their strength, with (2) as the strongest. The notion of 'strength' in question is given by the following pre-order on terms, which I call the *definability ordering* (Kanazawa 2001).

**Definition 1.** Let $M^A$ and $N^B$ be closed $\lambda$-terms (with constants) in $\beta$-normal form. $N^B$ is *BCI-definable* in terms of $M^A$ (written $N^B \preceq M^A$) if and only if there is a linear $\lambda$-term $P^B[z^A]$ without constants whose only free variable is $z^B$ such that $P^C[M^A] \twoheadrightarrow_\beta N^B$.

Note that if $N^B \preceq M^A$, the set of constants that occur in $M^A$ is the same as the set of constants that occur in $N^B$.

**Proposition 2.** *Let $M^A$ and $N^B$ be closed $\lambda I$-terms such that $N^B \preceq M^A$. If $M^A$ solves an instance of the Mapping Problem, then $N^B$ solves it, too.*

Continuing with the example (1), which solution does one want? One certainly does not want the strongest (2), which wildly overgenerates: for instance, it can be used to produce

$$\forall(\lambda x^e.{\rightarrow}(\mathbf{give}\ \mathbf{Bill}\ x\ \mathbf{John})(\mathbf{thing}\ x)) \tag{6}$$



as a meaning for *John gave Bill everything*.[1] Nor does one want the weakest (5), which cannot even generate the meaning for a sentence like *John saw everything*. The weakest meaning cannot be a principled solution because in general assigning the weakest meaning to one word in a sentence is incompatible with assigning the weakest meaning to another word in the same sentence. Kanazawa's (2001) algorithm finds the solution (4), which is too weak to generate the meaning for an intransitive sentence like *everything disappeared*. In this paper, I outline an algorithm that finds (3), which has the simplest type and happens to be the conventionally assumed meaning for *everything*.

A solution to the Mapping Problem which has a simplest type can be found by a syntactical proof of the *Interpolation Theorem* for intuitionistic propositional logic, which states:

**Interpolation Theorem.** *If a sequent $A_1, \ldots, A_m, B_1, \ldots, B_n \Rightarrow C$ is provable, then there are provable sequents $A_1, \ldots, A_m \Rightarrow E$ and $E, B_1, \ldots, B_n \Rightarrow C$ such that all propositional variables in $C$ occur both in $A_1, \ldots, A_m$ and in $B_1, \ldots, B_n \Rightarrow C$.*

There are two well-known syntactical methods for proving this theorem. Maehara's method (see Troelstra and Schwichtenberg 2000) works on sequent calculus and Prawitz's (1965) method works on natural deduction. Both methods take a (cut-free or normal) proof $\mathcal{D}$: $A_1, \ldots, A_m, B_1, \ldots, B_n \Rightarrow C$ as input and compute two proofs $\mathcal{D}_1$: $A_1, \ldots, A_m \Rightarrow E$ and $\mathcal{D}_0$: $E, B_1, \ldots, B_n \Rightarrow C$ which satisfy the condition in the theorem. Crucially for our purposes, the proofs $\mathcal{D}_1$ and $\mathcal{D}_0$ found by these methods in fact satisfy much stronger conditions. Let $N^C[x_1^{A_1}, \ldots, x_m^{A_m}, y_1^{B_1}, \ldots, y_n^{B_n}]$, $M^E[x_1^{A_1}, \ldots, x_m^{A_m}]$, $P^C[z^E, y_1^{B_1}, \ldots, y_n^{B_n}]$ be the $\lambda$-terms corresponding to the proofs $\mathcal{D}, \mathcal{D}_1, \mathcal{D}_0$, respectively. Then we have:

(i) $P^C[M^E[x_1^{A_1}, \ldots, x_m^{A_m}], y_1^{B_1}, \ldots, y_n^{B_n}] \twoheadrightarrow_\beta N^C[x_1^{A_1}, \ldots, x_m^{A_m}, y_1^{B_1}, \ldots, y_n^{B_n}]$;

(ii) No two occurrences of the same propositional variable inside $E$ are *linked* in $\mathcal{D}_1$ or $\mathcal{D}_0$.

The condition (i) is pointed out by Čubrić (1994) for Prawitz's method, and the condition (ii) is stated by Carbone (1997), who works on sequent calculus. The notion of *links* referred to in (ii) is easiest to explain with reference to cut-free sequent derivations: two occurrences of a variable in the endsequent are linked if they originated opposite to each other in an initial sequent. The condition (ii) implies[2] that each occurrence of a propositional variable inside $E$ has a counterpart linked to it outside $E$, and the usual condition for an interpolant follows.

Let us deviate from standard usage and call a term $M^E[x_1^{A_1}, \ldots, x_m^{A_m}]$ an *interpolant* to the term $N^C[x_1^{A_1}, \ldots, x_m^{A_m}, y_1^{B_1}, \ldots, y_n^{B_n}]$ if there is a term $P^C[z^E, y_1^{B_1}, \ldots, y_n^{B_n}]$ such that $M, N, P$ satisfy the above conditions (i) and (ii).

[1] One can indeed write a grammar (with syntax and semantics) where *everything* has the meaning (2) and *John gave Bill everything* is ambiguous between (1) and (6). One can do this with a Lambek categorial grammar if *everything* is allowed to be syntactically ambiguous. With a *lambda grammar* (Muskens 2001, to appear), one can even make *everything* syntactically unambiguous.

[2] The condition (ii) is stated for the relevance logic $R$, whose implicational fragment corresponds to the $\lambda I$-calculus. It needs to be strengthened for intuitionistic logic.

Replacing the constants **∀**, **→**, **thing**, **give**, **Bill**, **John** in (1)–(5) by free variables $x_1^{(e\to t)\to t}, x_2^{t\to t\to t}, x_3^{e\to t}, y_1^{e\to e\to e\to t}, y_2^e, y_3^e$, respectively, we see that (3) is an interpolant to (1) while (2), (4), (5) are not.

There are two complications, however. First, the Interpolation Theorem in fact does not hold in the form stated above for the implicational fragment of intuitionistic logic, which corresponds to the simply typed $\lambda$-calculus. Even if $A_1,\ldots,A_m,B_1,\ldots,B_n \Rightarrow C$ is a sequent in the implicational fragment, the interpolation formula $E$ may have to contain $\wedge$. Moreover, Maehara's and Prawitz's methods actually insert $\perp$ and $\wedge$ in places where they are not necessary; as a result, they produce interpolation formulas more complex than $(e \to t) \to t$ in the case at hand.

A way of circumventing this difficulty is to use a sequence of formulas $E_1,\ldots,E_m$ in place of a single formula $E$ in the statement of the theorem (see Wroński 1984 and Pentus 1997). Both standard methods can be easily modified to accommodate this change. The modified methods produce (3) when given (1) as input.

A second complication is that interpolants in the sense of (i), (ii) are not unique in general. Maehara's method (in the modified form) finds possibly different interpolants for different sequent derivations corresponding to the same $\lambda$-term; however, not all interpolants are found in this way. Prawitz's method finds one particular interpolant, but there is no good way of characterizing this interpolant except for the fact that it is the one found by Prawitz's method. In particular, a *strongest* interpolant (in the sense that its type implies the types of all others) is sometimes missed by both these methods.

In a paper in preparation, I describe an algorithm for computing a strongest interpolant. The algorithm is similar to the (modified) Prawitz method in that it works by induction on natural deduction proofs, but it is different in that in my method, assumptions never switch classes in the partition of the assumptions into two classes during the course of the induction, like they do in the Prawitz method.

For example, given a natural deduction proof

$$\dfrac{x_1 : (p_4 \to p_7 \to p_9) \to p_{10} \qquad \dfrac{\dfrac{\dfrac{y_1 : p_8 \to p_9 \qquad \dfrac{\dfrac{x_2 : (p_1 \to p_6) \to p_7 \to p_8 \qquad \dfrac{\dfrac{y_2 : p_5 \to p_6 \qquad \dfrac{\dfrac{x_3 : p_3 \to p_4 \to p_5 \qquad \dfrac{y_3 : p_2 \to p_3 \qquad \dfrac{x_4 : p_1 \to p_2 \quad w : p_1}{p_2}{\scriptstyle\to E}}{p_3}{\scriptstyle\to E}}{p_4 \to p_5}{\scriptstyle\to E} \qquad u : p_4}{p_5}{\scriptstyle\to E}}{p_6}{\scriptstyle\to E}}{p_1 \to p_6}{\scriptstyle\to I,w}}{p_7 \to p_8}{\scriptstyle\to E} \qquad v : p_7}{p_8}{\scriptstyle\to E}}{p_9}{\scriptstyle\to E}}{p_7 \to p_9}{\scriptstyle\to I,v}}{p_4 \to p_7 \to p_9}{\scriptstyle\to I,u}}{p_{10}}{\scriptstyle\to E}$$



my algorithm produces

$$\dfrac{\dfrac{x_1 : (p_4 \to p_7 \to p_9) \to p_{10} \qquad \dfrac{\dfrac{\dfrac{z_1 : ((p_2 \to p_6) \to p_8) \to (p_3 \to p_5) \to p_9 \qquad \dfrac{\dfrac{\dfrac{x_2 : (p_1 \to p_6) \to p_7 \to p_8 \qquad \dfrac{\dfrac{z_2 : p_2 \to p_6 \qquad \dfrac{x_4 : p_1 \to p_2 \quad w : p_1}{p_2}{\scriptstyle\to E}}{p_6}{\scriptstyle\to E}}{p_1 \to p_6}{\scriptstyle\to I,w}}{p_7 \to p_8}{\scriptstyle\to E} \qquad v : p_7}{p_8}{\scriptstyle\to E}}{(p_2 \to p_6) \to p_8}{\scriptstyle\to I,z_2}}{(p_3 \to p_5) \to p_9}{\scriptstyle\to E} \qquad \dfrac{\dfrac{\dfrac{x_3 : p_3 \to p_4 \to p_5 \quad z_3 : p_3}{p_4 \to p_5}{\scriptstyle\to E} \qquad u : p_4}{p_5}{\scriptstyle\to E}}{p_3 \to p_5}{\scriptstyle\to I,z_3}}{p_9}{\scriptstyle\to E}}{p_7 \to p_9}{\scriptstyle\to I,v}}{p_4 \to p_7 \to p_9}{\scriptstyle\to I,u}}{p_{10}}{\scriptstyle\to E}}{(((p_2 \to p_6) \to p_8) \to (p_3 \to p_5) \to p_9) \to p_{10}}{\scriptstyle\to I,z_1}$$

while the Prawitz method produces

$$\dfrac{\dfrac{x_1 : (p_4 \to p_7 \to p_9) \to p_{10} \qquad \dfrac{\dfrac{\dfrac{z_1 : ((((p_2 \to p_3) \to p_5) \to p_6) \to p_8) \to p_9 \qquad \dfrac{\dfrac{\dfrac{x_2 : (p_1 \to p_6) \to p_7 \to p_8 \qquad \dfrac{\dfrac{z_2 : ((p_2 \to p_3) \to p_5) \to p_6 \qquad \dfrac{\dfrac{\dfrac{x_3 : p_3 \to p_4 \to p_5 \qquad \dfrac{z_3 : p_2 \to p_3 \qquad \dfrac{x_4 : p_1 \to p_2 \quad w : p_1}{p_2}{\scriptstyle\to E}}{p_3}{\scriptstyle\to E}}{p_4 \to p_5}{\scriptstyle\to E} \qquad u : p_4}{p_5}{\scriptstyle\to E}}{(p_2 \to p_3) \to p_5}{\scriptstyle\to I,z_3}}{p_6}{\scriptstyle\to E}}{p_1 \to p_6}{\scriptstyle\to I,w}}{p_7 \to p_8}{\scriptstyle\to E} \qquad v : p_7}{p_8}{\scriptstyle\to E}}{(((p_2 \to p_3) \to p_5) \to p_6) \to p_8}{\scriptstyle\to I,z_2}}{p_9}{\scriptstyle\to E}}{p_7 \to p_9}{\scriptstyle\to I,v}}{p_4 \to p_7 \to p_9}{\scriptstyle\to I,u}}{p_{10}}{\scriptstyle\to E}}{(((((p_2 \to p_3) \to p_5) \to p_6) \to p_8) \to p_9) \to p_{10}}{\scriptstyle\to I,z_1}$$

which is strictly weaker. It remains to be seen whether there are instances of the Mapping Problem involving linguistically natural word meanings for which the choice among different interpolants is significant.

The decision to base a learning algorithm on interpolation has repercussions on the question of what $\lambda$-terms can be possible word meanings. The algorithm can only find $\lambda$-terms $M^E[x_1^{A_1},\ldots,x_m^{A_m}]$ that are interpolants to themselves. In addition to (2), (4), (5), this rules out otherwise innocent-looking

$$\lambda u^{e\to t}.u\,\mathbf{John}^e, \quad \lambda v^{(e\to t)\to t}u^{e\to t}.\mathbf{seem}^{t\to t}(vu), \quad \lambda u^{e\to t}x^e.\mathbf{try}^{t\to e\to t}(ux)x,$$
$$\lambda v^{(e\to t)\to t}x^e.v(\lambda y^e.\mathbf{find}^{e\to e\to t}\,y\,x),$$

in favor of

$$\mathbf{John}^e, \quad \mathbf{seem}^{t\to t}, \quad \mathbf{try}^{t\to e\to t}, \quad \mathbf{find}^{e\to e\to t},$$

while allowing both of

$$\lambda v^{(e\to t)\to t}x^e.\mathbf{try}^{t\to e\to t}(v(\lambda y^e.\mathbf{find}^{e\to e\to t}\,y\,x))x, \quad \lambda y^e x^e.\mathbf{try}^{t\to e\to t}(\mathbf{find}^{e\to e\to t}\,y\,x)x.$$

(I ignore intensionality for simplicity.) While this may not exactly be the restriction one wants, some such restriction on the $\lambda I$-terms that can represent word meanings should add a welcome new perspective to type-logical semantics.

Even with the restriction to 'self-interpolants', my algorithm may not necessarily find the correct meaning. For instance, if the meaning of *seeks* is represented by an unanalyzed constant $\mathbf{seek}^{((e\to t)\to t)\to e\to t}$ rather than in terms of $\mathbf{try}^{t\to e\to t}$ and $\mathbf{find}^{e\to e\to t}$, from the *de re* reading of *John seeks a unicorn*

$$\exists^{(e\to t)\to t}(\lambda y^e.\wedge(\mathbf{unicorn}^{e\to t}\,y)(\mathbf{seek}^{((e\to t)\to t)\to e\to t}(\lambda u^{e\to t}.uy)\mathbf{John}^e)),$$

the algorithm finds Montague's

$$\mathbf{seek}_*^{e\to e\to t} = \lambda y^e.\mathbf{seek}^{((e\to t)\to t)\to e\to t}(\lambda u^{e\to t}.uy),$$

rather than $\mathbf{seek}^{((e\to t)\to t)\to e\to t}$, which may not be a desirable result. This and many other problems must be dealt with in order to achieve a successful generalization of Siskind's elegant approach to type-logical semantics. I will pursue this goal further in future work.


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# Embedded Definites

Cécile Meier*

## 1 Introduction

Unembedded definite descriptions induce existence and uniqueness assumptions. If we utter the sentence *the cat is sleeping* we have a context in mind where there is a unique cat that is sleeping. The classical analyses for definite descriptions differ with respect to the status of these existence and the uniqueness conditions. Russell's analysis captures *the* as an existential quantifier and the uniqueness condition is part of the truth conditions of *the* Frege proposed the definite article to be a (partial) function that is defined only if its argument is a singleton. The function, then, returns the element of that singleton.

Strawson proposed in "On Referring" that some definite descriptions could be used to *say something about* an individual and not to *refer to (or mention)* an individual. The example in (1) illustrates the two usages of *the greatest French soldier* he had in mind:

(1) a. Napoleon was the greatest French soldier.
b. Wellington met the greatest French soldier.

In (1-a) the definite description is used to say something about Napoleon and in (1-b) it is used to refer (or mention) to Napoleon. The sentence (1-a) is about one individual only, (1-b) is about two individuals. In this view, the definite article may have an additional, predicative meaning.[1]

In this paper, I am going to argue that not only definite descriptions in predicative position but also definite descriptions embedded in certain prepositional constructions might best be analyzed by means of a predicative denotation of the definite article. Consider the sentence in (2). In this construction, the definite *the golden edge* does not refer to an individual but says something about the mug I want, namely that it has a (unique) golden edge.

(2) I'll have the mug with the golden edge.

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1. See [10] for the discussion of the one-one correlation between the quantificational and the predicate meaning of the definite article and linguistic evidence for its existence.

The analysis of embedded definites as predicates, however, requires a reinterpretation of the embedding preposition in order to ensure compositionality.

The organization of the paper is as follows. To begin, I will discuss predicative characteristics of embedded definites. It will be shown that only embedded definites in constructions with non-relational head nouns do exhibit these charactersitcs. Constructions with relational head nouns do not.[2] Next, I will discuss an observation that goes back to at least [6]. Some embedded definites are not restricted to contexts where their uniqueness presupposition is satisfied. We will observe once more an asymmetry between constructions with relational and non-relational head nouns. Only the constructions with relational head nouns do project the uniqueness conditions triggered by the definite. Finally, I present the proposal for the interpretation of non-relational and relational definites.

## 2 Predicative Characteristics

It is well known that predicative definite descriptions differ from other NPs in several respects; see [10] and [5] among others. In the following, I will show that embedded definite descriptions do not license discourse anaphora. This fact will be considerd to be evidence for their predicative nature. Furthermore, I will show that genuine quantifier phrases may not occur embedded in complex nominal noun phrases headed by a non-relational noun. This is evidence for the predicative nature of this position in general.

*Discourse anaphora*: Usually proper names, definites and indefinites do license discourse anaphora. But definite descriptions in predicative position do not, as in (3-a). Compare the acceptability of the sequence in (3-b) with a non-predicative use of a definite.

(3) a. De Gaulle wasn't the greatest French soldier$_i$. # He$_i$ was Napoleon.
 b. De Gaulle did't meet the greatest French soldier$_i$. He$_i$ was already dead.

As for embedded definites, arguments of relational nouns seem to license discourse anaphora (4). Definites linked to non-relational nouns don't (5).

(4) a. The encounter with the bear was terrifying. It was extremely big.
 b. The journalist's book appeared in 1993. He wrote it on a train.

(5) a. The rabbit in the hat was gray. #It was black.
 b. The lady with the dog is a princess. #It is extremely big.

2. Basically, I will follow the typology of [1]. He distinguishes relational nouns - derived nominals (*purchase*, *destruction*), kinship terms (*child*, *daughter*), body-part terms (*nose*), part-whole relations (*top*, *border*) and other more arbitrary relational nouns like *pen pal* - from non-relational nouns (*cat*, *yogurt*, *rabbit*, *hat*). Genuine possessive relations are usually found with non-relational nouns. The subclasses are evidenced syntactically in English. But see also the discussion of noun classification and argumenthood in [8].



This fact is easily explained if we assume that definites embedded in non-relational heads are interpreted as predicates.

*Quantifying into modifiers and arguments of non-relational nouns*: Quantifiers were observed to be unacceptable in predicative positions; see [5] and the references there.

(6) a. #Sam and Lisa are not few students.
 b. #John is every lawyer.

If (i) the observation is correct that genuine quantifiers do not occur in predicative positions and (ii) definite descriptions in PP-modifiers in definite non-relational constructions were predicative, we expect that quantifiers only be licit in constructions with relational nouns. Consider first the examples with non-relational head nouns as in (7). (7-a) is anomalous even if we imagine a situation where a unique student that is participating in most classes has the best grades. (7-b) does not have a sensible narrow scope reading. (7-c) is acceptable if we assume that we have a set of baskets (some of them broken) that are filled with one apple each. This sentence has the reading that every rotten basket is such that the unique apple in it is also rotten. The quantifier gets wide scope with respect to the definite description. This reading is only possible if the embedded quantifier is heavily stressed.

(7) a. #The student in most classes has the best grades.
 b. #The people from every walk of life like jazz. [4, p. 405]
 c. The apple in every bróken basket is rotten. (The other apples are still fine.)

Poesio (1994) discusses examples with an indefinite embedded in a definite non-relational noun, as in (8), that seems to be fine.

(8) I got these data from the student with a brown jacket.

Constructions with a relational head noun on the other hand are unproblematic, as illustrated in (9). These examples are well known from the literature on so-called inverse-linking constructions: see [4], and [11] and the references there.

(9) a. We witnessed the destruction of every city.
 b. I got these data from the student of a linguist.

They either show a narrow scope reading or a wide scope reading. Note that in these examples the uniqueness condition on the first definite may not be satisfied. There might be more than one event of destruction, more than one mother and more than one student contextually salient.

In sum, it is the semantics of the sentences that decide if there is a sensible narrow scope reading for the sentences in question and even if there is a narrow scope reading genuine quantifiers are not licit in constructions with non-relational head nouns. Wide scope readings are only possible if the embedded quantifier is heavily stressed. Disregarding stress patterns, the definites embedding quantifiers pattern with the genuine predicative constructions.

## 3 Uniqueness conditions

Complex NPs with relational and non-relational head nouns, respectively, differ in (at least) one more respect. Whereas embedded definites in the former seem to induce uniqueness conditions, those in the latter do not.

Consider the following situation: *There are two relevant rabbits; one of the rabbits is sitting in a hat and the other one is hopping around on the floor; a second hat is empty.* The sentence in (10) with a non-relational head noun *rabbit* may be used felicitously in this situation.

(10) The rabbit in the hat is gray.

However, the uniqueness condition induced by *the hat* is not satisfied.

Constructions with a relational head noun seem to behave differently. Consider the following scenario: *The Romans destroyed first a little village and then a big city. But another city on the other side of a river, they left intact.* The sentence in (11) is however not a smooth continuation in this scenario.

(11) The destruction of the city occurred at midnight.

Note that the acceptability of (11) improves significantly if we omit the information on the intact city. The construal of the two scenarios are parallel. Instead of two events of destruction we have two rabbits and instead of two cities we have two hats. Nevertheless, omitting the information that the second hat is empty in the rabbit scenario does not improve the acceptability of (10).

It is obvious that the classical theories cannot explain the asymmetry between constructions with a relational noun and a non-relational noun. A referentialist or a Russellian account makes better predictions for the truth conditions of relational constructions. The sentence in (10), however, is predicted to be false on Russell's account in the given scenario, and on Frege's it is undefined.[3]

The theory by [9] of presupposition projection for DRT fairs better since his mechanism for the translation of presuppositions of definite descriptions ignores the classical uniqueness condition. Uniqueness is not a necessary condition for the successful interpretation of a definite. He is following [7, 234f] who captures uniqueness as a side effect of the hearer's task of identifying the

3. I mention two repair strategies from the literature to explain the acceptability of the rabbit sentence: restrictions on domain selection and hidden parameters. See [3] for a successful use of these strategies. But in our case, we have neither good (psychological) arguments to exclude the empty hat from the individual domain in the first scenario nor can we assume that hidden parameters restrict the choice of the referent of the hat to the hat that has a rabbit in it without getting circular.



discourse referent (or file card) for the definite description. In this theory, the empty hat is ruled out as a good candidate for the referent of *the hat* in (10) by the assumption that the speaker is acting cooperatively. An empty hat cannot contain a rabbit. Therefore the complex NP *the rabbit in the hat* would not get a referent if the hearer chose the empty hat as a referent and the interpretation of the whole sentence is bound to crash. In particular, it is some version of Gricean reasoning (the first maxime of quality: Don't say what you believe to be false [or undefined]) that does the job and not familiarity, salience or prominence. This theory has problems to explain the oddity of the cases with the relational head nouns. Furthermore, it cannot explain, why discourse anaphora is not possible in those cases.

