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# Preface

This online proceedings volume contains selected and invited papers on topics in the interdisciplinary fields of linguistics, logic, computation, and philosophy, including the following:

- ✠ Formal syntax, semantics and pragmatics of natural language
- ✠ Model-theoretic and/or proof-theoretic semantics of natural language
- ✠ Computational approaches to semantics and pragmatics
- ✠ Nonclassical logic and its relation to natural language (e.g. substructural, fuzzy, categorical, and topological logic)
- ✠ Formal philosophy of language
- ✠ Scientific methodology and/or experimental design in linguistics

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## 1st Day: November 18 (Sat)

## 2nd Day: November 19 (Sun)

## 3rd Day: November 20 (Mon)

# Intonational meaning at the limits of grammar

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The existence of prosodic morphemes encoding information structure or speech-act type, which compose linguistic meaning together with their (non-prosodic) lexical counterparts, is rather well-documented. In contrast, intonation patterns with more elusive meaning, often distributed over various segments of an utterance, tend to be described as expressive in the sense of directly conveying psychological states, and are considered less "grammatical" in the sense of being part of the composition of linguistic meaning, or even "paralinguistic", *i.e.* not part of linguistic meaning at all.

More concretely, I use "prosody" (*cf.* Xu (2019) [7] for an overview of terminology) to refer to suprasegmental aspects of speech, in particular intonation, some parts of which are rather clearly "grammatical" in that their meaning can also be encoded by non-prosodic lexical items (such as lexical tone, information structure, or sentence-final intonation encoding speech-act type), while others are clearly "paralinguistic" in that their meaning can be expressed by non-linguistic means (such as sounding angry, happy or annoyed, intonationally conveyed register or gender roles).

While such a dichotomy is intuitively appealing, the view beyond English, the usual focus of (formal) semantics and pragmatics, shows that expressive prosody might be more grammatical (*i.e.* composotional) and lexically well-defined (encoding sharply delineable concpets) than previously assumed. In this paper, I argue for a more inclusive view of intonational meaning by example of prosodic morphemes encoding expressive meaning that occur in both Japanese and English.

## Prosodic morphemes in English and Japanese

The prosodic morphemes ↑ and ↓ occur sentence-finally in English declaratives and interrogatives, as illustrated in examples (1a) through (1c).

(1) a. You're coming.↓
    b. You're coming?↑
    c. Are you coming?↑

These morphemes, argued to resolve a particpant variable to speaker (↑) or addressee (↓), *cf.* Gunlogson (2003) [2], have been applied to Japanese in Davis (2009) [1], who claims they interact with sentence-final particles like *yo*. On my view, sentence-final ↑ and ↓ are distinct from prosodic morphemes interacting with *yo*, which I write as ↗ and ↘.

There are several reasons for treating these intonational morphemes as distinct. For instance, declaratives with *yo*↗ are readily used as answers to questions and require speaker commitment that questions do not, making it plausible that they are indeed declaratives. Furthermore, declaratives with *yo* are distinct from interrogatives with *yo*, in which the particle *ka* occurs. Below, I propose that these two sets of prosodic morhpemes operate on different levels of meaning and that either set occurs in both Japanese and English.

## Japanese prosodic morphemes and pragmatic particles

Like ↑ and ↓ indicating speaker- (S) or addressee (A) commitment in declaratives, preference for *yo*↗ or *yo*↘ depends on S- *vs.* A-orientation, but on a different level of meaning. For insatnce, the contrast in (2) is whether an action is to be performed by S or by A. Scenario: A suggests to buy paper cups for a party.

(2) S: kami koppu-wa mada takusan nokot-tei-ru yo{↗/↘}
paper cups-TOP still plenty left-RES-NPST SFP
"There are still plenty of paper cups left."

Preference for either version of (2) depends on who A suggests buy the paper cups. When A suggests to do this themselves, *yo*↘ is preferred, when A suggests that S do so, *yo*↗ is preferred. However, both versions are an assertion that