## 4 A Syntax and Semantics for embedded predicative defininte descriptions

*Syntax*: In order to account for the felicity of the utterance of (10) in the context in question, I assume that the preposition *in* combines in a first step with the definite article that is most deeply embedded[4], in a second step, with the embedded noun *hat*, and in a third step with the noun *rabbit* to give a predicate that itself is an argument of the topmost *the.*

(12) $[_{NP}$ the $[_{N}$ rabbit $[_{P}$ in the$]$ hat$]]$ is gray.

*Semantics*: The definite article has the following meaning. It combines with a property to give a property. This "reading" is usually relevant for the predicative uses of definite descriptions.

(13) $[\![\mathbf{the}_{pre}]\!] = \lambda P.\lambda x.P(x) \ \& \ \forall y[P(y) \Rightarrow x = y]$

In order to combine the preposition with a definite article, I amend the denotation for *in* as in (14).

(14) $[\![\mathbf{in}]\!] = \lambda D_{<<e,t>,<e,t>>}.\lambda P_{<e,t>}.\lambda Q_{<e,t>}.\lambda x.Q(x) \ \&$
$\exists y[D(\lambda z.x\text{in}z \ \& \ P(z))(y)]$

Therefore, I predict that the constituent *rabbit in the hat* denotes the property of being a rabbit that is in a unique hat.

(15) $[\![\mathbf{rabbit\ in\ the\ hat}]\!] =$
$\lambda x.\text{rabbit}(x) \ \& \ \exists y[x\text{in}y \ \& \ \text{hat}(y) \ \& \ \forall z[x\text{in}z \ \& \ \text{hat}(z) \Rightarrow y = z]]$

The truth conditions predict that the utterance of (10) is felicitous in a situation like our original situation but where there is an additional rabbit sitting in two hats.

4. The composition of the definite article and a preposition is witnessed at the level of surface structure in German for example by contraction phenomena: *in* + *dem*(def.det.dat.) → *im*.

As for constructions with relational nouns, I follow basically [2, p. 5]. Relational nouns are interpreted as predicates with at least two arguments and a theta role is considered as a lambda operator binding a variable at the level of logical form.

(16) $[\![\textbf{destruction}]\!] = \lambda y.\lambda x.\lambda e.e$ is an instance of $x$ destroying $y$[5]

In this sense, we may make our generalizations discourse anaphora and on missing uniqueness conditions more precise. It seems to be the case that we observe missing uniqueness conditions of embedded definites only if the definite does not satisfy a theta role of the head noun. Likewise, discourse anaphora is possible if the referent satisfies a theta role. And it becomes clear what explains the asymmetric behaviour between relational nouns and non-relational nouns. Embedded definites in non-relational nominal constructions are predicates. They do not introduce discourse referents.

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5. Unsaturated arguments get bound by default existential closure.



# Nominalization in Russian: eventuality types and aspectual properties

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**Abstract**

The paper surveys aspectual classes of deverbal nouns in *-nije/tije* in Russian. The most puzzling phenomenon is that there is a class of nouns that allow, unlike corresponding verbs, for both telic and atelic interpretations. The analysis of this phenomenon consists of two parts. For imperfective-based nominals, a hybrid aspectual behaviour is explained by assuming the IPFV operator that maps events from the original extension of a verbal predicate into their non-necessarily proper parts. For 'perfective-based' nouns, the vast majority of which are degree achievements, we suggest, first, that stems they are derived from are not perfective, and, secondly, assume that their telicity is determined by the difference value associated with a property that undergoes change in the course of the event.


## 1 Diagnostics

The aim of this paper is to identify main aspectual classes of deverbal nouns in *nije/tije* (e.g., *govorenije* 'speaking', *otkryvanije* 'opening') in Russian, to find out what motivates class membership of a particular noun, and to offer an analysis that relates that membership to eventuality types and aspectual properties of verbs a noun is derived from.

While telicity and atelicity of verbal predicates can be detected by the test on co-occurrence with time span and measure adverbials (e.g., *za dva chasa* 'in three hours' vs. *tri chasa* 'for three hours'), for nouns we adopt two main tests. First, adjectives like *trekhdnevnyj/trekhchasovoj* 'lasting for three days/hours' are only compatible with atelic nouns: **trekhshasovoje ograblenije* 'robbing that lasts for three hours' vs. *trekhdnevnoje khranenije* 'storing that lasts for three days'. Secondly, only telic nouns can show up as subjects of *zanimat'* *<time>* 'occupy, take' or *proiskhodit' za* *<time>* ('happen'): *Ograblenije banka zanjalo pjat' minut* '*lit.* robbing the bank took five minutes' vs. *??Khranenije bagazha zanjalo tri dnja* 'lit. storing the luggage took three days'.

## 2. Aspectual classes

Applying the above diagnostics to the whole set of Russian deverbal nouns in *-nije/tije* results in tripartition, with nouns falling within one of the following classes: atelic, telic, and mixed. Nouns like *noshe-nije* 'carrying, wearing', *nabljude-nije* 'observing', *khrane-nije* 'storing' only allow for the atelic reading. Telic nouns are only compatible with telic interpretation: *ograble-nije* 'robbing', *napisa-nije* 'writing to completion' (see examples


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above). The most numerous, however, is the mixed class containing nouns which show both telic and atelic reading, e.g. *raspiliva-nije* 'sawing', *vspakhva-nije* 'ploughing', *napolne-nije* 'filling'. Cf. *dvukhchasovoje raspilivanije dereva* 'sawing a tree for two hours' vs. *Raspilivanije dereva zanjalo dva chasa* 'it took two hours to saw a tree'.

## 3. Aspectual composition

The first puzzle to be addressed is that of aspectual composition. The way telicity/atelicity of deverbal nouns interact with quantization/cumulativity of incremental arguments ([1], [2], [3]) differs radically from corresponding interaction between verbs and arguments.

Perfective verbs produce familiar quantificational effect on the Incremental Theme ([4], [5], [6]): undetermined plural and mass NPs (e.g. *pis'ma* 'letters' in *napisat' pis'ma* 'write the||$^{??}$∅ letters') refer to a specific quantity of letters identified in the preceding discourse; the bare plural reading of the Incremental Theme is inappropriate. In contrast, aspectual composition in case of deverbal nouns is much the same as that in languages like English where cumulative arguments yield cumulative verbal predicates. Unlike in *Vasja vypil pivo* 'Vasja drank (all the) bear', the internal argument *piva* 'beer' in *Posle dvukhchasovogo vypivanija piva Vasja sovsem soshel s katushek* 'After drinking beer for two hours Vasja ran amok' can be interpreted as cumulative. (Of course, if *piva* 'beer' refers to a specific quantity of beer, ιx.**beer**(x), telic interpretation results: *Vypivanije piva zanjalo dva chasa* 'Drinking (this particular quantity of beer) took two hours').

Telic and mixed nouns differ as to the range of interpretations they have when combined with quantized arguments. Mixed nouns allow atelic reading as one of the possibilities, telic nouns do not: *dvukhchasovoje raslilivanije brevna/ dvukh breven / etikh breven* 'sawing a log / two logs / these logs for two hours' vs. **dvukhchasovoje vskrytije trupa/dvukh trupov/ etikh trupov*. Therefore, two questions arise:

Q1 Where does the difference between 'nominal' and verbal aspectual composition come from?

Q2 In case of mixed nouns, how can we explain atelic reading of nouns that take quantized arguments?

## 4 Morphological aspect and eventuality type

Other puzzles emerge if one examines relations between the morphological aspect of a verb, aspectual class of a verbal predicate and aspectual class of a corresponding noun, summarized in Table 1.

Table 1.

<table>
<tr><td>Morphological aspect of a verbs</td><td colspan="3">imperfective</td><td colspan="2">perfective</td></tr>
<tr><td>Aspectual class of a verbal predicate</td><td>state</td><td>process</td><td colspan="3">event</td></tr>
<tr><td>Aspectual class of a deverbal noun</td><td colspan="2">atelic</td><td colspan="2">mixed</td><td>telic</td></tr>
</table>



Two straightforward generalizations can be drawn from the table. First, if a verbal predicate denote an atelic eventuality, a state or a process, so does a derived noun. This is the case with verbal predicates based on imperfective incremental verbs combined with cumulative arguments (*raspilivanije derevjev* 'sawing trees'), as well as with lexically stative or atelic verbs (*side-nije* 'sitting', *cvete-nije* 'flowering'). Since preserving properties of a corresponding verb is a null hypothesis about deverbal nouns, this distribution is not unexpected.

Secondly, if a deverbal nominal is telic, it is derived from a perfective verb (*ograble-nije banka* 'robbing of a/the bank', *vzjatije goroda* 'capturing a/the city'). Again, given that perfective verbal predicates are telic, yielding telic nouns can be expected for them. What requires explanation is the distribution of members of the mixed class. Particularly, we have to answer questions Q3 and Q4.

Q3 Why do perfective verbs fall into two classes as to whether they yield telic or mixed nouns?

Q4 Why do imperfective verbal predicates denoting events yield mixed deverbal nouns?

## 5 Perfectivity and telicity

To answer Q1, Q2 and Q3 we need to take a finer look at nouns derived from perfective verbs. Two observations are crucial.

First and foremost, it is not a verbal prefix which is responsible for the quantificational effect on the internal argument of a verb: when nouns like *na-pisa-nije* 'PRF-writing' are build, the prefix is already there, but the range of interpretations of the argument is not restricted in the same way as that of an argument of a finite verb built from the same prefixed stem.

Secondly, contrary to what many aspectologists suggest, a verbal prefix is not an exponent of the perfective operator (cf. [6]). Compare perfective verbs *napolnit'* 'fill' and *napisat'* 'write, write down' with corresponding deverbal nouns *napolne-nije* 'filling' (mixed) and *napisa-nije* 'writing down' (telic): both perfective verbs are telic, but nouns differ as to the acceptability of atelic interpretation. Again, deverbal nouns are built when the prefix is already present; if it introduces the perfective operator, whatever the operator is, we do not expect to find any aspectual variability of nouns like *napolne-nije* 'filling'. Perfectives in Russian are unambiguous, so if stems from which nouns are built are perfective already, there is no way for nouns to escape being the same as corresponding verbs.

We suggest, therefore, that a prefixed stem of nouns like *napisa-nije* and *napolne-nije* are derive are not perfective, that the perfective operator comes into play after such nouns are formed, and that difference between them must be found in their event structure, identified independently from perfectivity.

The semantic contribution of prefixes, we suggest, can be characterized in terms of event structure formation/modification. In particular, prefixes map activity stems like *pis-* 'write' ($\lambda x \lambda e$ [write(x)(e)]) into accomplishment (= causative) stems like *na-pis-* 'write, write down' ($\lambda x \lambda s \lambda e$[plow(x)(e) $\wedge$ cause(e)(s) $\wedge$ plowed(x)(s)]).

An evidence supporting this analysis is that whereas non-prefixed verbs can occur without an object, prefixed ones cannot. As Levin and Rappaport Hovav argue ([7] and a few subsequent papers), verbs possessing an accomplishment event structure differ from those with an activity event structure in that the latter but not the former goes without a specific result state associated with the internal argument, hence can occur without the direct object[1].

On the assumption that at this stage of derivation we are dealing with pure event structure, without additional restrictions imposed by perfectivity[2], an answer to Q1 falls out for free. Perfectivity, an alleged source of quantificational effects on the internal argument, has not entered the scene when nouns like *napisa-nije*, *napolne-nije* and *otkrytije* are formed, so nothing prevents nominal predicates *pis'ma* 'letters' in *napisa-nije pisem* 'PRF-writing letters' or *sok* 'juice' in *vypiva-nije soka* 'PRF-drinking juice' from being either cumulative (λx.juice(x)), or quantized (ιx.juice(x)).

Prefixed stems from which deverbal nouns are formed fall into two main classes: incremental and non-incremental (see [3]). *Napisa-* and *napoln-* both denote incremental relations in which the part structure of some entity is mapped into the part structure of the event. With stems like *napoln'-*, there is one-to-one correspondence between the event and a scaleable property associated with the verb (e.g. 'full'); in case of *napis'-*, spatial extent of an individual corresponds to temporal progress of the event. Example of non-incremental deverbal noun formed from a 'perfective' stem is *otkrytije*; with relations like *otkry-*, neither Krifka's Mapping-to-subobjects, nor Mapping-to-subevents are met.

The solution to Q3 begins to emerge if one observes that deverbal 'mixed' nouns derived from prefixed stems are all incremental verbs involving change of a gradable property (a.k.a. degree achievements, [9], or gradual completion verbs), e.g. *napolne-nije* 'filling', *ugluble-nije* 'deepening'. At this point, we can apply Hay et al.'s [10] line of argument to explain their aspectual variability.

Hay et al. claim that the semantic representation of incremental change of state verbs like *lengthen* involves a difference value, that is, a measure for the amount of change of a relevant gradable property. Hay et al. predict that a degree achievement should have a telic interpretation if the difference value corresponds to a bounded measure of change, and an atelic interpretation otherwise. This accounts straightforwardly for the aspectual variability of nouns in *nije/tije* based on degree achievement stems. At the same time, lack of atelic readings of nouns based on other

1 We do not take up a challenging question about whether this modification occurs in the syntax, a point which is much under dispute this time, see [12]. Traditionally, prefixation is regarded as derivation, not as an inflection; Filip ([5], [6]) provides further arguments for this view, which is much in the spirit of Rappaport and Levin's proposal, as opposed, e.g., to [17], [18].

2 At this stage, passive participles which share morphology with deverbal nouns (see [13], [14]; cf. *izgotovl-e-n* 'manufacture , part. pass' — *izgotovl-e-n-ij-e* 'noun' vs. *otkry-t* 'open, part. pass' — *otkry-t-ij-e* 'noun') can also be built. To get a past participle, we need a stativizer λRλs∃e [R(s, e)] that existentially binds the event variable introduced by the verbal stem yielding a property of states (see [15] relying on [16]). In contrast, to continue with the derivation of nouns which only have the eventive reading, an eventizer λRλe∃s [R(s, e)] must apply. Note that *-n/t* shared by nouns and participles does not in itself mark a stem as either stative or eventive.



incremental 'perfective' stems (e.g. *napisa-nije* 'writing') suggests that Hay et al.'s proposal for degree achievements cannot be easily extended to the incremental verbs taking effected, affected, or consumed objects[3].

## 5 Imperfectivity and atelicity

To answer Q4 we have to observe that imperfective-based nominals fall into two morphological classes. Nouns like *pisa-nije* 'writing' are formed from a non-prefixed stem *pis-* which is, we assume, is atelic from the very beginning. Accordingly, its atelic reading does not require explanation, while the telic one, evidently, emerges as an entailment that follows from the incrementality of the relation 'write'. Nouns like *raspiliva-nije* 'sawing' contains the imperfective suffix *–(y)va* attached to a prefixed stem. Semantically, *-(y)va* can be characterized as an exponent of the imperfective operator; we adopt a non-modal mereological version of this operator that maps events from the original extension of a predicate into their non-necessarily proper parts ||IPFV|| = λPλe'∃e[P(e) ∧ e'≤ e]. Quantized predicates like *vs-pakh- pole* 'PRF-plow field:ACC' (λe∃s[plow(field)(e) ∧ cause(e)(s) ∧ plowed(field)(s)]) are mapped into cumulative ones (λe'∃e ∃s[plow(field)(e) ∧ cause(e)(s) ∧ plowed(field)(s)] ∧ e' < e). This gives rise to the atelic interpretation. At the same time, non-necessarily proper part relation '≤' in the representation of IPFV guarantees that 'complete' eventualities are also in the denotation of the predicate, thus explaining its telic reading. This analysis predicts that all nouns derived *(y)va*-stems belong to the mixed class. This prediction seems to be correct. Even imperfective causative verbs like *raz-bi-va-t'* 'break' produce nouns which allow for the atelic readings, as in *dvukhchasovoje razbiva-nije vasy iz nebjushchegosia stekla* ('attempts to break a vase made of unbreakable grass that lasted for two hours'). A clear advantage of this analysis is that it is consistent with want is proposed for Slavic imperfectivity in general (see [5], [6], [11]) and no idiosyncratic properties of deverbal nouns must be stipulated.

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3 At present, we leave open a question about what exactly the perfective operator should look like. Our assumptions outlined so far do not impose any specific conditions on it. No matter at which stage of derivation the perfectivity is introduced and what its morphological exponent is, it has to account, first, for obligatory telicity of perfective verbs and, secondly, for quantificational effects on their arguments. Possible candidates are, among others, Pinon's [11] perfecitve operator and Kratzer's [17] telicizer; both rely on the requirement that every part of the internal argument must participate in a situation: λRλxλe [R(x)(e) & ∀x' [x' < x → ∃e' [e' < e & R(x')(e')] ] ]. Alternatively, the perfective operator can be conceived of as imposing maximality condition on events with respect to event descriptions: Max(e, P) ↔ ¬∃e'[P(e') ∧ e< e']. Note that if the perfective operator picks up maximal events, for degree achievements this seems to exclude those events in which the amount of change of the gradable property is less than maximal. Evidently, this would be a desired result.

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# Universal and Existential Readings of Donkey-Sentences and the Role of a Structural Form of Domain Restriction in the Explanation of Some Distributional Anomalies

**Fabio Del Prete***

**Abstract**

I propose that a particular form of quantifier domain restriction is responsible for the unexpected readings of some donkey-sentences. The pragmatic restrictions that I take into account are shown to be recoverable from the linguistic structure of the sentences involved, according to a syntactic algorithm. Making domain restrictions explicit at LF enables one to keep both quantifying determiners and donkey-pronouns unambiguous, and to preserve monotonicity properties of quantifiers.

## 1 Two types of reading

The problem that I consider in this paper concerns the distribution of universal and existential readings of donkey sentences. This problem has to do with the interpretive patterns of sentences like (1) and (2), as they are schematized in (1') and (2'):

(1) Every farmer who owns a donkey beats it.

(1') $\text{EVERY}_x$ [farmer($x$) $\wedge$ $\exists y$ (donkey($y$) $\wedge$ own($x$, $y$))] [$\forall y$ ((donkey($y$) $\wedge$ own($x$, $y$)) $\rightarrow$ beat($x$, $y$))]

(2) No farmer who owns a donkey beats it.

(2') $\text{NO}_x$ [farmer($x$) $\wedge$ $\exists y$ (donkey($y$) $\wedge$ own($x$, $y$))] [$\exists y$ (donkey($y$) $\wedge$ own($x$, $y$) $\wedge$ beat($x$, $y$))]

The two formulas, which I assume to give the most natural interpretations of (1) and (2), make it clear what the semantic difference between these sentences amounts to: (1) is interpreted as involving universal quantification over donkeys owned by any farmer $x$, while (2) as involving existential quantification over the same domain. I will say that a sentence $\alpha$ has a *universal* (*existential*) reading, whenever the matrix formula in $\alpha$'s first-order translation is universal (existential).

The fact that (1) and (2) have different semantic construals may seem to posit a threat to a compositional analysis, given their formal identity up to their lexical determiners. In the semantic framework I adopt, based on Kanazawa's Dynamic Generalized Quantifiers (DGQs), the alternation of universal and existential matrices does not constitute *per se* a challenge for compositionality, as long as it can be seen as a reflex of distinct types of dynamics associated univocally to distinct types of determiners. In the case of (1) and (2), we translate the quantifying determiners 'every' and 'no' by means of DGQs with different dynamic properties; more exactly, the dynamic counterparts of the static generalized quantifiers 'EVERY' and 'NO' are defined on the basis of the following schemes[1]:

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(A) $Q^{\forall}_x [\varphi(x)] [\psi(x)] \quad =_{def} \quad Q_x [\varphi(x)] [\varphi(x) \rightarrow \psi(x)]$
(for the dynamic counterpart of 'EVERY')

(B) $Q^{\exists}_x [\varphi(x)] [\psi(x)] \quad =_{def} \quad Q_x [\varphi(x)] [\varphi(x) \wedge \psi(x)]$
(for the dynamic counterpart of 'NO')

If we take '$\varphi(x)$' = '$\exists y \alpha(x, y)$' (where the existential quantifier is defined as in DPL) and '$\psi(x)$' = '$\beta(x, y)$' (where the latter meta-formula is quantifier free), we get into the donkey case; the dynamic effects of our two DGQs will come down to the following:

(a) $EVERY^{\forall}_x [\exists y \alpha(x, y)] [\beta(x, y)]$
(b) $\text{EVERY}_x [\exists y \alpha(x, y)] [\exists y \alpha(x, y) \rightarrow \beta(x, y)]$
(c) $\text{EVERY}_x [\exists y \alpha(x, y)] [\forall y (\alpha(x, y) \rightarrow \beta(x, y))]$

(d) $NO^{\exists}_x [\exists y \alpha(x, y)] [\beta(x, y)]$
(e) $\text{NO}_x [\exists y \alpha(x, y)] [\exists y \alpha(x, y) \wedge \beta(x, y)]$
(f) $\text{NO}_x [\exists y \alpha(x, y)] [\exists y (\alpha(x, y) \wedge \beta(x, y))]$

I.e., we will have universal quantification of the donkey variable in the first case, and existential quantification of the same variable in the second. The difference in the quantificational structure is explained in this approach as one that comes down in the end to a difference in the dynamic properties of some lexical items (namely, quantifying determiners).

## 2 Anomalies for a monotonicity-based theory

Kanazawa shows that the choice of translating 'every' and 'no' by means of DGQs with different properties of dynamic binding is motivated by a *principle of monotonicity preservation*, for whose discussion I refer the reader to Kanazawa (1993). According to Kanazawa's theory of DGQs (hereafter, KDGQ), the distribution of universal and existential readings is indeed expected to correlate with monotonicity patterns of determiners. This is a prediction which has a significant amount of evidence in its favour. However, there are well known distributional phenomena that seem to undermine KDGQ. I am referring to some anomalous variations in reading-type that have been observed for donkey sentences with the same initial determiner. I will be concerned with the following representative pair:

(3) Every student who borrowed a book from the library returned it on time.
(3') $\text{EVERY}_x [\text{student}(x) \wedge \exists y (\text{book}(y) \wedge \text{borrow}(x, y))] [\forall y ((\text{book}(y) \wedge \text{borrow}(x, y)) \rightarrow \text{return}(x, y))]$
(4) Every person who had a credit card paid the bill with it.
(4') $\text{EVERY}_x [\text{person}(x) \wedge \exists y (\text{card}(y) \wedge \text{have}(x, y))] [\exists y (\text{card}(y) \wedge \text{have}(x, y) \wedge \text{pay-with}(x, y))]$

Intuitively, (3) and (4) get different types of reading, formalized by (3') and (4') respectively. This might strike one as a refutation of KDGQ, given that these sentences are construed with the same quantifying determiner 'every', which is translated unambiguously as the DGQ '$EVERY^{\forall}$'. (4) clearly

[1] 'Q' stands for the static quantifier corresponding to some determiner $\delta$, and '$\rightarrow$', '$\wedge$', denote DPL's implication and conjunction.



receives the existential reading (4'), thus it seems to require a different dynamic counterpart for 'EVERY', namely one that give the existential binding of donkey variables. An existential counterpart of 'EVERY', such as the one introduced through the scheme (B), would do the work. But such a quantifier would not preserve the full monotonicity pattern of 'EVERY'. Moreover, if we let in this new hypothetical quantifier, we would have two different interpretations for the same lexical item 'every', as long as we would still need the old '$EVERY^{\forall}$' in order to generate the intuitive readings of sentences like (1) and (3). We would end in putting a lexical ambiguity in quantifying determiners, what seems an unlikely result.

My thesis is that variation in reading-type displayed by the pair (3), (4), is a surface phenomenon, something that does not bear on the underlying semantics neither of determiners nor of pronouns. The fact that (4') provides a suitable formalization of (4)'s most natural reading, does not force us to recognize an existential construal of (4) in the grammar. Indeed, (4') can be taken as nothing more than the formal correlate of a 'lazy' paraphrase: 'every person who had a credit card paid the bill with *a credit card she/he had*'. My claim is that (4') conceals the underlying LF-structure of (4), and that the latter involves universal binding of the donkey pronoun, as predicted by KDGQ. According to this view of the matter, the problem with (4) comes down to determine what we must take the restrictor formula to be in the LF representation ($4_{LF}$):

($4_{LF}$) $EVERY^{\forall}_x [\exists y \alpha(x, y)] [\text{pay-with}(x, y)]$

An LF representation such as this would be rightly considered to have too strong consequences only under the tacit assumption that its restrictor '$\exists y \alpha(x, y)$' be determined on the exclusive ground of the nominal restriction 'person who had a credit card'. In that case, ($4_{LF}$) would be identical to the formula ($4_{LF}$'), that would reduce in turn to ($4_{LF}$''), by definition of '$EVERY^{\forall}$':

($4_{LF}$') $EVERY^{\forall}_x [\exists y (\text{person}(x) \wedge \text{credit-card}(y) \wedge \text{have}(x, y))] [\text{pay-with}(x, y)]$
($4_{LF}$'') $\text{EVERY}_x [\text{person}(x) \wedge \exists y (\text{card}(y) \wedge \text{have}(x, y))] [\forall y ((\text{card}(y) \wedge \text{have}(x, y)) \rightarrow \text{pay-with}(x, y))]$

This is too strong, insofar it predicts that a person $x$ who had three credit cards used each of his/her credit cards to pay the bill. The fact that $x$ used just one of his/her credit cards to pay the bill would suffice to falsify formula ($4_{LF}$'), but it would not be taken as evidence against sentence (4). The conclusion I draw from these facts is not that a different dynamic counterpart of 'EVERY' has to be introduced into our theoretical frame, but that a different restrictor formula must be in place in the case at hand. Before saying what I claim the quantifier restriction to be exactly, and how the extended restriction is determined on the present view, let me expand a bit on the basic idea through a brief discussion of a different example. Let's consider the following sentence:

(5) Every townsman puts his bicycle in front of the station.
(5') $\text{EVERY}_x [\text{townsman}(x)] [\text{THE}_y [\text{bicycle}(y) \wedge \text{of}(y, x)] [\text{put-in-front-of-the-station}(x, y)]]$

Here the presupposition triggered by the definite 'his bicycle' calls for accommodation at some level of the information structure. The minimal option is to accommodate the presupposition at the level of the quantifier domain restriction. The output of such a process would be as follows:

(5'') $\text{EVERY}_x\,[\text{townsman}(x) \wedge \exists! y\,(\text{bicycle}(y) \wedge \text{of}(y, x))]\;[\text{THE}_y\,[\text{bicycle}(y) \wedge \text{of}(y, x)]\;[\text{put-in-front-of-the-station}(x, y)]]$

We can devise a formal procedure operating in cases similar to (5), with a definite NP occurring in the VP of a quantified sentence. In general, the presuppositions of the definite NP are accommodated so as to restrict the domain of the quantified subject, according to a rule like (R):

(R) $Q_x\,[\varphi(x)]\,[\psi(x, (\iota y)(\zeta y))] \;\Rightarrow$

$\Rightarrow\; Q_x\,[\varphi(x) \wedge \exists! y \zeta(x, y)]\,[\psi(x, (\iota y)(\zeta(x, y)))]$

The upshot of integrating the definite's presuppositions into the quantifier's restriction is that they get bound in the resulting structure; we want indeed everything to be bound in our semantic representations. Accommodation at the level of the quantifier domain is not the only available option in a case such as (5); it is of course open to us to accommodate higher in the information structure. Anyhow, (5'') is the most general solution to the binding problem, one that is logically compatible with accommodating higher. This example should point to the possibility of syntax-driven pragmatic processes such as the projection schematized in (R).

## 3 Structural Domain Restriction

I propose that the proper treatment of the anomalous reading of (4) has to keep track of a pragmatic process of accommodation at LF. An utterance of (4) will be accompanied in the most natural cases by a presupposition to the effect that every person used at most one credit card to pay his/her bill. We may take ($\pi$) as the LF of such a presupposition:

($\pi$) $\forall x\,[(\text{person}(x) \wedge \exists y\,(\text{card}(y) \wedge \text{have}(x, y))) \rightarrow \exists y\,(\text{card}(y) \wedge \text{have}(x, y) \wedge \forall z((\text{card}(z) \wedge \text{have}(x, z) \wedge z \neq y) \rightarrow \neg\text{pay-with}(x, z)))]$

($\pi$) is integrated at the level of the restrictor formula in (4)'s LF. The effect of this process can be dynamically represented as follows[2]:

($4_{LF}$) $\mathit{EVERY}^{\forall}{}_x\,[\exists y(\text{person}(x) \wedge \text{credit-card}(y) \wedge \text{have}(x, y))]\;[\text{pay-with}(x, y)]$

$$(4_{LF1})\;\mathit{EVERY}^{\forall}{}_x \left[\begin{array}{l}\text{person}(x)\\ \exists y(\text{card}(y)\wedge\text{have}(x, y))\\ (\pi)\end{array}\right][\text{pay-with}(x, y)]$$

(from ($4_{LF}$), by accommodation of ($\pi$) at the restrictor level)

$$(4_{LF2})\;\mathit{EVERY}^{\forall}{}_x \left[\begin{array}{l}\text{person}(x)\\ \exists y(\text{card}(y)\wedge\text{have}(x, y))\\ \mathbf{\exists y(card(y)\wedge have(x, y)\wedge\forall z((card(z)}\\ \mathbf{\wedge have(x, z)\wedge z\neq y)\rightarrow\neg pay\text{-}with(x, z)))}\end{array}\right][\text{pay-with}(x,y)]$$

(from ($4_{LF1}$), by elimination of '$\forall x$' and application of *modus ponens*)

[2] In the logical formulas and in the subsequent paraphrase I specify the adjoined predicate in boldface, in order to mean that it is contextually integrated. I also give the relevant LFs in a non-linear notation; in this notation, the lines in the restrictive part of a KDGQ-formula have to be interpreted as dynamically conjoined in the top-down order.



$$(4_{LF3})\;\mathit{EVERY}^{\forall}{}_x \left[\begin{array}{l}\text{person}(x)\\ \exists y(\text{card}(y)\wedge\text{have}(x, y))\\ \mathbf{\forall z((ca(z)\wedge ha(x, z)\wedge z\neq y)\rightarrow\neg pay\text{-}with(x, z))}\end{array}\right][\text{pay-with}(x, y)]$$

(from ($4_{LF2}$), by splitting of the third restrictor-formula into an existential and a universal formula, and elimination of the existential component)

The last formula corresponds to the verbal statement (4res), that can be seen, according to my view, as an explicit version of sentence (4), where the pragmatic restriction on the quantified NP is made overt.

(4res) Every person who had [a credit card]$_y$ **and didn't pay with any [other]$_y$ credit card he/she had** paid the bill with [it]$_y$.

The idea is that the restriction made explicit in (4res) is causally linked with the rising of what may be phenomenally described as an existential reading of (4). Indeed, such 'existential reading' construal of (4) comes down to be equivalent to the universal reading of (4res). Once we have recognized the equivalence relation between (4) and (4res), we are in a position to explain away the apparent existential reading of (4): this sentence is processed in context as (4res), whereas this latter sentence can be shown to have an unproblematic representation in KDGQ, namely ($4_{LF3}$); the latter formula does not have the unwanted consequence that a person $x$ who had five credit cards used all of them to pay the bill: if $x$ has a 'normal' behaviour (i.e. $x$ pays bills with no more than one credit card at once), then ($4_{LF3}$) predicts that $x$ paid his/her bill with a credit card. I could say, with a maxim, that the apparent existential reading of (4) is explained away as *universal reading + domain restriction.*

KDGQ should thus be integrated into a more powerful theory, where contextual effects of domain restrictions of the kind I have just considered are represented in LF without postulating *ad hoc* ambiguities. Such a theory produces LFs of the following kind for quantified sentences whatsoever:

($\Sigma$) $Qx_i\,[\varphi(x_i) \wedge (f(x_j))(x_i)]\,[\psi(x_i)]$

'$f$' and '$x_j$' are variables of type <e,<e,t>> and e, respectively. Hence, '$f(x_j)$' is a complex variable of type <e,t>[3]. This is called 'domain variable', since its values contribute to determine which is the exact domain of the quantifier '$Qx_i$'. '$f$' and '$x_j$' may be either free or bound to some quantifier which have semantic scope over them. When a donkey sentence $\alpha$ is modeled within the scheme ($\Sigma$), we will have that 'Q' stands for the right DGQ, while '$\varphi(x_i)$' stands for an existential formula '$\exists y\alpha(x, y)$'. Let's suppose that $\alpha$ have an anomalous reading for KDGQ. My generalized hypothesis is that this reading can be eliminated by assigning suitable values to '$f$' and '$x_j$', i.e. by suitably restricting the quantificational domain of $\alpha$. More exactly, in the overall structure modeling $\alpha$, the individual variable '$x_j$' gets dynamically bound to the existential quantifier translating the antecedent indefinite NP, while the interpretation of the functional variable '$f$' is driven by an algorithm defined on the LF associated with $\alpha$. The syntactic algorithm can be expressed as follows:

(SDR) $Q^{X}{}_x\,[\varphi(x) \wedge \exists y\psi(x, y) \wedge (f(y))(x)]\,[V'(x, y)] \;\Rightarrow$

$\Rightarrow\; \lambda y.\lambda x.\forall z((\psi(x, z) \wedge z \neq y) \rightarrow \chi(x, z))$

[3] For a justification of complex domain variables of this form, see Stanley & Szabó (2000).

The λ-expression is the value of '$f$'. The predicate '$\chi$' may stay alternatively either for the verb V of the main clause of $\alpha$ or for its negation $\neg$V. More exactly, the formula '$\chi(x, z)$' in the λ-expression will be identical to '$V'(x, z)$' whenever the DGQ '$Q^{X}{}_{x}$' in the LF of $\alpha$ is '$Q^{\exists}{}_{x}$', while it will be identical to '$\neg V'(x, z)$' whenever the same DGQ is '$Q^{\forall}{}_{x}$'. If we look back at the previous analysis of (4), we can see this: the DGQ there involved is of type '$Q^{\forall}{}_{x}$', and in the adjoined predicate '$\forall z((\text{card}(z) \wedge \text{have}(x, z) \wedge z \neq y) \rightarrow \neg \text{pay-with}(x, z))$' we have negation of (4)'s main verb (the corresponding verbal restriction, as made explicit by (4res), is indeed the complex predicate '(who)$_x$ did *not* pay with any other$_y$ credit card he$_x$/she$_x$ had'); it is properly the negation of its matrix verb, in the presuppositional form I have described, that induces the mirage of a switch from the expected universal construal of (4) to the unexpected existential one. But consider now (6)'s reading: it is expected to be existential, while being intuitively judged universal.

(6) No man$_x$ who has an umbrella$_y$ leaves it$_y$ home on a day like this.

I expect a presupposition $\pi$ to be made salient in this case. Notice that, in order to get (6)'s reading right, accommodation of $\pi$ should generate a restrictive predicate with the following LF:

$$[\lambda y.\lambda x.\forall z((\text{umbrella}(z) \wedge \text{have}(x, z) \wedge z \neq y) \rightarrow \text{leave-home}(x, z))](y)(x)$$

This will correspond to a complex verbal predicate like '(who)$_x$ leaves-home every other$_y$ umbrella he$_x$ has'. In this case, the presuppositional predicate should thus contain the matrix verb itself, *not* its negation. A presupposition $\pi$, to the effect that a man takes at most one umbrella with him when he goes out on a rainy day, would do this work. And it seems plausible to assume that such a presupposition be there in the context of an utterance of (6). This latter example, involving an underlying DGQ of type '$Q^{\exists}$', should provide an illustration of what I have previously stated with respect to (SDR): the predicate '$\chi$' in the λ-expression that gives the value of '$f$' stands for the matrix predicate of the sentence, whenever the initial quantifier translates as a DGQ of type '$Q^{\exists}$'. This is intuitively justifiable, given that in deviant sentences with LF-structure '$Q^{\exists}{}_{x}$ $[\exists y\varphi(x, y) \wedge (f(y))(x)]$ $[\psi(x, y)]$' the generated reading is existential, and in order to get at the surface universal reading we have to extend application of the matrix predicate '$\psi$' to any object y satisfying the antecedent clause, besides the one introduced by the antecedent indefinite NP.

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# Again


**Rob van der Sandt and Janneke Huitink***



**Abstract**

We present an analysis of *again* which splits the presuppositional contribution into two components, a component encoding a given eventuality and an embedded structure encoding the requirement of temporal anteriority of this eventuality. The analysis yields a straightforward solution to the puzzles Kamp and Kripke signalled with respect to the behaviour of *again* in conditional and quantificational environments. It moreover explains why the presupposition of *again* yields fully transparent readings in attitude contexts and tends to access positions that are normally thought to be inaccessible for anaphoric reference.


## 1 Preliminary observations

It is commonly held that the contribution of *again* to (1) is the presupposition that there was an event or temporal moment before Christmas during which Floppy was on the run.

(1) At Christmas Floppy will be on the run again.

The utterance of (1) then says that she will be on the run at Christmas. According to this view *again* only contributes to (1) in a presuppositional way.

Kamp and Kripke pointed out that the standard account gives rise to problems when we consider embeddings in conditional (Kripke) or quantificational (Kamp) environments. In order to account for the unexpected behaviour in these environments they proposed to assign a different presupposition. Kripke [6] observed that even if the presupposition is licensed by another clause as in (2), and prevailing theories thus predict that it is neutralised, there is still a substantial inference forthcoming. We infer that Mary's party is after Christmas, an inference which does not go through for its counterpart without the presuppositional adverb. Kripke thus suggested that the presupposition of (2) is not that Floppy was on the run at some moment before Christmas, but proposed to assign instead the presupposition that Mary's party is after Christmas.[1]


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1. With respect to *too* Kripke notes that such a presupposition 'cannot be assigned to the consequent without knowing the antecedent' and states that it comes not 'in addition to, but actually replaces the existential presupposition given by the usual account'. We will simply require that the relevant temporal inferences fall out as a result from the analysis.

(2) If Floppy will be on the run at Christmas, she will be on the run again at Mary's party.

Kamp noted that the standard view runs into problems when the presupposition is induced in the scope of a quantifier.[2] Consider the following minimal pair:

(3) a. #Floppy will be on the run at Christmas, but she will never be on the run.
b. Floppy will be on the run at Christmas, but she will never be on the run again.

Sentence (3a) only differs from (3b) in that the latter does not contain the temporal adverb. However, the latter is fine, but the former is a straightforward contradiction. This is puzzling. For if *again* only contributed to (3b) by inducing the presupposition that there is a previous state of Floppy being on the run, one would expect it to project out and link up to the first conjunct. But then it is difficult to see how we could explain the difference. Kamp thus proposes to enter the temporal condition as part of the non-presuppositional content.

Two further observations are relevant at this point. Firstly, the presupposed eventuality is able to access positions that are otherwise inaccessible for anaphoric reference. Consider the following modification of (3b).[3]

(4) Floppy may be on the run at Christmas, but she will never be on the run again.

Here the presupposed eventuality is licensed by material in the scope of the modal operator. In this respect *again* follows the behaviour of *too*, which likewise allows reference to formally inaccessible positions.[4]

Note finally that the presupposition of *again* behaves like the presupposition of *too* in yet another respect. It allows for a fully transparent reading in attitude contexts.

(5) Floppy was on the run at Christmas and Larry believes that she will be on the run again at his party.[5]

(5) may be uttered felicitously in a situation where Larry is not aware of the fact that Floppy was on the run before, i.e. the presupposition of (5) may be read so as not to contribute anything to the beliefs ascribed to Larry.

2. Kamp (pc). See Kamp [5]. Though the observation is not found there, it is presumably the reason for entering the temporal condition as part of the non-presuppositional content.
3. We owe this observation to Cleo Condoravdi.
4. See in Zeevat [9, 10] and Van der Sandt & Geurts [8]
5. See Fauconnier [1] and Heim [4]. Heim's example is on two children talking on the phone. The first says 'I am already in bed'. Her friend replies 'My parents think I am also in bed.'



## 2 The presuppositional structure of *again*

To account for these observations we introduce a modification of the standard way to encode the presupposition of *again*. As in the case of *too*, we split the presuppositional contribution into two separate but interrelated components.[6] The first encodes the presupposed eventuality, the second the requirement of temporal anteriority. We will then allow the projection mechanism to resolve each of these independently against the incoming discourse. In simple cases this gives the same result as the classical analysis. However, it turns out that this modification also captures the data presented by Kamp and Kripke. It explains, moreover, why the presupposition induced by *again* is able to access purportedly inaccessible positions and allows for fully transparent readings in attitude contexts.

We follow the analysis of *too* in Van der Sandt & Geurts [8] and distinguish in the initial encoding of the presuppositional structure of $\text{AGAIN}\varphi(s,t)$[7] between the structure encoding the presupposed eventuality, $\partial[s'|\varphi(s'), s' \circ t']$, and a temporal anaphor consisting of an anaphoric variable $t'$ with the condition $t' < t$.[8] The full presuppositional structure for (1) then comes out as (6). Note that the structure for the eventuality embeds the temporal structure.

$$(6)\quad \left[\, n\ t\ s \;\middle|\; \begin{array}{c} n < t,\ s \circ t,\ \text{christmas}(t),\ \text{flop.run}(s) \\ \partial\left[\, s' \;\middle|\; \begin{array}{c} s' \circ t',\ \text{flop.run}(s') \\ \partial\left[\, t' \;\middle|\; t' < t \,\right] \end{array} \right] \end{array} \right]$$

A few remarks are in order. Note first that, as in the case of *too*, the non-presuppositional contribution can be interpreted independently of the presuppositional structure. Its non-presuppositional counterpart thus simply expresses the proposition that Floppy will be on the run. This is very unlike the situation with other presupposition inducers as e.g. definite descriptions or verbs of transition where the anaphoric variable of the presuppositional expression binds a variable in the non-presuppositional remainder, and the latter thus lacks an interpretation if the former fails. Note furthermore that the discourse referent in the embedded structure binds a variable in its embedder (but not vice versa). We will see in a moment that the latter property is the central feature in our explanation of the Kripke/Kamp puzzles, while the former property accounts for the fact that the presupposition of *again* has access to 'inaccessible' positions and can be interpreted fully transparently in belief attributions.

## 3 The Kripke/Kamp puzzles

Let us first consider Kripke's problem. After some preprocessing the initial representation of (2) comes out as (7a):

6. See Van der Sandt & Geurts [8] and Geurts & Van der Sandt [3]
7. $s$ ranges over eventualities (states—in this paper) and $t$ over times.
8. Note the free time variable which will be bound by the tense of the main verb.

(7) a. $$\left[\begin{array}{l|c} n\ t\ t' & \begin{array}{c} n<t,\ n<t',\ \text{christmas}(t),\ \text{m.party}(t') \\ \left[s \mid s\circ t,\ \text{flop.run}(s)\right] \rightarrow \left[\begin{array}{l|c} s' & \begin{array}{c} s'\circ t',\ \text{flop.run}(s'), \\ \partial\left[\begin{array}{l|c} s'' & \begin{array}{c} s''\circ t'',\text{flop.run}(s'') \\ \partial\left[t'' \mid t''<t'\right]\end{array}\end{array}\right]\end{array}\end{array}\right]\end{array}\end{array}\right]$$

b. $$\left[\begin{array}{l|c} n\ t\ t' & \begin{array}{c} n<t<t',\ \text{christmas}(t),\ \text{m.party}(t') \\ \left[s \mid s\circ t,\ \text{flop.run}(s)\right] \rightarrow \left[s' \mid s'\circ t',\ \text{flop.run}(s'),\right]\end{array}\end{array}\right]$$

(7a) resolves as follows. We first process the most deeply embedded presupposition. This amounts to equating $t''$, the primary referent of the temporal structure, to $t$ and transferring the associated condition to its binding site. This enters the temporal information at toplevel. Next we process its embedder. The eventuality now finds its antecedent in the protasis of the conditional. Equating $s''$ with its antecedent marker $s$ gives (7b). Note that the eventuality cannot be resolved any higher as this would unbind a variable in a condition and note, furthermore, that the two presuppositional components are resolved to different levels of discourse structure. Note finally that the resulting output only differs from its counterpart without *again* in that the presuppositional variant adds the condition $t < t'$ to the main context. The function of *again* is to locate the eventualies in the temporal structure, thus accounting for Kripke's observation that we infer from (2) that Mary's party is after Christmas.

The possibility to resolve the two presuppositional components to different levels of discourse structure is also the key to the solution of Kamp's puzzle. Given our analysis (3a) is predicted to be contradictory, but (8a), the representation of (3b), resolves in two steps to (8c).[9]

(8) a. $$\left[\begin{array}{l|c} n\ t\ s & \begin{array}{c} n<t,\ s\circ t,\ \text{christmas}(t),\ \text{flop.run}(s) \\ \left[t' \mid n<t'\right]\langle{}^{\text{NO}}_{t'}\rangle \left[\begin{array}{l|c} s' & \begin{array}{c} s'\circ t',\ \text{flop.run}(s') \\ \partial\left[\begin{array}{l|c} s'' & \begin{array}{c} s''\circ t'',\ \text{flop.run}(s'') \\ \partial\left[t'' \mid t''<t'\right]\end{array}\end{array}\right]\end{array}\end{array}\right]\end{array}\end{array}\right]$$

b. $$\left[\begin{array}{l|c} n\ t\ s & \begin{array}{c} n<t,\ s\circ t,\ \text{christmas}(t),\ \text{flop.run}(s) \\ \left[t' \mid n<t<t'\right]\langle{}^{\text{NO}}_{t'}\rangle \left[\begin{array}{l|c} s' & \begin{array}{c} s'\circ t',\ \text{flop.run}(s') \\ \partial\left[s'' \mid s''\circ t,\ \text{flop.run}(s'')\right]\end{array}\end{array}\right]\end{array}\end{array}\right]$$

c. $$\left[\begin{array}{l|c} n\ t\ s & \begin{array}{c} n<t,\ s\circ t,\ \text{christmas}(t),\ \text{flop.run}(s) \\ \left[t' \mid n<t<t'\right]\langle{}^{\text{NO}}_{t'}\rangle \left[s' \mid s'\circ t',\ \text{flop.run}(s')\right]\end{array}\end{array}\right]$$

9. As in the previous example we assume some preprocessing. In the present case the temporal restriction of the quantifier comes about by resolution of $\partial[t^\circ : n < t^\circ]$, the temporal structure representing the future tense. Since the temporal condition contains a variable which is bound by the principal variable of the duplex condition, it will be intercepted locally in the restriction of the quantifier in exactly the same way as the temporal condition induced by *again*.



Note that the temporal condition $t'' < t'$ contains the variable $t'$ which has to be bound by the quantifier. This condition thus cannot be resolved at toplevel as this would create a free variable in a condition. Instead, it is intercepted at subordinate level, thus restricting the domain of the quantifier. This structure then yields, after resolution of the presupposed eventuality, (8c) as the final outcome. This DRS correctly captures the meaning of (3b), saying that Floppy will be on the run at Christmas and that she will not be on the run at any time after Christmas.

It is worth noting that Kamp's and Kripke's examples are in some sense mirror images. In Kripke's examples the temporal condition projects out to the main context, while the eventuality is bound at a subordinate level. In Kamp's example we observe exactly the opposite. The temporal condition is intercepted by the quantifier and thus remains on a subordinate level, while the descriptive information links up to the incoming discourse. This is a prototypical case of trapping[10] but note that this requires that we allow the anaphoric variable to be resolved at a higher position along the accessibility line than the associated conditions.[11]

## 4 Inaccessible contexts and transparent readings

The presuppositional independence of *again* is responsible for two seemingly unrelated phenomena we mentioned in section 1. Firstly, *again* patterns with *too* in its ability to access contexts that are inaccessible given the standard definitions in DRT. This clearly cannot happen when the structure is partitioned in the way it is when e.g. a definite description is involved. Here the anaphoric variable in the presuppositional structure binds a variable in its inducing matrix. Thus when the presupposition is projected it has to retain the binding relation with the non-presuppositional remainder for the latter to have an interpretation. However, given the fact that the presupposition of *again* does not contribute to the non-presuppositional content, the latter will still express a determinate proposition in case the former fails or ends up in a position in the discourse structure from where it cannot formally access its inducing matrix. Consider (9a) the initial representation of (4).

(9) a. $$\left[\begin{array}{l|c} n\ t & \begin{array}{c} n<t,\ \text{christmas}(t),\ \Diamond\left[s \mid s\circ t\ \text{flop.run}(s)\right] \\ \left[t' \mid n<t'\right]\langle{}^{\text{NO}}_{t'}\rangle \left[\begin{array}{l|c} s' & \begin{array}{c} s'\circ t',\ \text{flop.run}(s') \\ \partial\left[\begin{array}{l|c} s'' & \begin{array}{c} s''\circ t'',\ \text{flop.run}(s'') \\ \partial\left[t'' \mid t''<t'\right]\end{array}\end{array}\right]\end{array}\end{array}\right]\end{array}\end{array}\right]$$

b. $$\left[\begin{array}{l|c} n\ t & \begin{array}{c} n<t,\ \text{christmas}(t),\ \Diamond\left[s \mid s\circ t,\ \text{flop.run}(s)\right] \\ \left[t' \mid n<t',\ t<t'\right]\langle{}^{\text{NO}}_{t'}\rangle \left[s' \mid s'\circ t',\ \text{flop.run}(s')\right]\end{array}\end{array}\right]$$

10. Van der Sandt [7]
11. Geurts [2]

Setting $t''$ to $t$ and transferring the associated condition to its binding site resolves the temporal condition to the main context. When resolving its embedder we see that the eventuality finds its antecedent under the scope of the modal operator. Resolution thus gives (9b) which is a proper DRS to which the standard verification conditions apply. Again, the result is obtained in view of the two central characteristics of the presuppositional encoding, its independence of the non-presuppositional remainder and the fact that the two components are resolved independently and thus may access.

The independence of the non-presuppositional remainder is also responsible for the phenomenon of attitudinal transparency. For, if the presupposition projects out, the content of the attitude is divorced from the presuppositional contribution. Our account thus yields (10b) as the transparent reading of (5):

(10) a. $$\left[ n\ t\ t'\ s \;\middle|\; \begin{array}{c} t < n < t',\ s \circ t,\ \text{christmas}(t),\ \text{party}(t'),\ \text{flop.run}(s) \\ \text{larry.believe} : \left[ s' \;\middle|\; \begin{array}{c} s' \circ t';\ \text{flop.run}(s'), \\ \partial \left[ s'' \;\middle|\; \begin{array}{c} s'' \circ t'',\ \text{flop.run}(s'') \\ \partial \left[ t'' \mid t'' < t' \right] \end{array} \right] \end{array} \right] \end{array} \right].$$

b. $$\left[ n\ t\ t' s \;\middle|\; \begin{array}{c} t < n < t',\ s \circ t,\ \text{christmas}(t),\ \text{party}(t'),\ \text{flop.run}(s) \\ \text{larry.believe} : \left[ s' \mid s' \circ t',\ \text{flop.run}(s') \right] \end{array} \right]$$

We obtain (10b) by setting $t''$ to $t$ and then resolving both the eventuality and the temporal structure to the main DRS. The presupposition resolves without leaving a trace in the subordinate DRS encoding Larry's beliefs. This is again a result of the fact that the anaphoric variable of the presuppositional structure does not enter into binding relations with the non-presuppositional content.

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# Non-Redundancy: A Semantic Reinterpretation of Binding Theory

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Within generative grammar, Binding Theory has traditionally been considered a part of *syntax*, in the sense that some derivations that would otherwise be interpretable are ruled out by purely formal principles. Thus *He$_i$ likes him$_i$* would in standard theories yield a perfectly acceptable interpretation, but it is ruled out by Chomsky's Condition B, which in this case prohibits co-arguments from bearing the same index. We explore a semantic alternative in which Condition B, Condition C, the Locality of Variable Binding of Kehler 1993 and Fox 2000, and Weak and Strong Crossover effects follow from a non-standard interpretive procedure (modified from de Bruijn's interpretation of the λ-calculus and Ben-Shalom 1996). Constituents are evaluated top-down under a pair of two sequences, the sequence of evaluation s and the quantificational sequence q. The initial sequence of evaluation always contains the speaker and the addressee (thus if John is talking to Mary, the initial sequence of evaluation will be j^m, as we assume throughout). The bulk of the work is then done by a principle of **Non-Redundancy**, which prevents any object from appearing twice in any sequence of evaluation. We may think of the sequence of evaluation as a *memory register*, and of Non-Redundancy as a principle of *cognitive economy* which prohibits any element from being listed twice in the same register[1]. For reasons of space, we do not compare this proposal to other semantic approaches to Binding Theory, e.g. important works by Jacobson, Keenan, Branco, Butler, Barker & Shan.

## 1 R-expressions and Condition C

When an R-expression (=proper name, definite description or demonstrative pronoun) is processed, its denotation is added at the end of the sequence of evaluation, as defined in (1) and illustrated in (2):

(1) **Treatment of R-expressions**[2]
If α is a proper name, a definite description or a demonstrative pronoun, $[\![ [\alpha\ \beta] ]\!]^w s, q = [\![ [\beta\ \alpha] ]\!]^w s, q = [\![\beta]\!]^w s\hat{}([\![\alpha]\!]^w s,q), q$

(2) $[\![\text{Ann runs}]\!]^w j\hat{}m, \emptyset = [\![\text{runs}]\!]^w j\hat{}m\hat{}a, \emptyset = 1$ iff $a \in I_w(\text{runs})$

Because individual-denoting expressions are entered in the sequence of evaluation in a fixed order, the arguments of an n-place predicate are systematically found in the last n positions of the sequence of evaluation.

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[1] For conceptual reasons, the elements listed in a memory register should not be objects but *descriptions* thereof. For simplicity we entirely disregard this point, although it has important consequences for (i) the analysis of exceptions to binding theory noted by Reinhart, and (ii) the treatment of quantification. See Schlenker 2003 for discussion.

[2] In the final version of the system, *that*-clauses are also considered as R-expressions, and thus fall under (1). We also use the following (standard) interpretive rule: $[\![ [\text{that } p] ]\!]^w s,q = \#$ iff for some w' in W, $[\![p]\!]^{w'} s, q = \#$. Otherwise, $[\![ [\text{that } p] ]\!]^w s, q = \lambda w': w' \in W. [\![p]\!]^{w'} s, q$.

For this reason, it makes sense to define the truth of a predicate at a sequence of evaluation (or rather, at a pair of sequences, for reasons to be discussed in Section 4). When we further incorporate Non-Redundancy to the interpretive rule for atomic predicates, we obtain the following:

(3) **Treatment of Atomic Predicates**
If V is a predicate taking n individual arguments, $[\![V]\!]^{w}s, q=\#$ iff (i) s violates Non-Redundancy[3], or (ii) one of the last n arguments of n is not an individual. Otherwise, $[\![N]\!]^{w}s, q=1$ iff $s_n(q)\in I_w(V)$, where $s_n(q)$ is the list of the last n elements of s (...properly resolved by q if some of them are formal indices; see (14) below).

In standard generative analyses, Condition C states that *an R-expression cannot be in the scope of a coreferential expression.* Instead of being a primitive, this principle is now derived from the interaction of (1) and (3), as is illustrated in (4) (# is used throughout to denote semantic failure):

(4) $[\![\text{Ann [likes Ann]}]\!]^{w}j\hat{}m, \emptyset = [\![\text{likes Ann}]\!]^{w}j\hat{}m\hat{}a, \emptyset$
$= [\![\text{likes}]\!]^{w}j\hat{}m\hat{}a\hat{}a, \emptyset = \#$ because $j\hat{}m\hat{}a\hat{}a$ violates Non-Redundancy.

It can be shown that no violation of Non-Redundancy arises when the second expression is not in the scope of the first, as in *Ann's teacher likes Ann*: if t=Ann's teacher, the second occurrence of *Ann* is evaluated under the sequence $j\hat{}m\hat{}t$, which contains t but not a. Interestingly, Non-Redundancy also rules out sentences in which an R-expression is used to denote the speaker or addressee - a desirable result in view of the deviance of *John runs* as uttered by or to John. The derivation proceeds as follows:

(5) $[\![\text{John runs}]\!]^{w}j\hat{}m, \emptyset = [\![\text{runs}]\!]^{w}j\hat{}m\hat{}j, \emptyset = \#$ because $j\hat{}m\hat{}j$ violates Non-Redundancy.

## 2 Anaphoric Pronouns, Condition B and Condition A

When an anaphoric pronoun is processed, some element of the sequence of evaluation is recovered and moved to the end of the sequence, leaving behind an empty cell #[4]. In order to indicate which element is moved, anaphoric pronouns are given *negative indices* such as -1, -2, etc, which indicate *how far from the end of the sequence their denotation is found:*

(6) **Treatment of Anaphoric Pronouns**
If $\alpha$ is a pronoun $pro_{-i}$, $[\![\,[\alpha\ \beta]\,]\!]^{w}s\hat{}d_i\hat{}d_{i-1}\hat{}\ldots\hat{}d_1, q$
$= [\![\,[\beta\ \alpha]\,]\!]^{w}d_m\hat{}\ldots\hat{}d_i\hat{}d_{i-1}\hat{}\ldots\hat{}d_1, q = [\![\beta]\!]^{w}s\hat{}\#\hat{}d_{i-1}\hat{}\ldots\hat{}d_1\hat{}d_i, q$

Consider the sentence *(Ann says that) she*$_{-1}$ *runs*. After *Ann says that* is processed, the sequence of evaluation contains a in its last position, yielding for various values of w':

(7) $[\![\text{she}_{-1}\text{ runs}]\!]^{w'}j\hat{}m\hat{}a, \emptyset = [\![\text{runs}]\!]^{w'}j\hat{}m\hat{}\#\hat{}a, \emptyset = 1$ iff $a\in I_{w'}(\text{runs})$

[3] Within the present system, Non-Redundancy should be defined as follows: s violates Non-Redundancy iff s contains the same element *other than #* in at least two positions.
[4] When tense is taken into account, the device of empty cells can be eliminated. The qualification *'other than #'* can then be eliminated from fn. 2. See Schlenker 2003.



However, in *Ann likes her*$_{-1}$, where *her*$_{-1}$ 'tries' to corefer with Ann, a failure is predicted because the predicate *like* ends up being assessed under a sequence of evaluation which contains a non-individual, namely #, in its penultimate positions. By clause (ii) of (3), this is disallowed - intuitively, an n-place predicate cannot be evaluated with respect to a sequence which contains an empty cell in one of its last n positions:

(8) $[\![\text{Ann likes her}_{-1}]\!]^{w}j\hat{}m, \emptyset = [\![\text{likes her}_{-1}]\!]^{w}j\hat{}m\hat{}a, \emptyset = [\![\text{likes}]\!]^{w}j\hat{}m\hat{}\#\hat{}a, \emptyset = \#$
because one of the last 2 elements of $j\hat{}m\hat{}\#\hat{}a$ is not an individual.

This derives Reinhart & Reuland's version of Condition B, which states that *two co-arguments of a predicate may not corefer* (...unless a reflexive pronoun is used; see the next section). This account has well-known deficiencies, in particular for the treatment of, say, **John believes him*$_{-1}$ *to be clever,* which cannot mean that John believes that John is clever. We are forced to posit that in such cases *him*$_{-1}$ is (despite appearances) an argument of *believes*. The details are admittedly tricky.

Why can a coreferential interpretation of (8) be achieved when *her* is replaced with *herself*? We assume that the reflexive pronoun *herself* is composed of two parts: (i) *her*$_{-1}$, which is a garden-variety anaphoric pronoun, and (ii) *-self*, which is an operator that reduces the arity of the predicate. This yields a version of Condition A if *-self* is constrained to apply to the closest predicate. We then obtain the following interpretation:

(9) a. Ann likes herself
a'. Logical Form: Ann self-likes $her_{-1}$
b. $[\![a']\!]^{w}j\hat{}m, \emptyset = [\![\text{self-like him}_{-1}]\!]^{w}j\hat{}m\hat{}a, \emptyset = [\![\text{self-like}]\!]^{w}j\hat{}m\hat{}\#\hat{}a = 1$
iff $a\in I_w(\text{self-like})$, iff $\langle a, a\rangle\in I_w(\text{like})$.

## 3 The Economy of Variable Binding

Why can *Peter said that he likes him* not mean that Peter said that Peter likes Peter? In standard syntactic accounts, the explanation is not trivial, for although *him* is too 'close' to *he* to corefer with it (as this would violate Condition B), it is not obvious why *him* cannot corefer with *Peter*, which is further away. This problem does not arise in the present framework. An initial sequence $j\hat{}m$ becomes $j\hat{}m\hat{}p$ after *Peter* is processed. Hence if *he* is to refer to Peter, it must bear the index -1. After *he*$_{-1}$ is processed, the sequence becomes $j\hat{}m\hat{}\#\hat{}p$. Therefore if *him* is to refer to Peter, it has no choice but to bear the index -1. After *him*$_{-1}$ is processed, *like* is then assessed under a sequence of evaluation $j\hat{}m\hat{}\#\hat{}\#\hat{}p$, which yields a failure because one of the last two elements (namely #) is a non-individual. This is the correct result. When the first and the second pronoun are not co-arguments, as in (10), no failure arises, but we predict that if both pronouns refer to Peter, the second *he* must bear -1 (and cannot bear -2):

(10) Peter said that $he_{-1}$ thinks $he_{-1}$ is competent
a. ok
b. *

The reasoning is the same as before: after *Peter* and the first *he*$_{-1}$ have been processed, the sequence of evaluation is j^m^#^p. If the second *he* bore index -2, *is-competent* would be evaluated under a sequence j^m^#^p^#, which would yield a semantic failure (because the last element is a non-individual). No problem arises if the second *he* bears index -1, since in that case *is-competent* is evaluated under the sequence j^m^#^#^p. This observation can be generalized, and derives the principle of *variable binding economy* of Kehler 1993 and Fox 2000: binding dependencies must be 'as short as possible' to achieve a given interpretation.

Kehler and Fox proposed this principle to account for Dahl's 'many pronouns' puzzle (Fiengo & May 1994). The puzzle is that in structures such as (11), ellipsis resolution does not allow *his* to be read as 'sloppy' if *he* is itself read as 'strict', as shown by the unavailability of (11)d:

(11) Peter said that he$_{-1}$ thinks he$_{-1}$ is competent, and Oscar did too ~~say that he$_{-1}$ thinks he$_{-1}$ is competent~~
a. $^{Ok}$sloppy - sloppy: Oscar said that Oscar thinks Oscar is competent
b. $^{Ok}$sloppy - strict: Oscar said that Oscar thinks Peter is competent
c. $^{Ok}$strict - strict: Oscar said that Peter thinks Peter is competent
d. *strict - sloppy: Oscar said that Peter thinks Oscar is competent

The generalization (Fiengo & May 1994) is that *if an elided pronoun is resolved as strict, all the elided pronouns that are in its scope must be read as strict too.* We derive this result by assuming that (i) syntactically, the elided verb phrase is a literal copy of its antecedent (and it thus includes the same indices, as in (11)), and (ii) semantically, an elided anaphoric pronoun may optionally bring to the end of the sequence of evaluation the value of its unelided counterpart. (11)a is obtained when the semantic interpretation of the elided Verb Phrase proceeds without making use of (ii), yielding the sequence 'history' j^m → j^m^o → j^m^#^o → j^m^#^#^o. When only the second elided pronoun makes use of (ii), the beginning of the sequence history is the same, i.e. j^m → j^m^o → j^m^#^o. But when the second pronoun is processed, it turns j^m^#^o into j^m^#^#^p by substituting 'at the last minute' the value of its unelided counterpart, i.e. p, for o; this yields (11)b. When the first pronoun makes use of (ii), j^m^o is turned into j^m^#^p (again by substituting 'at the last moment' p for o); whether or not the second *he* makes use of (ii), the final sequence is j^m^#^#^p, yiedling (11)c. Having exhausted the interpretive possibilities, we see that (11)d cannot be derived, which accounts for Dahl's puzzle.

## 4 Quantification, Weak Crossover and Strong Crossover

### 4.1 The Treatment of Quantification

For theory-internal reasons, we are forced to stipulate that quantifiers manipulate the quantificational sequence rather than the sequence of evaluation (note that so far the quantificational sequence has been entirely idle). Otherwise we would wrongly predict that *Peter likes everyone*



cannot mean that Peter likes everyone *including himself*, because *everyone* would trigger the appearance of d in the sequence of evaluation, for each d which is a person. Thus *likes* would be evaluated under sequences of the form j^m^p^d, and for d=Peter Non-Redundancy would be violated. To avoid this undesirable result, we stipulate that quantifiers introduce elements in a different sequence, the quantificational sequence. The syntactic 'trace' that a quantifier leaves in its original position after moving to its scope site has the role of *introducing in the sequence of evaluation an index that cross-references the relevant element of the quantificational sequence*, as in (12), where the index 1 cross-references the first element of the quantificational sequence:

(12) [[everyone [t$_{-1}$ runs]]] $^{w}$j^m, ø=1 iff for each d, [[t$_{-1}$ runs]] $^{w}$j^m, d=1 iff for each d, [[runs]] $^{w}$j^m^1, d=1, iff for each d, (j^m^1)$_1$(d)∈I$_w$(runs), iff for each d, d∈I$_w$(runs), since (j^m^1)$_1$(d) is the last element of j^m^1, properly resolved by d, i.e. it is simply 1-membered list d.

In this way we divide quantification into two separate steps: (i) first, *everyone* introduces d in the quantificational sequence, for each individual d, and then (ii) the trace *t*$_{-1}$ triggers the appearance in the sequence of evaluation of an index that cross-references d. On a technical level, it can be checked that the correct results are obtained by postulating the interpretive rules in (13) for quantifiers and traces, and by defining s$_n$(q), i.e. the n-resolution of the sequence of evaluation s given q, as in (14):

(13) a. [[ [ [every n] e] ]] $^{w}$s, q=# iff (i) for some individual x, [[n]] $^{w}$s, q^x=#, or (ii) for some individual x satisfying [[n]] $^{w}$s, q^x=1, [[e]] $^{w}$s, q^x=#. Otherwise, [[ [ [every n] e] ]] $^{w}$s, q=1 iff for each individual x satisfying [[n]] $^{w}$s, q^x=1, [[e]] $^{w}$s, q^x=1.
b. [[ [t$_{-i}$ β] ]] $^{w}$s, q= [[ [β t$_{-i}$] ]] $^{w}$s, q= [[β]] $^{w}$s^(|q|+1-i), q

(14) If n>|s|, s$_n$(q)=*; if n≤|s|: (d$_m$^ ...^d$_n$^ ...^d$_1$)$_n$(q)= d$_n$(q)^ ...^d$_1$(q), where for each i∈[[1, n]] d$_i$(q)=d$_i$ if d$_i$∉ℕ and d$_i$(q)=the d$_i$$^{th}$ coordinate of q if d$_i$∈ℕ

### 4.2 Weak and Strong Crossover Effects

So far the introduction of the quantificational sequence was motivated solely by theory-internal reasons. Interestingly, however, our stipulations derive so-called 'Crossover' effects, which prohibit a quantificational element from moving past a pronoun that it attempts to bind. We start with 'Weak Crossover' effects, which obtain when the offending pronoun does not c-command the trace of the quantifier, as in (15)a, whose Logical Form is (15)a' after *everyone* has moved to its scope position:

(15) a. ??His mother likes everyone
a'. Everyone [[his$_{-i}$ mother] [likes t$_{-1}$]]
b. [[a']] $^{w}$j^m, ø=1 iff for each d, [[ [his$_{-i}$ mother] likes t$_{-1}$]] $^{w}$j^m, d=1

No matter what the index of *his*$_{-i}$ is, *his*$_{-i}$ cannot retrieve d because d is in the 'wrong' sequence: it is in the quantificational sequence, whereas *his*$_{-i}$

can only retrieve elements of the sequence of evaluation. However if the trace $t_{-1}$ had been processed 'before' *his*$_{-i}$ *mother*, i.e. in a position that c-commands it, there would have been no such problem:

(16) [[everyone [$t_{-1}$ likes $his_{-1}$ mother]]]$^{w}$ j^m, ø=1 iff for each d,
[[$t_{-1}$ likes $his_{-1}$ mother]]$^{w}$ j^m, d=1,
iff for each d [[likes $his_{-1}$ mother]]$^{w}$ j^m^1, d=1

At this point there is an element (the index 1) in the sequence of evaluation that cross-references d. *his*$_{-1}$ can access this element and thus indirectly come to denote d, as is desired.

Why is the violation in (15)a relatively mild, thus earning it the title of a *Weak* Crossover violation? We argue that this is because the structure allows for a repair strategy, which is to treat the pronoun *his* as if it were a trace. By contrast, in a Strong Crossover configuration such as **He likes everyone* (whose logical form is *everyone [he likes* $t_{-1}$*]*, where the pronoun c-commands the trace of the quantifier), treating the pronoun *he* as if it were a trace $t_{-1}$ yields a violation of Non-Redundancy: when the object trace is processed, two occurrences of the index 1 will appear in the same sequence of evaluation, because both will cross-reference the same element d of the quantificational sequence. This is illustrated in (17):

(17) a. He likes every man.
a'. Actual LF: [Every man] [he likes $t_{-1}$]
a". Attempted Repair: [Every man] [$t_{-1}$ likes $t_{-1}$]
b. [[a"]]$^{w}$ s, ø=# iff for some x such that [[man]]$^{w}$ s, x=1, [[ $t_{-1}$ likes $t_{-1}$]]$^{w}$ s, x =#, iff for some x such that [[man]]$^{w}$ s, x=1, [[likes $t_{-1}$]]$^{w}$ s^1, x =#, iff for some x such that [[man]]$^{w}$ s, x=1, [[likes]]$^{w}$ s^1^1, s=#.
The latter condition is always met because s^1^1 violates Non-Redundancy. Hence a" yields a semantic failure.

Our analysis thus derives in a new way Chomsky's old insight that Strong Crossover violations are Weak Crossover effects that also violate Condition C - for us, Non-Redundancy.

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# Underspecified Focus Representation

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**Abstract**
Sentences involving more than one focus are quite common in natural language. Multiple focus constructions can be ambiguous with respect to the association of focuses and focus operators. We show how this form of ambiguity can be handled alongside with scope ambiguity within the framework of Minimal Recursion Semantics. We start from the ideas of Structured Meaning Theory for focus constructions and show how this theory can be extended such that it handles focus associations not handled by the original form of the theory, it allows for various degrees of underspecification and it is compositionally implemented in HPSG.

## 1 Multiple focus constructions

Focuses have disambiguating impact on sentences. The sentences

(E1) John only$_{O}$ introduced Bill to [Sue]$_{F}$.
(E2) John only$_{O}$ introduced [Bill]$_{F}$ to Sue.

have different truth conditions due to different associations with "only". Sentences involving more than one focus and more than one focus operator can be ambiguous with respect to association of focuses and operators, like

(E3) John even$_{O1}$ only$_{O2}$ introduced [Bill]$_{F1}$ to [Sue]$_{F2}$.

where associating F1 with O1 and F2 with O2 results in truth conditions different from those when associating F1 with O2 and F2 with O1.

Alternative Semantics ([3]) and Structured Meaning Theory (SMT) ([2]) are the paradigmatic approaches to the interpretation of focus. Among these only the latter is able to handle a broad range of multiple focus constructions (MFCs) properly. Alternative Semantics fails when dealing with MFCs because the impact of different focuses cannot be distinguished within the *focus meaning*. SMT preserves the information on focuses within a given constituent as it is required for the proper interpretation of MFCs within SMT's meaning pairs.

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Problematic cases of focus association are the following ones: (C1) Two focuses are both in the scope of two focus operators, like in (E3). (C2) A focussed constituent F1 contains another focus F2, like in

(E4) John even$_{O1}$ only$_{O2}$ [introduced Bill to [Sue]$_{F2}$]$_{F1}$.

(C3) A focus is associated with more than one operator, as e.g. in

(E5) John even$_{O1}$ only$_{O2}$ introduced Bill to [Sue]$_{F2,F1}$.

In SMT meaning pairs $\langle B, F\rangle$ are assumed, where $B$ is the meaning of the background and $F$ the meaning of the focus such that $B(F)$ yields the meaning of the phrase disregarding the focus. Due to constraints on the relation between $B$ and $F$ not all possible associations of type (C1) can be represented within this approach, or otherwise unintuitive ambiguities of focus operators have to be assumed. Consider $\langle\lambda\langle y, z\rangle\lambda x[\text{introd}(x, y, z)], \langle b, s\rangle\rangle$ as the meaning of "introduced [Bill]$_{F1}$ to [Sue]$_{F2}$". In order to get both possible focus associations of (E3), there must be two readings of "only" corresponding to the two focus associations in a compositional semantic approach.

$$\lambda\langle B, \langle y, z\rangle\rangle[\langle\lambda z'\lambda x[\forall y' \in \mathbf{ALT}(y)[B(\langle y', z'\rangle)(x) \rightarrow y' = y]], z\rangle] \qquad (1)$$

corresponds to the F1-O2, F2-O1 association.

$$\lambda\langle B, \langle y, z\rangle\rangle[\langle\lambda y'\lambda x[\forall z' \in \mathbf{ALT}(z)[B(\langle y', z'\rangle)(x) \rightarrow z' = z]], y\rangle] \qquad (2)$$

corresponds to the F1-O1, F2-O2 association. Other readings of "only" have to be assumed for cases of more or fewer than two focuses within the scope of "only".

Analogous readings for focus operators have to be introduced in case (C2), if we consider sentences like (E4) and if we assume that the meaning of "[introduced Bill to [Sue]$_{F2}$]$_{F1}$" is

$$\langle\lambda\langle P, z\rangle[P(z)], \langle\lambda z\lambda x[\text{introd}(x, b, z)], s\rangle\rangle \qquad (3)$$

New type variants of the meaning of "only" are necessary for cases like (C3).

## 2 Focus Minimal Recursion Semantics

Within the framework of Minimal Recursion Semantics (MRS) (cf. [1]), focussed constituents can be treated as elementary predications (EPs). Their handles are marked as focussed. We therefor extend MRS triples to Focus MRS (FMRS) quadruples $\langle T, L, F, C\rangle$ where $T$ is a handle (the topmost handle), $L$ is a set of EPs, $F$ is a set of handle pairs (connecting the slots of focussed constituents with



the handles of the constituents themselves)[1] and $C$ is a set of handle constraints. We consider $F$ as a function, and we write $F(h)$ for $h'$ if $\langle h : h'\rangle \in F$, and $\mathbf{Def}(F)$ for the set of the first members of the pairs in $F$. The VP "introduced [Bill]$_{F1}$ to [Sue]$_{F2}$" is represented as $\langle h0, \{h0 : \lambda x[\text{introd}(x, h1, h2)], h3 : b, h4 : s\}, \{h1 : h3, h2 : h4\}, \emptyset\rangle$. A focus operator like "only" takes two arguments: firstly the topmost handle of the FMRS structure $\langle T', L', F', C'\rangle$ of its scope and secondly a nonempty sequence of some subset of $\mathbf{Def}(F')$. Let us consider the association of F1 (or $h1$) with "only" in (E3). An adequate resulting FMRS structure is $\langle h3, \{h3 : \lambda x[\forall y \in \mathbf{ALT}(h4)[\text{introd}(x, h1, h2)] \leftrightarrow y = h4], h1 : y, h4 : b, h5 : s\}, \{h2 : h5\}, \emptyset\rangle$

Therefore – for the sake of simplicity, we disregard the distinction between presupposition and assertion – we define:

$$\mathbf{only}_y(h, h') := \lambda t[\forall y \in \mathbf{ALT}(F(h'))[h'' \leftrightarrow y = F(h')]] \qquad (4)$$

where $h : \lambda t[h'']$ and $t$ is some sequence of variables. When applying a focus operator to its scope, the variable bound by the focus operator (here $y$) has to be associated with the focus handle (here by adding the EP $h' : y$ to $L$).

More generally, the functional application of some focus operator $h_O : O_\xi(h, h')$ to some FMRS structure $\langle h_S, L, F, C\rangle$ yields a structure

$$\langle h_O, \{h_O : O_\xi(h, h')\} \cup L, F, \{h >_F h'\} \cup C\rangle \qquad (5)$$

This FMRS structure is underspecified regarding the association of $O_\xi$ with some handle of $\mathbf{Def}(F)$. The condition $h >_F h'$ demands that the handle to be associated with $O_\xi$ should be one of those focus handles which are dominated by $h_S$. We define:

**Definition D-2-1 (Dominance)** *A handle $h$ dominates $h'$ ($h > h'$) iff*
**(a)** *$h = h'$ or*
**(b)** *$h'$ is a handle of an expression which contains some handle $h''$ which is dominated by $h$.*

**Definition D-2-2 (F-Dominance)** *A handle $h$ F-dominates $h'$ ($h >_F h'$) iff*
**(a)** *($h > h'$) and*
**(b)** *$h' \in \mathbf{Def}(F)$.*

Given these definitions the various readings of (E3) lead to the FMRS

1. This representation is similar to that in [4], but the latter representation has still limitations which prevents it from handling cases (C2-3).

structure

$$\langle h0, \{h0 : \textbf{even}_x(h1, h2), h1 : \textbf{only}_y(h3, h4), h3 : \text{introd}(j, h5, h6), h7 : b, h8 : s\}, \{h5 : h7, h6 : h8\}, \{h1 >_F h2, h3 >_F h4\}\rangle \tag{6}$$

Similar to the concept of scope-resolution in [1] we define:

**Definition D-2-3 (Focus-resolved FMRS structure)** *A focus-resolved FMRS structure is a FMRS structure $\langle h, L, F, C\rangle$ where all focus arguments (second arguments) of focus operators are identified with some handle of* $\textbf{Def}(F)$.[2]

The set of focus-resolved FMRS structures fulfilling the constraints of (6) (incl. the constraint in the footnote) consists of the two following FMRS structures and equivalent ones:

$$\langle h0, \{h0 : \textbf{even}_x(h1, h5), h1 : \textbf{only}_y(h3, h6), h3 : \text{introd}(j, h5, h6), h7 : b, h8 : s\}, \{h5 : h7, h6 : h8\}, \emptyset\rangle \tag{7}$$

$$\langle h0, \{h0 : \textbf{even}_x(h1, h6), h1 : \textbf{only}_y(h3, h5), h3 : \text{introd}(j, h5, h6), h7 : b, h8 : s\}, \{h5 : h7, h6 : h8\}, \emptyset\rangle \tag{8}$$

## 3 FMRS in HPSG

Before we turn to the question how case (C3) is treated within the framework of FMRS, we sketch the integration of the compositional construction of FMRS structures into a feature-structure based syntactical framework like HPSG. Let us assume that a FMRS structure $\langle T, L, F, C\rangle$ is represented as a feature structure

$$\begin{bmatrix} \textbf{fmrs} & \\ \text{LTOP} & \boxed{1} \\ \text{LZT} & \boxed{2} \\ \text{FOC} & \boxed{3} \\ \text{H-CONS} & \boxed{4} \end{bmatrix} \tag{9}$$

2. If we assume that each focus handle can be associated with some focus operator only once, we have to add the further condition that the focus arguments of different focus operators must not be identified with the same handle.



where $\boxed{1}$ corresponds to $T$, and $\boxed{2}$-$\boxed{4}$ are lists corresponding to $L, F, C$ respectively. Members of $\boxed{3}$ are feature structures of type

$$\begin{bmatrix} \textbf{assoc} & \\ \text{ARG} & \boxed{5} \\ \text{VALUE} & \boxed{6} \end{bmatrix}$$

We describe the operation of focus-marking a constituent as the application of a focussing operator $[\cdots]_F$. The focussing operation on an argument with the FMRS structure (9) results in the FMRS structure

$$\begin{bmatrix} \textbf{fmrs} & \\ \text{LTOP} & \boxed{\xi} \\ \text{LZT} & \boxed{2} \\ \text{FOC} & \left\langle \begin{bmatrix} \textbf{assoc} & \\ \text{ARG} & \boxed{\xi} \\ \text{VALUE} & \boxed{1} \end{bmatrix} \right\rangle \oplus \boxed{3} \\ \text{H-CONS} & \boxed{4} \end{bmatrix} \tag{10}$$

Here $\xi$ is some new variable, and $\oplus$ is the concatenation operator for lists. A focus operator is a constituent with the FMRS structure

$$\begin{bmatrix} \textbf{fmrs} & \\ \text{LTOP} & \boxed{7} \\ \text{LZT} & \left\langle \begin{bmatrix} \textbf{focop} & \\ \text{HNDL} & \boxed{7} \\ \text{BV} & \boxed{8} \\ \text{SCOPE} & \boxed{1} \\ \text{ASSOC-FOC} & \boxed{9} \end{bmatrix}, \begin{bmatrix} \textbf{refind} & \\ \text{HANDLE} & \boxed{9} \\ \text{INDEX} & \boxed{8} \end{bmatrix} \right\rangle \oplus \boxed{2} \\ \text{FOC} & \boxed{3} \\ \text{H-CONS} & \left\langle \begin{bmatrix} \textbf{focdom} & \\ \text{DOMED} & \boxed{9} \\ \text{DOMING} & \boxed{1} \end{bmatrix} \right\rangle \oplus \boxed{4} \end{bmatrix} \tag{11}$$

where the FMRS structure of the argument is specified as (9).

With these specifications double-focussing a constituent with (9) as its FRMS structure yields the FRMS structure

$$\begin{bmatrix} \textbf{fmrs} & \\ \text{LTOP} & \boxed{11} \\ \text{LZT} & \boxed{2} \\ \text{FOC} & \left\langle \begin{bmatrix} \textbf{assoc} & \\ \text{ARG} & \boxed{11} \\ \text{VALUE} & \boxed{10} \end{bmatrix}, \begin{bmatrix} \textbf{assoc} & \\ \text{ARG} & \boxed{10} \\ \text{VALUE} & \boxed{1} \end{bmatrix} \right\rangle \oplus \boxed{3} \\ \text{H-CONS} & \boxed{4} \end{bmatrix} \tag{12}$$

In the usual MRS notation we therefore get for the VP "introduced Bill to $[\text{Sue}]_{F2,F1}$"

$$\langle h0, \{h0 : \lambda x[\text{introd}(x, b, h1)], h3 : s\}, \{h1 : h2, h2 : h3\}, \emptyset\rangle$$

For (E4) we get

$$\langle h4, \{h4 : \mathbf{even}_x(h5, h6), h5 : \mathbf{only}_y(h0, h7), h0 : \text{introd}(j, b, h1), h3 : s\}, \{h1 : h2, h2 : h3\}, \{h5 >_F h6, h0 >_F h7\}\rangle \quad (13)$$

With the usual definition of **even**

$$\mathbf{even}_y(h, h') := \lambda t[\forall y \in \mathbf{ALT}(F(h'))[y \neq F(h') \rightarrow (h'' >_p \forall y[y = F(h') \rightarrow h'']]\wedge \forall y[y = F(h') \rightarrow h'']] \quad (14)$$

where $h''$ is as above in (4), we get the intended meaning from focus resolution

$$\forall y \in \mathbf{ALT}(s)[y \neq s \rightarrow (\forall x \in \mathbf{ALT}(y)[\text{introd}(j, b, x) \rightarrow x = y] >_p \forall y[y = s \rightarrow \forall x \in \mathbf{ALT}(y)[\text{introd}(j, b, x) \rightarrow x = y]])\wedge \forall y[y = s \rightarrow \forall x \in \mathbf{ALT}(y)[\text{introd}(j, b, x) \rightarrow x = y]]] \quad (15)$$

Analogously cases like (E4) can be treated.

## 4 Conclusion

The description of unspecified focus associations within the framework of MRS allows for the analogous treatment of scope ambiguities and quantifier scope ambiguities and focus association ambiguities within a single framework. A compositional construction of FMRS structures with both kinds of underspecification can be built into an HPSG-like grammar in the way shown.

## References


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# The VP operator analysis of tenses and the puzzle of tenseless languages

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**Abstract**

In this paper, I argue that a 'dynamic' implementation of the VP operator analysis of tenses, as in Muskens 1995, can serve as the basis for a treatment of tenseless languages, capturing certain morphosyntactic facts in a less stipulative way that alternative analyses of tenses as pronoun-like. I provide evidence from one language, West Greenlandic, for the existence of tenseless languages and argue that these can be analysed in terms of Muskens' approach to temporal interpretation. On this approach, the burden of encoding temporal information falls mostly on the VP, VPs manipulating the position of the reference time in different ways depending on their aspectual class, with tenses simply adding conditions on the reference time, requiring it to be before, after, or at speech time. Since tenses on this approach are VP operators, interpreted as functions from predicates to predicates, they should in principle be omissible, consistent with the hypothesized tenselessness of West Greenlandic. Such an approach suggests that true tenselessness entails neither a radical indeterminacy in the temporal interpretation of tenseless sentences nor radically different descriptions of tensed and tenseless languages, as some have claimed.


## 1 Introduction

A great deal of work on tense has explored the analogy between tenses and pronouns made by Partee [10], with many analyses making this analogy explicit and accordingly taking times as arguments of predicates and treating tenses as indexicals, directly denoting times, or as temporal anaphors or bound variables. An alternative line of inquiry, traceable to Bach [1], treats tenses as VP operators and seeks to capture the anaphoric properties of tenses by other means – in particular, by treating reference times as contextual items that the hearers keep track of in their processing of a discourse. In this paper, I shall be comparing these two approaches to tense as they pertain to the analysis of tenseless languages – that is, those that license sentences with no temporal marking and thus no linguistic encoding of a relation between reference time, R, and speech time, S. What I shall argue is that the 'dynamic' tenses-as-operators (henceforth DTaO) approach suggests an analysis of these languages less stipulative than that suggested by the tenses-as-pronouns (henceforth TaP) approach, while still capturing a key insight of the latter approach: namely, the 'referential' character of locating situations in time. The DTaO approach thereby makes possible an account of tensed and tenseless languages that attributes no radical difference in their respective syntactic or semantic properties, yet remains sensitive to the data that have led many researchers to recognize the existence of tenseless languages.

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## 2 The two approaches in more detail

The basic difference between the TaP and the DTaO approaches can be readily seen in the meanings that they respectively assign to tenses. For example, on the influential analysis of Kratzer [6], past tense is assigned the value given in (1a), according to which it simply denotes a past time. In contrast, past tense on the analysis of Muskens [8] and others is a function from predicates to predicates (predicates in his framework being of type <e, <s, <s, t>>>, functions from individuals and pairs of contextual states to truth values), which imposes the condition that Ri, the input reference time, be before speech time (in the current world).

(1) a. PAST: $[\![\text{past}]\!]^{g,c}$ is only defined if c provides an interval t that precedes $t_0$ (the utterance time). If defined, then $[\![\text{past}]\!]^{g,c} = t$.

b. PAST: $\lambda P \lambda x \lambda ij\ (Pxij \wedge Ri < Si \wedge Ri \text{ in } Wi)$

Arguably, the respective successes of the TaP and the DTaO approaches have been complementary, the former addressing mostly issues related to intrasentential tense patterns such as that in (2a), and the latter mostly those related to patterns of tenses in discourse, such as that in (2b):

(2) a. When Susan walked in, Peter left. ([10], 605)

b. Mary turned the corner. John saw her. She crossed the street. ([8], 176)

Yet tenseless languages can provide a useful point of comparison for the two approaches. This is because these approaches can be seen to make different predictions about the rôle of tense in the composition of sentence meanings and thus about the nature of cross-linguistic difference in the temporal domain. That is, since the DTaO approach takes tenses to be predicate modifiers, as we have just seen, tenses on this approach are in principle omissible, inasmuch as combining a tense with a predicate leads to an expression of the same type as that of the input expression. In contrast, the TaP approach takes tenses to be arguments of predicates – a tense combining with a predicate (or on Kratzer's account, with an Aspect Phrase) to yield an expression of a different type. On Kratzer's set-up, tenses, of type <i>, combine with Aspect Phrases, of type <i,<s, t>> to yield propositions, <s, t> (*i* being the type of intervals and *s* the type of worlds). On such a set-up, then, no analysis of truly tenseless languages is obviously available, and thus no such languages are predicted to be possible. This framework of assumptions has accordingly led to a treatment of tenseless languages as instantiating phonetically null tenses (e.g., [7]). On this approach, languages without tenses are essentially assimilated to those with them, the difference between the two kinds of languages reducing to lexical differences related to their inventories of tense morphemes.

Now, for those with no particular devotion to the syntactic or morphological properties of 'exotic' languages, it seems fair to ask whether the decision between identifying a language as having phonetically null tense morphemes and identifying it as having no tense morphemes at all has any bearing on an analysis of the temporal properties of sentences in this language. My (somewhat prejudiced) answer is yes, for the following reason. This is that tense morphemes in languages that clearly have them exhibit distributional properties that distinguish them from other linguistic devices for locating situations in time, such as temporal adverbs. Moreover, even when



phonetically null exponents of tenses have been recognized in a given tense system (as they often are in the analysis of languages with impoverished inflectional morphology, such as English), these tense morphemes have also been recognized to conform cross-linguistically to a clear semantic pattern: namely, that they contrast directly with overt tenses in being 'attributed the same meanings as overt [forms] would have if they were available' ([2], 91). Thus, by assembling criteria to identify tenses, we can give empirical content to the question whether tense is a linguistic universal and how the grammar of a given language has determined the temporal division of labour between the temporal marking devices that it actually has.

## 3 Some evidence for tenseless languages

The question to be addressed, then, is whether or not there are languages with no tense morphemes. My answer to this question, based on data from West Greenlandic (henceforth WG), is yes. The relevant data include not only temporally 'bare' verb forms but also those with affixes such as *-sima-* (a past or perfect marker) and *-ssa-* (a future marker). While such affixes seem, at first sight, to be identifiable as tenses, various grammatical criteria for identifying tenses, assembled from the literature (e.g., [3], [13]), strongly suggest that they are not. These criteria include (i) the obligatoriness of tenses in matrix clauses and (ii) occurrence only once in a clause; (iii) their being typically morphologically bound, and when bound, (iv) their representing inflectional morphology and thus (v) occurring in a fixed position on the verb form – namely, at its edge – and (vi) occurring 'outside of' derivational morphology.

One strong indication that these affixes are not tenses is that they are not obligatory – verb forms without temporal marking, such as those in (3), being unexceptional in the language ([5], 272, 278):[1]

(3) a. aggirpuq.
aggir-puq
come-IND.3SG
'He is/was coming.'

b. tikippuq.
tikit-puq
have.arrived-IND.3SG
'He has come/came.'

Another indication is the existence of verb forms in which these affixes are separated from inflectional morphology by one or more affixes, as shown in (4) ([5], 316; ([4], 259–260):

(4) a. allattu-i-vvi-ssaaliqi-sar-sima-qa-anga
write.down-1/2.TRANS-place-lack-ITER-PERF-very-IND.1SG
'I was really short of note-books.'

b. ungasinnirulaatsiassaqquuqaaq
ungasiq-niru-laar-tsiar-ssa-qquur-qi-vuq
be.far-more-a.little-somewhat-FUT-undoubtedly-!-IND.3SG
'It will undoubtedly be somewhat further off.'

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[1] I use the following glosses in WG examples (based on [4], [5]): FUT = future; IND = indicative ITER = iterative; PERF = perfect; (1/3) SG = ($1^{st}/3^{rd}$ person) singular; 1/2.TRANS = half-transitivizer.

From the WG glosses, we can see that *-sima-* in (4a) is separated from inflection by one morpheme, *-qa-*, and that *-ssa-* in (4b) is separated by two morphemes, *-qquur-* and *-qi-*. As such, these temporal affixes are clearly distinguishable from inflection and not at the edge of the verb form. In addition, *-ssa-* and *-sima-* may both occur on a single verb form, different orders of the two correlating with different interpretations, as shown in (5) ([4], 267–268):

(5) a. atursimassavaa
atur-sima-ssa-vaa
use-PERF-FUT-IND.3SG/3SG
'He must have used it.'

b. atussasimavaa
atur-ssa-sima-vaa
use-FUT-PERF-IND.3SG/3SG
'He presumably will have used it.'

What is also worth noting about *-ssa-* and *-sima-* is that the former, which is the nearest that WG has to 'an absolute or "pure" future', is a likelier candidate for a tense than the latter, whose temporal and aspectual uses are difficult to disentangle ([5], 274, 272). Yet the distribution of the two affixes – and, in particular, the observation that *-ssa-* can appear in the scope of *-sima-*, as in (5b) – makes it difficult to classify either affix as a tense. Such distributional facts are thus difficult to square with the possibility (entertained in [7] for the language St'át'imcets) that these affixes are the overt counterparts of phonetically null tenses, the latter associated with sentences lacking overt temporal marking.

Another reason that such a positing of phonetically null tenses is unattractive is the following one. As argued in [7], a phonetically null counterpart of affixes like those just described would have to be semantically underspecified, in order to capture the interpretation of forms like those given in (3). Yet this possibility is clearly at odds with the observation made above that null tenses across languages systematically have the same sorts of meanings as overt ones, rather than the more general ones that would be required here. One might accordingly claim, then, that every verb form in WG was associated with a phonetically null tense, with which temporal affixes could also occur. But since WG verb forms lacking temporal marking can occur with adverbials locating situations in the past, present, or future, this would lead in turn to one of two rather stipulative claims: either that WG has null past, present, and future tenses; or that it has only one, null, tense, indeterminate between past, present, and future meanings. A more plausible conclusion is that WG simply does not have tenses.

## 4 Toward an analysis of tenseless languages

Arguably, the case sketched above for identifying WG as a tenseless language (more detailed versions of which appear in [12], [13]) is compelling enough – and consistent enough with the data of a range of other languages – that it is worth investigating its implications. As already noted, the absence of tense morphemes in WG and other languages is at odds with the TaP approach to tenses, on which the meanings of tenses are basic to the meanings of (at least independent)[2] sentences. However, it appears to

[2] This qualification is necessary given that on the assumptions of [6] and other works, the complement clauses of attitude verbs and certain other embedded clauses denote properties of times rather than propositions.



create no special problems for the DTaO approach, on which tenses are simply predicate modifiers. Of course, the simple omissibility of tense consistent with this approach does not speak to the issue of how speakers of tenseless languages can be described as having situation-locating resources commensurate with those possessed by speakers of tensed languages, as any analysis of the former languages would need to do.

Here, though, the 'dynamic' resources of this approach present a view of the grammar's 'division of temporal labour' that can address this issue. Rather than taking the burden of encoding temporal information to fall largely on tense, this approach takes it to fall largely on the VP. The basic idea is that VPs provide information about R, which is understood to be one on a list of contextual items, or 'stores', that make up the hearer's 'contextual state' at a given point in a discourse. It is the (possibly changing) values of these stores that the hearer keeps track of in processing the discourse and moving from one contextual state to another. Verbs contribute to this updating task by virtue of their aspectual properties, which regulate the position of R with respect to E, the event time. More specifically, as Muskens' translations ([8], 172) show, a 'kinesis' verb like *yawn* tests whether the yawner yawns at the current R, then sets a new value for R that is just after the old one; while a stative expression like *be drunk* does not shift R, but simply tests whether the current R is included in the situation of the subject's being drunk:[3,4]

(6) a. yawn: $\lambda x \lambda ij\ (\text{yawn } x(Ri) \wedge i[R]j \wedge Ri \lesssim Rj)$
b. be drunk: $\lambda x \lambda ij \exists e\ (i = j \wedge \text{drunk } xe \wedge Ri \subseteq e)$

According to this picture of temporal interpretation, VPs in tensed and tenseless languages alike relate R to E; and in each case, the value of R is an element of the context that the hearer is keeping track of.. The relevant difference between a tensed sentence in English like *Mary yawned* and its tenseless counterpart in WG would thus amount only to the condition on R that the English past tense imposes, requiring R to be before S. In the WG sentence, which by hypothesis has no such morpheme, the relation between R and S would not be linguistically specified (although, of course, it could be by means of the temporal affixes described above or other temporal adverbials). Yet the status of R as a contextual item means that the hearer will be able to identify this time even without this linguistic specification of the R-S relation. The difference just sketched is shown in (7), where it clearly reflected in the presence of the past tense's condition on the R-S relation in (7a), taken to correspond to the English sentence; and the absence of this condition in (7b), taken to correspond to the WG sentence (abstracting away from details of inflectional morphology):

(7) a. Mary (PAST (yawn)): $\lambda ij\ (v_1\, i = \text{mary} \wedge \text{yawn}\ (v_1\, i)(Ri) \wedge i[R]j \wedge Ri \lesssim Rj \wedge Ri < Si \wedge Ri \text{ in } Wi)$

[3] In Muskens' translations as given in (6)–(7), 'x' and 'y' are variables over individuals; 'i' and 'j' are variables over states; 'e' is a variable over events; '$v_1$' is a store name, one of the 'special constants [...] that refer to stores'; 'i[v]j' indicates that states *i* and *j* agree in all stores of a given type except possibly in *v* and *i* and *j* agree in all stores of all other types; '$\subseteq$' indicates temporal inclusion; and '$\lesssim$' indicates that $t_1$ is before $t_2$ and there is no $t_3$ between them ([8], 152, 160).

[4] Admittedly, such a treatment does not address many significant aspectual matters. For a far more detailed dynamic treatment of the aspectual properties of verbs, see e.g., [9].

b. Mary (yawn): $\lambda ij\ (v_1\ i = mary \wedge yawn\ (v_1\ i)(Ri) \wedge i[R]j \wedge Ri \leq Rj)$

What this brief investigation of tenseless languages suggests, then, is that the desideratum of capturing the 'referential' aspect of temporal interpretation need not commit us to a TaP analysis of tenses, as Partee herself [11] has noted. It also suggests that we can recognize the existence of tenseless languages without adopting descriptions of them that are radically different from those of their tensed counterparts – or that predict a radical indeterminacy in the temporal interpretation of tenseless sentences, as has sometimes been claimed (e.g., [7]).

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# Reconstruction and Its Problems


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## Abstract

This paper is concerned with reconstruction theories of *which*-questions, and shows that one major limitation of these approaches lies in the way these theories derive *de dicto* readings of sentences such as *Mary knows which children cried.* Specifically, we show that when a wide range of *de dicto* facts is considered, an analysis where *wh*-phrases never reconstruct must be preferred over the reconstruction approach.


## 1 Why reconstruct?

The reconstruction approach, originally proposed in [4] and recently taken up in [1] among others, states that *wh*-phrases are interpreted in their base position and, therefore, those which are 'displaced' in the overt syntax 'reconstruct' at LF. This approach presents three immediate advantages.

First, it offers a straightforward analysis of *wh*-phrases that appear 'undisplaced' in the overt syntax, as in (1):

(1) Which man loves which woman?

Secondly, it accounts for some Binding Theory properties of the predicate of 'displaced' *wh*-phrases. For example, in (2) (from [8]), the prohibition on coreference between *Diana* and *she* can be seen as a consequence of reconstruction together with Condition C: after reconstruction *Diana* is c-commanded by *she*. According to Condition C of the Binding Theory, they cannot refer to the same individual.

(2) How many stories about **Diana** is **she** likely to invent _?

Finally, reconstruction theories predict the *de re*/*de dicto* ambiguity of *wh*-phrases (observed in [3]). Assuming explicit world variables in the object language, and assuming that the world argument of *child* may be freely indexed, the *de dicto*/*de re* ambiguity of (3a) is reflected in (3b) (assume also, from now on, that Dan and Sam are the children who actually cried):

(3) a. Mary knows which children cried.

b. Mary believes in $w \cap \{p: \exists x[p(w) = 1\ \&\ p = \{w': x$ cried in $w'$ and $x$ is a child in $w/w'\}]\}$

The reconstruction approach in its original format, however, presents a major drawback, when cases like (4a) are taken into account, as first pointed out in [12]:

(4) a. Which philosopher didn't _ come to the party?

b. Intuitive meaning: for which x, x a philosopher, x didn't come to the party.


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c. Predicted meaning: for which x, it is not the case that x is a philosopher and came to the party.

The problem, later referred to as 'the Donald Duck problem', has to do with what should count as a possible answer to a question where the *wh*-phrase is base generated within the scope of a Downward Entailing operator, as in (4a). If the *wh*-phrase were to be interpreted in this environment (as in (4c)), "Donald Duck" should be a possible answer to (4a), contrary to our intuitions. The correct meaning of this question (i.e. (4b)) is derived if the *wh*-phrase is interpreted in its surface position.

[12] and [13] spell out two variants of the reconstruction approach, the choice function approach (CFA) and the presuppositional approach (PA), both retaining the above-mentioned main advantages of the original approach, and, at the same time, avoiding the Donald Duck problem. For the purposes of the present discussion, it will be sufficient to illustrate this point for the PA.[1] The PA avoids the problem by treating the reconstructed/*in-situ* phrase as a definite description; as shown in (5):

(5) Q: For which individual x, the philosopher x didn't come to the party.
A: #Donald Duck (presupposition failure)

Although we agree that a presuppositional analysis of *wh*-phrases would represent a solution to the Donald Duck problem, we think that this type of approach remains problematic in another important respect: it fails to fully account for the wide range of facts regarding *de dicto*/*de re* ambiguities.[2] Before turning to the discussion of the problematic cases, it is worth concluding this introductory section by illustrating with an example how the PA generally derives *de re*/*de dicto* ambiguities:

(6) a. Mary knows which children cried.
b. Mary believes in w $\cap\{p: \exists x[p(w) = 1 \;\&\; p = \{w': \text{the-child}_{w'/w}\; x \text{ cried in } w'\}]\}$
Mary believes in w $\{w': \text{the child}_{w'/w}\text{ Dan \& the child}_{w'/w}\text{ Sam cried in } w'\}$

If the world-index of *child* is w', the child-status of the children who cried is presupposed to be known by Mary. This is because any world where the proposition *that the child Dan and the child Sam cried* has a truth value at all is one where Dan and Sam are children. Since the sentence asserts that all the worlds compatible with what Mary believes are such that this proposition is true in them, it also presupposes that Mary knows that Dan and Sam are children. Rullmann and Beck see this as a desirable outcome, as it makes their analysis compatible with the claim made in [10] and [6] that attitude verbs presuppose that the attitude holder believes the presuppositions of the complement of the verb.

## 2 Embedding verbs and *de dicto* readings

The PA predicts that *de dicto* readings should always be available, regardless of the particular choice of embedding verb. This prediction is incorrect. Consider (7) and (8):

(7) Mary didn't know which children cried, because, although she knew that Sam and Dan cried, she was not aware that they were children.

[1] We illustrate every point throughout the paper only for the PA, but every point applies also to the CFA.
[2] The same conclusion is reached in [14], where a Hamblin-style reconstruction analysis is criticized.



(8) # It surprised Mary which children cried, because although she (correctly) expected Sam and Dan to cry, she was not aware that they were children.

(8) shows us that the embedded question is interpreted *de dicto*: Mary's lack of knowledge about the child-status of the children suffices to make *Mary knew which children cried* false. However, within the PA, Mary's knowledge of the child-status of the crying children is a presupposition and should therefore escape negation (see (6b) above). Given this, the outcome should be a contradiction between assertion and presupposition, unless the presupposition is "locally accommodated" into the assertion part, giving us (9):[3]

(9) Mary didn't believe in w $\cap\{p: \exists x[p(w) = 1 \;\&\; p = \{w': x \text{ is a child in } w' \text{ and the child}_{w'}\; x \text{ cried in } w'\}]\}$

An analysis in terms of accommodation, however, cannot explain the fact that (8), where the embedding verb is *surprise*, is quite odd. If the acceptability of (7) is due to local accommodation then (8) should be good as well. To see this, let us first look at the predicted *de dicto* interpretation of the first conjunct in (8), without accommodation (for the semantics of *surprise* adopted here, see [11]):

(10) Mary expected in w NOT p, where p = *that the child Dan & the child Sam cried*

Now, we expect to be able to accommodate the presupposition as we did in (9):

(11) Mary expected in w NOT *that Sam & Dan are children and they cried*

According to the accommodation analysis, the second conjunct of (8) doesn't contradict its first conjunct. Therefore the sentence should be fine.

A potential objection to our argument might be that the meaning of *surprise* is more complicated than we assumed above. Specifically, besides a past incorrect expectation, this predicate also conveys knowledge of the complete answer to the question at the time of discovering the actual facts (cf. [14]). Conceivably, the relevant presupposition should also hold at the time the subject is surprised. Therefore, the meaning of the first conjunct in (8) should look roughly as in (12):

(12) $\exists t[t < \text{now}$ and Mary believes p at t & $\exists t'[t' < t$ and Mary expected at t' NOT p]], where p = *that the children Dan and Sam cried.*

However, notice that even if this were correct, local accommodation (see (13)) would still suffice to resolve the contradiction in (8). Example (14) below makes a similar point:

(13) There is a time t < now such that Mary believes at t that Sam & Dan are children and they cried and there is a time t' < t, such that Mary expects at t' NOT (that Sam and Dan are children and they cried).

(14) # Although Mary had expected Sam and Dan not to cry, it still didn't surprise her which children cried when she found out that Sam and Dan cried, because she never found out that they were children.

We conclude, from the contrast between (7) and (8), that the child-status of the children who cried is relevant to the semantics of *know*, but irrelevant to the semantics of *surprise*, and that the question-complement of *surprise* doesn't have a *de dicto*

[3] What makes local accommodation plausible in this case is precisely the prevention of a contradiction, cf. [5].

reading. This is problematic for the PA, which predicts questions to have *de dicto* readings under any verb.

A second argument against the PA comes from Quantificational Variability data (see [11], [2]), which show that Mary's awareness of the child-status of the children who cried is entailed by (7), rather than presupposed. To see this, consider (15a). Its meaning involves accommodating the presuppositions of the nuclear scope into the restrictive clause. If the *wh*-phrase is indeed reconstructed, the nuclear scope of *with no exceptions* is 'Mary knows that the child x cried', and 'Mary believes that x is a child' is one of its presuppositions. As such, it gets accommodated into the restrictive clause (as roughly illustrated in (15b)).

(15)a. With no exceptions, Mary knows which children cried.

b. For no x such that x cried and x is a child and Mary believes that x is a child, Mary doesn't know that the child x cried.

However, if the interpretation (15b) were indeed available for (15a), we would incorrectly expect (15a) to be true in the scenario described in (16).

(16) Dan and Sam are the children who cried. Mary believes that Dan is a child, but that Sam is not. She knows that Dan cried, but not that Sam did.

We conclude that the presuppositional analysis of *wh*-phrases is problematic.

## 3 Contextual *de dicto* readings

It is claimed in [13] that (17) has a *de dicto* reading:

(17) Which unicorns does John want to play with?

Rullmann and Beck argue that in our world, where unicorns do not exist, this question means something like: "which entities that are unicorns according to John does he want to play with?" The PA predicts this reading, assuming that *want* presupposes that the subject of *want* believes the presuppositions of the complement. We argue, however, that this is a very different *de dicto* reading from the one observed in [3], and we call it "contextual *de dicto*". For the contextual *de dicto* reading to come about, *unicorns* has to be uttered with a special intonation (and for some speakers, must be accompanied by a gesture of drawing quotation marks in the air). In addition, the contextual *de dicto* reading does not require a presuppositional trigger such as *want*; it can arise in matrix questions too. For example, we can ask *Which unicorns played the piano?*, with the same special intonation, drawing quotation marks in the air, to mean something like: "which imaginary unicorns played the piano?".

Interestingly, *know* and *surprise*, which show a contrast with respect to *de dicto* readings in (7)-(8), are both good when they embed (17):

(18) Mary knows which unicorns John wants to play with.

(19) It surprised Bill which unicorns John wants to play with.

We conclude from this that the contextual *de dicto* reading illustrated in (17) is very different in nature from the *de dicto* reading in the sense of [3] and our theory should reflect that. Contextual *de dicto* readings should probably be analyzed within a theory of quotation (which we do not discuss here).



## 4 Proposal

We propose that *which*-phrases are not interpreted in their base position. Following ideas in [7] and [14], we propose that a verb such as *know* has a Groenendijk-and-Stokhof-like meaning (inherently strongly exhaustive and *de dicto*, see [3]) as one of its meanings, while a verb such as *surprise* has a Karttunen-like meaning (inherently weakly exhaustive and *de re*, see [9]) as its only meaning. This yields (20) as a possible interpretation of (3a), and (21) as the only interpretation of *It surprised Mary which children cried.*

(20) Mary believes in w $\{w': \bigcap\{p: p(w') = 1 \text{ and } \exists x[x \text{ is a child in } w' \text{ and } p = \text{that } x \text{ cried}]\} = \bigcap\{p: p(w) = 1 \text{ and } \exists x[x \text{ is a child in } w \text{ and } p = \text{that } x \text{ cried}]\}\}$ (i.e., Mary believes in w that Sam and Dan are children-criers and everyone else is not a child-crier).

(21) Mary expected in w NOT $\bigcap\{p: p(w) = 1 \text{ and } \exists x[x \text{ is a child in } w \text{ and } p = \text{that } x \text{ cried}]\}$ (i.e., Mary expected in w that Sam and Dan didn't cry).

The claim that *know* is strongly exhaustive is due to [3]. Evidence that *surprise*, by contrast, is inherently weak comes from an observation made in [7] that (22) is intuitively false, while (23) can be true.

(22) Although Mary expected Dan and Sam – the children who cried – to cry, it still surprised her which children cried because she also expected Ann, who didn't cry, to cry.

(23) Although Mary knows that Dan and Sam – the children who cried – cried, she still doesn't know which children cried (at least not completely), because she doesn't know that Ann didn't cry.

According to our proposal, *know* exhibits a *de dicto*/*de re* ambiguity, but *surprise* cannot. This is consistent with the judgments in (7), (8) and (14). The oddity of (8) and (14) comes from the fact that the child-status of the children who cried is completely irrelevant to the interpretation of the question embedded under *surprise*. As for (15a), it is roughly interpreted as follows: "for all x such that x cried and x is a child, Mary knows that x cried (and x is a child)" (and therefore judged false in (16)).

To conclude, the uneven distribution of *de dicto* readings, which is problematic for reconstruction theories, follows from the semantics of the relevant embedding verbs, if *wh*-phrases never reconstruct. Although we have nothing to say about Condition C effects (see section 1), we believe that the advantages of not reconstructing outweigh the apparent advantages afforded by the reconstruction approach with respect to the Binding Theory.

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# The Semantic Diversity of Characterizing Sentences

**Veerle Van Geenhoven** *

**Abstract**
Concentrating on the West Greenlandic aspect marker *-tar-*, I address the question of whether this kind of marker supports a uniform relational analysis of habitual and other characterizing sentences, as proposed in [12]. I argue that it does not. I show that the distribution of *-tar-* leads to a semantic diversity in the class of characterizing sentences, which brings along different sources of their nonparticular, generic nature.

## 1 Introduction

[12] distinguish habitual characterizing sentences (HabCS) from lexical ones (LexCS), also known as 'i-level predicates'. In (1) we find HabCSs, in (2) LexCSs:

(1) a. Mary smokes.
b. A bird lays eggs.
c. John sells books.

(2) a. Peter knows Danish.
b. A horse has a long tail.

In addition to CSs like those in (1) and (2), [12:81ff] discuss sentences with "a distinctive property interpretation". In [12]'s view, these are not to be treated as CSs even though "they seem to be just some more cases of ... characterizing sentences." For example, if the distinctive property *eat horsemeat* were characterizing, (3a) should have the same and not a weaker meaning than (3b), just like the CS in (4a) has the same meaning as the one in (4b):

(3) a. Frenchmen eat horsemeat. b. A Frenchman eats horsemeat.
(4) a. Birds lay eggs. b. A bird lays eggs.

Following [10]'s analysis of conditionals and [4]'s view on generic sentences, [12] interpret all CSs in a relational way. In particular, they propose that a generic operator GEN binds a situation variable that is part of the lexical meaning of the verbal predicate. (1a) and (2a) then get the tripartite structures in (1a') and (2a'), respectively:

(1) a'. GEN [x,s;][x = Mary & x *in* s; x *smokes in* s]
(2) a'. GEN [x,s;][x = Peter & x *in* s; x *shows knowledge of Danish in* s]

The operator GEN is interpreted in terms of a conditional: *Mary smokes* means that if Mary is in a particular situation *s*, she is smoking in this situation *s*. The conditional analysis is based on the idea that CSs are not necessarily episodic: For (1c) to be true, John must not have sold a single book. He must simply be a book seller. In addition, [12] treat GEN as a sentence-level operator. This sentence-level treatment of CSs is (apparently) supported by the fact that CS markers are tightly related to the verb, i.e.,

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to the head of a CS. Standard examples of CS marking in English are adverbs like *usually* (e.g., *Mary usually smokes*) and the periphrastic form *used to* (e.g., *Mary used to smoke*). A sentence-level treatment seems also supported by the fact that in many (native American) languages (see e.g., [1], [9]) we find habituality markers on the verb. A case in point is the West Greenlandic (WG) affix *-tar-* in (5a) and (5b), the WG correspondents of (1a) and (1b):[1]

(5) a. Maria pujortar**tar**poq.
Maria pujurtar-**tar**-puq
M.ABS.SG smoke-**regularly**-IND.[-tr].3SG
'Mary smokes.'

b. Timmiaq manniliortarpoq.
timmiaq
bird.ABS.SG
manni-liur-**tar**-puq
egg-make-**regularly**-IND.[-tr].3SG
'A bird lays eggs.'

The question I address is whether a marker like *-tar-* supports a uniform relational analysis of CSs. Interestingly, if we look at (6), which shows WG correspondents of the CSs in (1c), (2a), and (2b), we see that they do not contain *-tar-*. In contrast, a WG correspondent of the distinctive property in (3) contains *-tar-*, as shown in (7):

(6) a. Juuna atuakkanik tuni**niaa**soq. 'profession'
Juuna atuakka-nik tuni-**niar**-suq
J.ABS.SG book-INS.PL sell-**intend/try**-NOM.ABS.SG
'Juuna is a bookseller (lit. Juuna is someone who intends/tries to sell books).'

b. Piitaq qallunaatut nalunngilaq. 'i-level predicate'
Piitaq qallunaa-tut nalunngi-laq
P.ABS.SG danish-EQ know- IND.[-tr].3SG
'Peter knows Danish.'

c. Hiisti takisuumik pamioqarpoq. 'i-level predicate'
hiisti takisuu-mik pamiu-qar-puq
horse.ABS.SG long-INS.SG tail-have-IND.[-tr].3SG
'A horse has a long tail.'

(7) Kalaallit puisi mikiartoq neri**sar**paat. 'distinctive property'
kalaalli-t puisi mikiartuq niri-**tar**-paat
Greenlander-ERG.PL seal.ABS.SG fermented.ABS.SG eat-**repeatedly**-IND.[-tr].3SG.3PL
'Greenlanders eat fermented seal.'

I argue that the distribution of *-tar-* in WG CSs leads to a number of subclasses of CSs, namely, one class whose VPs are pluractional (the 'true' habituals, including distinctive properties), one whose VPs describe attitude reports, dispositions, prescriptions (the nonepisodic CSs), and one whose VPs express inalienable properties (the i-level predicates). A uniform GEN-based relational analysis of CSs fails to account for this semantic diversity. Rather, this diversity brings along different sources of the nonparticular, generic nature of CSs and yields a novel view on the quantificational structure of CSs.

The paper is organized as follows. Section 2 is about how we arrive at habitual readings. Section 3 discusses nonepisodic CSs. Section 4 is about LexCSs, that is, i-level predicates. Section 5 shows that distinctive properties are habituals. Section 6 closes the paper.

[1] The abbreviations used are ABS 'absolutive', EQ 'equative', ERG 'ergative', IND 'indicative', INS 'instrumental', NOM 'nominalization', PL 'plural', SG 'singular', tr 'transitive'.



## 2 The pluractional source of habitual readings

In contrast to [8], who regards WG *-tar-* as a genericity marker, and to [2], who analyzes it as an adverb of quantification, I regard *-tar-* in (5a) and (5b) as a marker of frequentative aspect in the first place. In [16] and [17], I argue that frequentative aspect is an instance of 'pluractionality', that is, of verbal plurality (see [6], [13]). WG *-tar-* is thus a marker of verbal plurality. If *-tar-* is added to a verb, the verb is pluralized in the sense that it distributes subevent times over the overall event time. Moreover, *-tar-* creates atelic predicates: *-tar*-verbs meet the principle of cumulative reference (see [14]). For example, *pujortar-tar* in (5a) expresses the plural property of being smoking and smoking and ... Hence, the generalization we can derive from this, namely, that Mary has the habit of smoking, has an episodic source, namely, an unbounded plurality of smokings. That we understand (5a) as describing a habit of Mary's depends on the length of the time interval at which her involvement in a plurality of smokings holds, as well on the number of smokings. This is captured in (8):

(8) *Maria pujortartarpoq* is understood as 'Mary has the habit of smoking at t' iff
- there is a plurality of smokings by Mary at t;
- the time at which the repetition holds, i.e. t, has an appropriate length;
- the number of repeated event times in t is appropiately large.

I assume that in English, habitual readings result from the presence of an implicit pluractional *tar*-like operator. Note that this does not correspond to expressions like *used to*. While WG *-tar-* is a pluractional marker, English *used to* is an 'appropriate length' indicator. Hence, unlike *-tar*-sentences *used to*-sentences do not necessarily receive a frequentative interpretation (e.g., *The statue of Lenin used to stand here*).

In [12], the semantic structure of CSs is equal to the relational structure of sentences that contain an adverb of quantification, where GEN corresponds most closely to the adverb *usually*.[2] Hence, when a CS contains a *when-* or a *whenever*-clause, as in (9), this clause is analyzed as the restrictor of GEN:

(9) Mary smokes when/whenever she is at work.
(9') GEN [x,s;][x = Mary & x *is at work in* s; x *smokes in* s]

In WG *tar*-sentences, temporal subclauses are marked with the morpheme *-gaanga-*:

(10) Nukappiaraq ballonisi**gaanngα**mi qaartoor**tar**paa. ([2]:64)
nukappiaraq balloni-si-**gaannga**-mi qaartuur-**tar**-paa
boy.ABS.SG balloon-get-**when.frequently**-3SG.PROX break-**regularly**-IND.[+tr].3SG.3SG
'When a boy gets a balloon, he breaks it.'

According to [2], the affix *-tar-* is an adverb of quantification while the *gaanga*-clause is its restrictor. However, in [15] I show that a temporal subordinate clause does not necessarily provide the restrictor of a quantificational adverb, neither does such a

[2] Negation makes this correspondence disappear. In *Mary usually doesn't smoke* negation has narrow scope w.r.t. *usually*, while in *Mary doesn't smoke* negation has scope over the habit *smoke*.

clause necessarily trigger a tripartite structure. I propose that, like *-tar-*, *-gaanga-* is a pluractional marker. In particular, (10) illustrates what I call 'pluractional agreement': If a matrix clause describes a plurality of event times (marked by *-tar-*), a temporal subordinate clause does too (marked by *-gaanga-*). Similarly, in English HabSCs *when(ever)*-sentences are pluractional markers, which distribute event times 'in agreement with' the distribution performed by the pluractional matrix verb. Hence, a *when(ever)*-clause restricts a habit in that it is part of the habit's description:

(11) *Mary smokes when(ever) she is at work* is understood as 'Mary has the habit of smoking-when-she-is-at-work at t' iff (among other things) there is a plurality of smokings-when-she-is-at-work by Mary at t.

## 3 Nonepisodic CSs do not describe habits

According to [12], crucial support for a conditional analysis of CSs is that CSs are not episodic. [12] argues that for (1c) to be true, John must not have sold a single book. (12) is the GEN-analysis of (1c)'s profession reading 'John is a book seller':

(12) GEN [x,s;y][x = John & x *in* s; x *sells* y & y *are books in* s]

Given [12]'s view, you may expect that in WG (1c) is a *tar*-sentence and conclude that *-tar-* is the linguistic realization of GEN. However, (6a) makes clear that *John sells books* is not necessarily a *-tar*-sentence. Moreover, if *-tar-* is used, as in (13), Juuna must have sold books for this sentence to be true:

(13) Juuna atuakkanik tunisi**sar**poq.
Juuna atuakka-nik tuni-si-**tar**-puq
J.ABS.SG book-INS.PL sell-AP-**regularly**-IND.[-tr].3SG
'Juuna sold/is selling books regularly.'

(13) does not describe Juuna's profession but an event in which he is involved regularly. It could therefore be one of his habits. The nominalization in (6a) describes Juuna's profession. (6a) contains the intensional morpheme *-niar-* ('try'). It presents a CS that must be interpreted as an attitude report. Similarly, to capture the profession reading of (1c) we need to stipulate the presence of a modal operator. Note that we also need modal operators to interpret *This machine crushes oranges* as a disposition and *Mary handles the mail from Antarctica* as a prescription, which are other famous examples that apparently support a conditional analysis of CSs.

## 4 I-level predicates describe inalienable properties, not habits

[12] and [7] defend a conditional analysis of i-level predicates (see (2a')) as an alternative to the treatments of i-level predicates we find in [3] and [11]. [7] wants to account for — among other things — why an i-level predicate cannot combine with a locative, as in *?? John knows French in his office*. In [7], an i-level predicate is therefore seen as inherently generic and the restriction on a built-in GEN operator is



the property of being at an arbitrary location: *John knows French* then means 'Wherever John is, he knows French'. This arbitrariness is incompatible with *in his office*. However, in this view the sentence *John knows French anywhere* should be fine, which in my opinion it is not. Moreover, we saw in (6b) and (6c) that WG i-level predicates do not contain *-tar-*. Hence, there is no linguistic evidence to treat them and other CSs alike. Yet, how can we account for the *'in his office* effect'?

I suggest that the answer lies in the fact that i-level predicates express inalienability and as such they hold of an individual fully independent of the individual's location, irrespective of whether this is an arbitrary or a particular location. Body part names (e.g. *tail*) are known to express inalienability. I suggest that also particular verbs, e.g. *know*, express inalienability. Hence, the inalienability in the meaning of nouns (*have a tail* vs. *have a house*) and verbs (*know a language* vs. *speak a language*) that make up i-level predicates, is responsible for their inability to combine with a locative like *in his office*. Why? *In his office* is understood as the frequency adverb 'whenever he is in his office' and, hence, it triggers pluractional agreement. This means that it combines only with a predicate that expresses frequentative aspect, i.e., with a property that is distributable over separated intervals of time. Given its inalienability, an i-level predicate does not meet this requirement.

## 5 Distinctive properties are habituals

[12] conclude that a semantics of CSs must distinguish between 'distinctive' and 'characterizing' properties. Comparing (3) with (4), their distinction is based on the following contrast: If we know that Frenchmen eat horse meat, this does not necessarily imply that a Frenchman eats horse meat. However, if we know that birds lay eggs, this implies that a bird lays eggs. Interestingly, (7) illustrates that in WG *-tar-* is used to express distinctive properties: If you want to express in WG that Greenlanders eat fermented seal meat, you use *-tar-*. Similarly, if you say that birds lay eggs, you use *-tar-*. This is shown in (5). Still, the majority of Greenlanders will not conclude from (7) that a Greenlander eats fermented seal meat. Most of them think that it is disgusting. Someone who is not from Greenland, though, and who does not know the habits of Greenlanders, could easily draw this conclusion just like someone who does not know the habits of Frenchmen could conclude (3b) from (3a). From this, I conclude that the distinction between (3) and (4) is not part of grammar. Rather, it is extra-linguistic knowledge that semantics must not account for.

## 6 Conclusion

The diversity in the linguistic realization of CSs in WG makes us conclude that we have CSs whose VPs are pluractional (the 'true' habitual predicates), CSs whose VPs describe attitude reports, dispositions, and prescriptions (the nonepisodic, modal CSs), and CSs whose VPs express inalienability (the i-level predicates). A uniform relational analysis of CSs does not account for this semantic diversity in that it does not distinguish CSs which have an episodic source, from CSs which do not, and in that it does not recognize the nondistributable nature of i-level predicates. Neither does it include the class of so-called distinctive properties.

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# A Counterfactual Analysis of the Progressive

**Károly Varasdi***

**Abstract**
The approach presented in this paper[1] sees the basic problem of the progressive aspect as one of identifying the *truth-makers* of progressive sentences.[2] One of the basic tenets of the truth-maker approach is that *truth supervenes on reality*, ie., that the truth-value of a proposition is somehow determined by what exists. The question of *what types* of truth-makers there are or may possibly be is still fairly controversial but there seems to be consensus that *situations* should be among them. In the case of the progressive this boils down to the question of describing those situations that make a progressive sentence true, false, or undefined. An especially flexible framework for theorizing about situations and their relation to natural language is Lenhart Schubert's **FOL**** formalism developed in [10], which will be used in this paper as a general framework for the analysis.

## 1 Introduction

Since David Dowty's work in [4] on the progressive, it has been customary to try to define the meaning of the progressive in terms of "blocking factors" whose elimination would guarantee that the culmination will eventually take place. However, there can be reasons completely "internal to the event", to use Landman's phrase in [6], that prevent the culmination, such as when I decide, by mere caprice, not to finish the letter I've already started to write. Actions (and events in general) do not seem to have the kind of *inertia* required by the type of explanation suggested by Dowty or Landman. Rather, we can argue for a picture in which events propagate freely, as it were, some of them culminating, others not, but those culminating *must have* arrived at their culmination point following a specific path. [3] This suggests a kind of *backward-looking approach*, according to which instead of trying to find out what the eventual outcome

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1. This paper might be seen as a complementer analysis of the one developed by Gendler Szabó in [11]. I thank Chris Piñón for drawing my attention to Gendler Szabó's article.
2. A good survey of the truth-maker theory is [5].
3. As the motto of Gendler Szabó's article shows, the roots of this idea can be traced back to at least Plato's *Theaetetus*.

may be on the basis of what is going on now, we should find out what *must be* going on now *if* a particular outcome awaits us in the future. In the case of telic eventualities this strategy amounts to evaluating the truth of a progressive sentence by checking if *certain necessary preconditions* of the culmination of the eventuality obtain in the present. Note that by checking *necessary* preconditions (*sine qua nons*, as I will call them), we avoid the *imperfective paradox*, because the truth of the progressive will not guarantee that the eventuality will ever culminate.

This informal idea can be made precise in terms of counterfactuals claiming that *if* certain conditions were not true now, *then* the culmination would not obtain later. We say that in this case there is a (weak) dependency between those conditions and the culmination, or that the conditions in question have an eliminating potential as to the culmination. It still remains to be explained, however, what is meant by "certain" in the phrase "certain conditions", for it is clear that just taking *any* necessary precondition of the culmination will not do. We can solve this problem by requiring that the necessary preconditions we are after be such that they have *minimal* eliminating potential in the sense that the precondition only eliminates the culmination (and its consequences) but leaves everything else intact. The truth-conditions of the progressive should then be explained in terms of these "proper sine qua nons" as truth-makers.

## 2 Thomason's problem

In his *Word meaning and Montague gammar*, David Dowty presents a problem that he attributes to Richmond Thomason.[4] Recently, Andrea Bonomi has discussed two very similar problems, one of them being essentially isomorphic to Thomasons's.[5] The problem is this.

Suppose that an ideally fair coin has been flipped up into the air and is on its way down. Then both (1) and (2) are infelicitous to utter, while (3) is true:

(1) #The coin is coming up heads.
(2) #The coin is coming up tails.
(3) The coin is coming up heads or tails.

Dowty's earlier attempt to define the truth conditions of the progressive predicted that both (1) and (2) are true, which is — as Dowty puts it — "a counterintuitive result". To cope with this problem Dowty introduced the notion of *inertia worlds* suggested by David Lewis. On the inertia worlds approach, (1) and (2) come out as false, which is also questionable. In fact, as Ralf Naumann

4. See [4, p. 147]. Sentence (3) is not present in Dowty' discussion of the problem.
5. The problem of the avalanche, see [2, pp. 182–183]. Bonomi uses his cases to refute Landman's theory, and he introduces the thought experiment of the avalanche to cope with a possible objection to his first thought experiment.



and Christopher Piñón remark in [9], "such sentences tend to lack a truth value in most circumstances"[6], and a theory of the progressive should treat them as such.[7]

On the approach developed here we have a simple and intuitive explanation of why neither (1) nor (2) can be true, despite (3) being so. Note that in this scenario *neither* ⟨outcome be heads⟩ *nor* ⟨outcome be tails⟩ can have a proper sine qua non, *precisely because* the game is indeterministic as to the outcome. In contrast, the disjunction ⟨outcome be heads⟩ ∨ ⟨outcome be tails⟩ *does* have a proper sine qua non, *viz.* ⟨the coin be flipped⟩. Note further that although this latter sine qua non is a *sine qua non* of the respective disjuncts, it is not a *proper* sine qua non thereof. This explains why (1) and (2) are not true. But we still ought to explain the fact that they are not false, either.

Let us relax the constraint that the game is indeterministic. Suppose that that there is some causal factor, $C_{heads}$, whose obtaining causes ⟨outcome be heads⟩. $C_{heads}$ being the cause of ⟨outcome be heads⟩ means — given Lewis's analysis of causality in [7] — that

$$\neg C_{heads} \mathrel{\Box\!\!\rightarrow} \neg\langle\text{outcome be heads}\rangle \wedge C_{heads} \mathrel{\Box\!\!\rightarrow} \langle\text{outcome be heads}\rangle.$$

So, $C_{heads}$ actually implies ⟨outcome be heads⟩, due to the second conjunct and the actual existence of $C_{heads}$.[8] Since this outcome does exclude ⟨outcome be tails⟩, $C_{heads}$ is also minimal in the sense required by the progressive (ie., a proper sine qua non). In other words, the existence of $C_{heads}$ would make

(4) The coin is coming up heads.

true while it would falsify the sentence

(5) The coin is coming up tails.

because its existence excludes the possible truth-makers of (5).[9]

6. Fn. 4. on p. 242.
7. Naumann and Piñón explain the semantic ill-formedness of (1) and (2) as a case of *presupposition failure*. They claim that the progressive has a presupposition according to which the outcomes cannot be incompatible and if the speaker believes that this presupposition is not fulfilled, the sentence will lack truth-value. See also footnote (9).
8. This is due to a property of counterfactuals, see [8, p. 27].
9. It is clear that the presence of $C_{heads}$ does not change the fact that the outcomes are incompatible. What it changes is only the *probability* of their occurrence, and that the coin cannot land on its both sides at the end of the flipping will remain a fact. So Naumann and Piñón would have to find some way to incorporate probabilities in an *essential manner* in their account. But the chances of this are low, as Dowty's following remark testifies:

> "There are occasions on which we can look back into the past and say truthfully (at least with the benefit of hindsight) that a certain accomplishment or achievement *was occurring* at that time, even though the probability of its completion was very small." ([4, p. 148] , italics there)

## 3 The framework

In what follows I briefly describe Lenhart Schubert's **FOL**$^{**}$ developed in [10], to which I add certain relations not present in the original. Schubert's system aims at unifying the merits of Situation Semantics ([1]) and those of event semantics inspired by Davidson's [3]. **FOL**$^{**}$ is like first order logic but has in-built tools to express various relations between situations, such as $\tau_1 \sqsubseteq \tau_2$ ("situation $\tau_1$ is part of situation $\tau_2$"), and derived relations that specialize the general part-of relation: $\tau_1 \trianglelefteq \tau_2$ ("$\tau_1$ is a temporal segment of $\tau_2$", ie. the runtime of $\tau_1$ is a subset of the runtime of $\tau_2$), and $\tau_1 \preceq \tau_2$ ("$\tau_1$ is a concurrent part of $\tau_2$", ie. the runtime of $\tau_1$ is equal to the runtime of $\tau_2$). Beside these, **FOL**$^{**}$ has two operators, '$*$' and '$**$', that connect a formula $\varphi$ and a situation term $\tau$: the intended meaning of $\varphi * \tau$ is that $\varphi$ *(partially) describes* (or *holds in*) $\tau$, while that of $\varphi ** \tau$ is that $\varphi$ *characterizes* (or *describes completely*) $\tau$. The model for **FOL**$^{**}$ contains a nonempty set of individuals, $\mathcal{D}$, a complete join semilattice of situations, $Sit$, a set of time points with a strict linear ordering $<$ on it, $\mathcal{T}$, a temporal trace function, *time*, and a pair of interpretation functions, $\mathcal{I}^+$ and $\mathcal{I}^-$ which provide the extension and the anti-extension of predicate constants, respectively. There are further interesting features of the system but as I will not use all of its machinery below, the interested reader is referred to Schubert's article for further details.

I add to the above a *similarity relation* on the set of $Sit$ in the spirit of David Lewis's [8]. Also, I introduce '$\Box\!\!\rightarrow$' as a new operator connecting two **FOL**$^{**}$ formulas: if $\alpha, \beta \in \mathbf{Form_{FOL^{**}}}$, then $\alpha \Box\!\!\rightarrow \beta \in \mathbf{Form_{FOL^{**}}}$. As for its semantics, I intend a semantics which is *mutatis mutandis* the same as the one Lewis gave to $\Box\!\!\rightarrow$. I will not go into the precise details here as they can be found elsewhere.[10] For the sake of simplicity, I will also apply the following *Convention*: In a formula $\varphi * \tau_1 \Box\!\!\rightarrow \psi * \tau_2$, the situation $\tau_1$ lies in the past of the situation $\tau_2$ (and similarly with $**$).

A remark is in order. **FOL**$^{**}$ is being used here because of its great expressive power but this choice is not necessary, although convenient. The important point is that we should be able to talk about propositions (or formulas) being true *in* a situation or *of* a situation as well as express various relations between those situations themselves.[11]

Now we define the **sine-qua-non** relation between situations.

**Definition 1** *[Sine qua non (weak dependency)]*

$$\varphi ** \tau \ \textbf{sine-qua-non}\ \psi ** \tau' \overset{def}{\Longleftrightarrow} \neg(\varphi ** \tau) \Box\!\!\rightarrow \neg(\psi ** \tau')$$

The dependency cone of $\varphi ** \tau$ is the set of all proposition–situation

10. See [8, p. 16].
11. Work toward a more complete formalization in **FOL**$^{**}$ is in progress.



pairs which depend on $\varphi ** \tau$. The dependency cone represents the eliminative potential of $\varphi ** \tau$:

**Definition 2** *[dependency cone]*

$$\textbf{depcone}(\varphi ** \tau) \overset{def}{=} \{ \langle \psi, \tau' \rangle \mid \varphi ** \tau \ \textbf{sine-qua-non}\ \psi ** \tau' \}$$

The dependency domain of $\psi ** \tau'$ is the set of all proposition–situation pairs on which $\psi ** \tau'$ depends:

**Definition 3** *[dependency domain]*

$$\textbf{depdom}(\psi ** \tau') \overset{def}{=} \{ \langle \varphi, \tau \rangle \mid \varphi ** \tau \ \textbf{sine-qua-non}\ \psi ** \tau' \}$$

The field generated by $\psi * \tau'$ is a set of ordered pairs whose first component is a proposition–situation pair on which $\psi * \tau'$ depends, and the second is the set of proposition–situation pairs depending on the first component:

**Definition 4** *[Field generated by $\psi ** \tau'$]*

$$\textbf{field}(\psi ** \tau') \overset{def}{=} \{ \langle \langle \varphi, \tau \rangle, \textbf{depcone}(\varphi ** \tau) \rangle \mid \langle \varphi, \tau \rangle \in \textbf{depdom}(\psi ** \tau') \}$$

In the field of $\psi ** \tau'$ we look for those proposition–situation pairs whose elimination would change history minimally. Instead of trying to define what this means, I simply assume that there exists a function $\omega$ from $(\mathbf{Form_{FOL^{**}}} \times Sit) \times \mathcal{P}(\mathbf{Form_{FOL^{**}}} \times Sit)$ to $[0, 1]$ that assigns weights to proposition–situation pairs on the basis of their dependency cone.[12] We use the definition of minima of a function $f$: if $S \subseteq \mathbf{dom}\, f$, then $\min_S f \overset{def}{=} \{ x \in S \mid (\forall y \in S)(f(y) \geq f(x)) \}$, and we collect those proposition–situation pairs that are proper sine qua nons:

**Definition 5** *[Proper sine qua non]*

$$\varphi ** \tau \ \textbf{p-sine-qua-non}\ \psi ** \tau' \overset{def}{\Longleftrightarrow} \langle \varphi ** \tau, \textbf{depcone}(\varphi ** \tau) \rangle \in \min_{\textbf{field}(\psi ** \tau')} \omega$$

Finally, we define the progressive of a sentence $S$ as follows (where $\textbf{culm}(S)$ denotes the the proposition that $S$ has just culminated):

12. We might require however that if $\varphi_1 ** \tau_1$ has a dependency cone that is a subset of that of $\varphi_2 ** \tau_2$, then $\omega$ should assign less weight to $\varphi_1 ** \tau_1$ than to $\varphi_2 ** \tau_2$.

**Definition 6** *[Progressive]*

$$\mathbb{PROG}(S) * \tau \overset{\text{def}}{=} 1 \textit{ if } (\exists\varphi, \tau', \tau'')(\tau' \preceq \tau \wedge \tau < \tau'' \wedge \mathbf{culm}(S) ** \tau'' \wedge (\varphi ** \tau') \textbf{ p-sine-qua-non } (\mathbf{culm}(S) ** \tau'')),$$

$$\mathbb{PROG}(S) * \tau \overset{\text{def}}{=} 0 \textit{ if } (\exists\tau_c > \tau)(\mathbf{culm}(S) ** \tau_c) \wedge (\forall\tau' \preceq \tau)(\forall\tau'' > \tau)((\mathbf{culm}(S) ** \tau'') \rightarrow \neg\Diamond\exists\varphi((\varphi ** \tau') \textbf{ p-sine-qua-non } (\mathbf{culm}(S) ** \tau'')),$$

$$\mathbb{PROG}(S) * \tau \overset{\text{def}}{=} 2 \textit{ otherwise.}$$

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# Imperative Logic, Moods and Sentence Radicals

**Berislav Žarnić***

The aim of this essay is to examine two challenges that the imperative logic poses to the received view of sentence moods. According to the received view, there are three logico-semantic moods, indicative, imperative and interrogative; and there are two main components in natural language sentences, modal element and sentence radical. First we will examine whether change expression forces us to abandon one-radical-per-sentence view. Second, we will examine the doubts regarding threefold division of moods, which stem from the epistemic imperative conception of questions.

We take Wittgenstein's footnote remark to be the *locus classicus* of the received view:

> Imagine a picture representing a boxer in a particular stance. Now, this picture can be used to tell someone how he should stand, should hold himself; or how a particular man did stand in such-and-such situation; and so on. One might (using the language of chemistry) call that picture a proposition-radical. [10] §23.

Speaking in terms of the picture-metaphor: the picture, or rather - a combination of picture fragments means something, but that meaning is *unsaturated* until it has been used in a certain way. The component of the sentence that determines the *use* of the sentence-radical is called the modal element, logico-semantic mood [8] or illocutionary force indicator.

## 1 Change expressions and sentence radicals

It seems that the received view assumes that it is possible to extract one sentence radical from each sentence. That assumption is challenged by the change and action semantics, which in their turn seem to provide a suitable basis for imperative logic.

In a neglected paper of Lemmon [4], imperatives are treated as a kind of change expressions. Change expression is an "expression of the form $(A/B)$ where $A$ and $B$ are truth functional expressions". Lemmon gives the semantics of imperatives in terms of obedience and disobedience conditions: an imperative $!(A/B)$ is obeyed if and only if the change from $A$ to $B$ takes place. A

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suitable reading for Lemmon-style imperative $!(A/B)$ could be: "Change initial $A$ situation into resulting $B$ situation!". If we take the sentence-radical to be a description of a (actual, possible, desirable,...) situation, then change-expression semantics threatens such a view, since for a change expression the use of two radicals is allowed.

Although not relying on the semantics that uses two sentence radicals, several successful action oriented approaches in imperative logic have been devised. Influential approaches include: Chellas [2], Belnap's and Perloff's [1] STIT semantics, in which the content of any imperative is an agentive, *i.e.* an agency ascribing sentence, and Segerberg's [6] approach, where imperatives are treated as prescribed actions. In this paper an update semantics for Lemmon-style imperative logic will be proposed. The proposed imperative semantics is closely related to the action logic tradition but differs in some respects. The most prominent difference in our approach is the inclusion of the information on the initial situation in the semantics of imperatives.

### 1.1 Twofold divisions of actions and imperatives

According to G. H. von Wright, the actions can be divided in two groups [7]. There are actions that bring about a change, *i.e.* actions of producing and destroying a state of affairs, and there are actions that prevent a change, *i.e.* actions sustaining and suppressing a state of affairs. Combining the idea of imperatives as proscribed actions with the twofold division of actions, we arrive at the twofold division of imperatives. Complementary imperatives are imperatives that command that a change is to be brought about; their form being $!(\neg A/A)$, read: "Produce $A$!". Symmetric imperatives command that a change is to be prevented; $!(A/A)$, read: "Maintain $A$!". The "right-side imperative" having the form $!(\top/A)$, or "See to it that $A$!" has drawn much attention in the literature. Nevertheless, the "right-side imperative" does not count as a basic on our approach. Defined in this way, the two basic imperatives bear information on the initial situation.

Following and modifying the minimal action semantics in von Wright's style [7], it seems the minimal imperative semantics requires at least three "points". The initial point is the initial situation in which the prescribed action should begin, the end-point is the situation resulting from the eventual and successful execution of the prescribed action, and the "null-point" is the situation which could occur if the course of events is not altered by the prescribed action. "Three points semantics" makes it possible to introduce three indicative modal elements,'$\cdot$' for 'in the *before*-situation it holds that...', '$\cdot_N$' for 'in the *later*-situation it is unavoidable that...', '$\cdot_P$' for 'in the *later*-situation it is possible that...'. Three point semantics can account for the following indicative entailments (where $A$ is a contingent proposition and $A \Leftrightarrow B$ or $A \Leftrightarrow \neg B$) :

(Initial point: initial situation is defined) $!(A/B) \Rightarrow \cdot(A/\top)$

(End point: resulting situation is possible) $!(A/B) \Rightarrow \cdot_P(\top/B)$

(Null-point: resulting situation is avoidable) $!(A/B) \Rightarrow \cdot_P(\top/\neg B)$



The pair of a positive and a negative imperative is given by a pair of imperatives that deal with the same initial situation and which point to the alternative resulting situations. On that account, 'Don't produce $A$!' or '$\neg!(\neg A/A)$' is equivalent to 'Maintain $\neg A$!' or '$!(\neg A/\neg A)$'. Understood in this way, positive and negative imperatives are on an equal footing with respect to their binding force and informational layers [9].

(Imperative negation) $\neg!(A/A) \Leftrightarrow !(A/\neg A)$

Equipped with the definition for imperative negation, it seems that a variant law of contraposition holds for conditional imperatives. 'Produce $B$ if $A$ is the case.' is equivalent to 'Maintain $\neg B$ only if $\neg A$ is the case.' $0 \cdot(A/\top) \rightarrow$ $!(\neg B/B) \Leftrightarrow !(\neg B/\neg B) \rightarrow \cdot(\neg A/\top)$

Given the restriction on the change expression that may occur in an imperative sentence, we are now in position to reconcile Lemmon based semantics and one-radical-per-sentence view. If $A$ and $B$ are contingent and logically independent propositions, it is obvious that a change expression $(A/B)$ cannot be understood as a description of one situation.

One strategy of defending the received view could proceed as follows. It can be easily shown that any complementary or symmetric imperative can be decomposed into an indicative and a "right-side" imperative: $!(A/B) \Leftrightarrow$ $\cdot(A/\top)\wedge!(\top/B)$. On that basis one can argue that it is a one sentence radical that is used in imperatives.

In another strategy, the two basic imperatives remain unanalyzed. In the first step, one must prove that the restriction of the formal language on the two (plus one) types of imperatives does not reduce the expressive power of Lemmon-style language. In the framework of update semantics, it can be done by showing that for each member from the family of models there is a text that generates it. After that, one may argue that it is the same descriptive content that is used both in symmetric and complementary imperatives. The case of the symmetric imperative is obvious. For complementary imperatives, one may say that the same proposition is being used in two ways: taking an intersection and a complement of the same descriptive content out of a set of valuations.

### 1.2 Questions: imperatives with interactively constituted semantics

The threefold division of moods is challenged by the theory of epistemic imperative. Åqvist [5] formalized questions in terms of two different modal operators: imperative operator and epistemic operator. *Yes/no* questions are interpreted as 'Let it (turn out to) be the case that either I know that $A$ or I know that $\neg A$'. The proposed semantics of imperatives can explain why questions convey, *inter alia,* information that the interrogator does not know the answer. *Yes/no* question regarded as an epistemic imperative appears to be an instance of the complementary imperative: $!(\neg K_i A \wedge \neg K_i \neg A / K_i A \vee K_i \neg A)$. The epistemic imperatives could be used for the purpose of extending Groenendijk's [3] erotetic logic towards modelling the semantic impact of a question on the answerer's cognitive-motivational state.

It seems possible even to introduce the notion of a negative question. Using the idea that positive and negative imperatives differ only with respect to the right part of embedded change expression, the negative *yes/no* question becomes $!(\neg K_i A \wedge \neg K_i \neg A / \neg K_i A \wedge \neg K_i \neg A)$ or 'Let it remain the case that neither I know that $A$ nor I know that $\neg A$'.

A cooperative interrogator is not certain which change she has commanded. The eventual full determination of proscribed epistemic action depends on the answerer's cognitive state. Therefore, an answerer-side semantics for epistemic imperative requires at least two distinct elements: (i) the model of interrogator's initial doxastic state and interrogator's intended doxastic state, (ii) the model of the answerer's cognitive state . The interaction of the two elements must be possible in order to enable the understanding of a question.

Epistemic imperatives may introduce doubt regarding threefold division of moods. But is it really the case that there are only two logico-semantic moods: indicatives and imperatives? The fact that the semantics of imperatives requires interaction between interrogator and the answerer in the determination of the proscribed epistemic action makes epistemic imperatives essentially different from the practical imperatives.

## 2 An update semantics for Lemmon-style imperative logic

(The language $L_{LIL}$ of imperative logic) If $A$ is a sentence in the language of classical propositional logic, then $!(A/A)$, $!(A/\neg A)$, $!(\top/A)$, $\cdot(A/\top)$, $\cdot_N(\top/A)$, $\cdot_P(\top/A)$ and their negations are sentences in $L_{LIL}$. If $\phi$ is an imperative and $\psi$ a $\cdot$-type indicative sentence in $L_{LIL}$, then $\phi \rightarrow \psi$ and $\psi \rightarrow \phi$ are sentences in $L_{LIL}$. Nothing else is a sentence in $L_{LIL}$. A sequence of sentences $\phi_1; ...; \phi_n$ is a text in $L_{LIL}$.

Sets *Init* and *Res* are sets containing all the elements from the set *val* containing all the binary valuations for the propositional letters in the language under consideration coupled with the instants in which initial and resulting situation occur: $Init = \{\langle v, before\rangle : v \in val\}$, $Res = \{\langle v, later\rangle : v \in val\}$. The set of instants is $T = \{before, later\}$. The time designated intension of a component in a change expression is the set $|A|^t = \{\langle v, t\rangle : v \in val \wedge t \in T \wedge v(A) = \top\}$. The intension of a change expression $(A/B)$ is the set $\|A/B\| = |A|^{before} \times |B|^{later}$. The set of cognitive-motivational states of an ideal addressee $a$ with respect to the language under consideration is defined as $\Sigma_a = \{\langle \rho, \lambda\rangle : \rho \subseteq Init \times \lambda, \lambda \subseteq Res\}$. Its subset $\Phi = \{\langle \rho, \lambda\rangle : \langle \rho, \lambda\rangle \in \Sigma \wedge \rho = \emptyset\}$ is called the set of final states, containing state $1 = \langle \emptyset, \emptyset\rangle$.

(Basic sentences)

$$\langle \rho, \lambda\rangle[!(A/B)] = \begin{cases} \langle \|A/B\| \cap \rho, \lambda\rangle \text{ if } |B|^{later} \neq \lambda \\ 1, \text{ otherwise,,} \end{cases}$$

where $A = B$ or $A = \neg B$ or $A = \top$.

$$\langle \rho, \lambda\rangle[\cdot(B/\top)] = \langle \|B/\top\| \cap \rho, \lambda\rangle$$



$$\langle \rho, \lambda\rangle[\cdot_N(\top/B)] = \langle \|\top/B\| \cap \rho, |B|^{later} \cap \lambda\rangle$$

$$\langle \rho, \lambda\rangle[\cdot_P(\top/B)] = \begin{cases} \langle \rho, \lambda\rangle \text{ if } \langle \rho, \lambda\rangle[\cdot_N(\top/B)] \notin \Phi \\ 1, \text{ otherwise.} \end{cases}$$

$$\langle \rho, \lambda\rangle[\cdot(A/\top) \rightarrow !(B/C)] = \begin{cases} \langle \rho \cap \|B/C\|, \lambda\rangle \text{ if } \langle \rho, \lambda\rangle[\cdot(A/\top)] = \langle \rho, \lambda\rangle \\ \langle \rho \cap \|\neg A/\top\| \cap \|B/\top\|, \lambda\rangle, \text{ otherwise,,} \end{cases}$$

where $B = C$ or $B = \neg C$ or $B = \top$.

(Defined sentences) For $\sigma \in \Sigma_a$

$\sigma[\neg!(A/B)] = \sigma[!(A/\neg B)]$, where $A = B$ or $A = \neg B$ or $A = \top$

$\sigma[\neg\cdot(A/\top)] = \sigma[\cdot(\neg A/\top)]$

$\sigma[\neg\cdot_N(\top/B)] = \sigma[\cdot_P(\top/\neg B)]$

$\sigma[\neg\cdot_P(\top/B)] = \sigma[\cdot_N(\top/\neg B)]$

$\sigma[!(B/C) \rightarrow \cdot(A/\top))] = \sigma[\cdot(\neg A/\top) \rightarrow !(B/\neg C)]$, where $B = C$ or $B = \neg C$ or $B = \top$.

(Text)

$\sigma[\phi_1; ...; \phi_n] = \sigma[\phi_1]...[\phi_n]$.

### 2.1 Some examples

On this account it is obvious that the Imperator cannot coherently command (1) changing of the situation that does not obtain. Imperator cannot command an action that should bring about a historically impossible (2) or a historically inevitable situation (3 with analytical consequence added).

(1) The door is closed. Close it!

$\forall \sigma : \sigma[\cdot(C/\top); !(\neg C/C)] \in \Phi$

(2) Post the letter! But you will not post it.

$\forall \sigma : \sigma[!(\neg P/P); \cdot_N(\top/\neg P)] \in \Phi$

(3) Stay tall.

$\forall \sigma : \sigma[!(T/T); \cdot_N(\top/T)] \in \Phi$.

### 2.2 A sketch of semantics for epistemic imperatives

Using the idea from simple dynamic semantics, the interrogator's cognitive state may be modeled as a set of doxastically possible situations, and situations are modelled as sets of propositional letters. Thus $K_i A$ becomes identified with the assertion that there is in an information state $\sigma$ such that $A$ is accepted in it, $[A]\sigma = \sigma$ and such that agent $i$ is in $\sigma$, plus the assertion that $A$ is the case. The modelling must be modified accordingly. We have to change the points in the model in such a way that the sets of valuations take the role previously assigned to (time indexed) valuations.

We will restrict modelling of the interrogator's cognitive state to the set $l$ of propositional letters appearing in the *desideratum* of the question. Let $\sigma \subseteq \wp(l)$ where $l$ is set of propositional letters occurring in the desideratum. We will need these sets of possible interrogator's doxastic states with respect to $A$: $|\neg B_i A| = \{\sigma \mid \sigma[A] \neq \sigma\}$, $|B_i A| = \{\sigma \mid \sigma[A] = \sigma \wedge \sigma \neq 1\}$, $|\neg B_i \neg A|$, $|B_i \neg A|$. For doxastic assertions without iterated operators we set $|\phi \wedge \psi| = |\phi| \cap |\psi|$,

$|\phi \vee \psi| = |\phi| \cup |\psi|$ and $\|\phi/\psi\| = |\phi| \times |\psi|$ . We define the function *block* that delivers partitions of information states for disjunctive epistemic assertions as

$$block(E) = \begin{cases} \{|B_i\phi_1|, ..., |B_i\phi_n|\}, \\ \quad \text{if } E = K_i\phi_1 \vee ... \vee K_i\phi_n \text{ and } n \geqq 2 \\ \emptyset, \text{ otherwise.} \end{cases}$$

The determination of the desirable partition depends on the answerer's cognitive state. In order to enable interaction of the two elements, the set of relevant cognitive-motivational states of the answerer must at least combine the model $\rho$ of interrogator's cognitive-motivational state (combining a set of possible ignorant states and set of possible desired states) with the answerer's cognitive state $\lambda$: $\Sigma = \{\langle\rho, \lambda\rangle \mid \rho \subseteq \wp(l) \times \wp(l), \lambda \subseteq \wp(l)\}$. The proposed semantics of the *yes/no* question shows that the epistemic action remains undefined if the answerer does not know the answer:

$$\langle\rho, \lambda\rangle[!(\neg K_iA \wedge \neg K_i\neg A/K_iA \vee K_i\neg A)] =$$

$$= \begin{cases} \langle\|\neg B_iA \wedge \neg B_i\neg A/B_iA \vee B_i\neg A\| \cap \rho \cap \lambda, \lambda\rangle \\ \quad \text{if } \exists\lambda' : \lambda' \in block(K_iA \vee K_i\neg A) \wedge \lambda \subseteq \lambda' \\ \langle\|\neg B_iA \wedge \neg B_i\neg A/B_iA \vee B_i\neg A\| \cap \dot{\rho}, \lambda\rangle, \text{ otherwise.} \end{cases}$$

The inability of Interrogator to completely determine the desired state shows the difference between epistemic and practical imperatives. On the other hand, epistemic imperatives bring information on the state that is to be changed and that makes them similar to practical imperatives.

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# Lexical Competition: 'Round' in English and Dutch

**Joost Zwarts***


**Abstract**

This paper studies the semantic division of labour between three Dutch words, *om*, *rond* and *rondom*, all three corresponding to the English word *(a)round*. First the range of senses covered by the English word is described in model-theoretic terms and ordered according to strength. Relating these senses to the three Dutch words shows that they are themselves ordered from weak to strong: *om* < *rond* < *rondom*. This ordering corresponds to a phonological and morphosyntactic ordering, a finding that can be explained by pragmatic principles in a framework that uses bidirectional optimization.


## 1 Introduction

The English preposition *(a)round* corresponds to three words in Dutch: *om*, *rond* and *rondom*.

(1) a. A man put his head round the door - Een man stak zijn hoofd *om* de deur

b. They sat round the television - Ze zaten *rond* de televisie

c. the area round the little town - het gebied *rondom* het stadje

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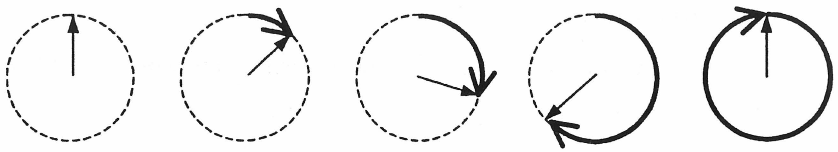
How do these words divide the semantic labour of that single English word? Do they each have their own fully specified lexical meaning or is there a general principle that regulates their specialization from underspecified meanings? In order to answer this question we first need a good description of the range of meanings covered by *round*.

## 2 The semantics of 'round'

In [7] I describe in formal terms the range of shapes (paths) that can be described as *round* in English, using a vector-based spatial model [5] in which a path is a sequence of vectors. A vector can either represent the *position* of (a part of) an object relative to an origin (in the shape sense of *being round* and the motion sense of *going round*), or the *axis* of an object (needed for the rotation sense of *turning round*) [6].

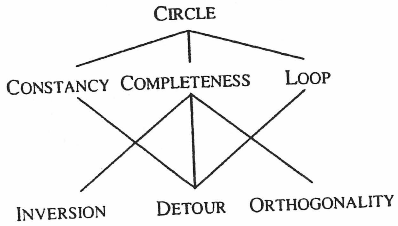
The strongest sense of *round* is that of a perfect CIRCLE represented as the set of perfectly circular paths (*a round disk, go round in circles*), but there are many weaker senses.



Some uses only retain the idea that every direction is represented in the path (COMPLETENESS: *the moat round the castle, to spiral round*) and drop the property of CONSTANCY (that all the vectors of the path have the same length). Sometimes only part of the circle is present (INVERSION 'semicircle': *a round arch, to round the cape, to turn round*; ORTHOGONALITY 'quartercircle': *a round chin, round the corner*). Other uses of *round* involve paths that return to their point of origin (LOOP: *a round-trip*) or are not straight (DETOUR: *the long way round*). These senses,



when defined as sets of paths in a model, are partially ordered by the subset relation:




The strongest (most restrictive) meaning is at the top and the weaker meanings, that are implied by it, are below it. Intuitively then, the meanings of *round* range from perfectly round at the top to less round when we go downwards.

The interpretation chosen for *round* is usually the strongest meaning compatible with the (linguistic) context, in line with the Strongest Meaning Hypothesis for reciprocals [2]. [7] casts this hypothesis in Optimality Theoretic terms.

## 3 'Round' in Dutch

The next step is to determine how Dutch *om*, *rond* and *rondom* divide up the meaning range of *round* that we mapped out in the preceding section. I will single out one pattern in the data.[1] In most constructions, *om* and *rond* show a clear contrast:

(2) Postpositions: *de hoek om* 'round the corner' ORTHOGONALITY
*de kamer rond* 'round the room' COMPLETENESS

[1] Not all uses of these three words can be captured in terms of the path meanings of section 2. For example, in the temporal domain we find *om vijf uur* 'at five o'clock' versus *rond vijf uur* 'round five', senses that require definitions that go beyond the scope of this paper.

| | | |
|---|---|---|
| Predicates: | *Deze weg is om* 'This way is longer' DETOUR | |
| | *We zijn rond* 'We are back where we started' LOOP | |
| Compounds: | *omweg* 'detour' DETOUR | |
| | *rondweg* 'ring road' COMPLETENESS | |
| Particles: | *omkijken* 'look behind' INVERSION | |
| | *rondkijken* 'look around' COMPLETENESS | |

What we see is that *rond* takes on stronger interpretations than *om*. This is especially clear with minimal pairs (like *omweg* 'detour'and *rondweg* 'ring road'). It can also be seen in the semantics of particle verbs with *om* and *rond*. Dutch grammars show that *rond* only takes interpretations involving COMPLETENESS (*rondbazuinen* 'trumpet in all directions', *rondfietsen* 'cycle in circles'). *Om* on the other hand productively expresses interpretations with DETOUR meaning (*omrijden* 'take a detour driving'), INVERSION (*omdraaien* 'turn around') and ORTHOGONALITY (*omschoppen* 'kick over'), all three weaker than COMPLETENESS. The COMPLETENESS uses of *om* that exist are no longer productive (e.g. *ombinden* 'tie around'). This strongly suggests that as particles *om* and *rond* have complementary meanings.

*Rondom* is clearly restricted to the stronger meanings when we compare it with *om* and *rond*:

(3) CIRCLE: *om/rond/rondom de paal lopen* 'walk round the pole'
COMPLETENESS: *om/rond/rondom de balk gebonden* 'tied round the beam'
INVERSION: *om/rond/?rondom de televisie zitten* 'sit round the television'
ORTHOGONALITY: *om/?rond/?rondom de hoek staan* 'stand round the corner'



These examples also show us that, as prepositions, *om*, *rond* and *rondom* are not always complementary. The generalization that suggests itself is that while *om* and *rond* can relate to the same basic range of meanings that we find for English *round*, in certain constructions *om* has a tendency towards weaker meanings and *rond* towards stronger meanings, while *rondom* is restricted to the senses involving COMPLETENESS. We can therefore order these words semantically from weak to strong in the following way:

om < rond < rondom

## 4 Pragmatics of 'round'

Why would the three Dutch words for 'round' divide their labour in this way? What I would like to suggest is that this division of labour is the result of a grammaticalization process that can be understood in pragmatic terms (using Horn's division of pragmatic labor [3], Levinson's M-principle [4] and Blutner's (weak) bidirectional optimization [1]): markedness in form corresponds with markedness in meaning. The increasing semantic markedness in *om*, *rond* and *rondom* is aligned with a markedness ordering *om* < *rond* < *rondom* on the sound and syntax side. This formal markedness can be seen in a variety of ways. It is shown phonologically in the relative weight of the three words and their stress behaviour (*om* can remain unstressed in verbal compounds, for instance). *Om* and *rond* are morphologically simple, *rondom* is a compound. *Om* is part of the native stratum of Dutch, *rond* was borrowed from French. *Om* participates in a wide range of grammatical constructions and uses, while *rond*, and especially *rondom*, are much more restricted in their grammatical behaviour and grammaticalization. For example, *om* can be stranded, like the other basic prepositions of Dutch, but *rond* and *rondom* cannot: compare *er om* (derived from *om het* 'around it') with **er rond* and **er rondom*.

It is interesting to note that the Middle Dutch form of *om* (*omme*) still covered the whole range of meanings that it now has to share with *rond* and *rondom*. While *om* is being grammaticalized (becomes weaker in meaning), its original strong, lexical meaning is being taken over by other words.

We can see that the combination of model-theoretic semantics and Neo-Gricean pragmatics proves its fruitfulness in explaining language contrasts, historical developments and patterns of polysemy.

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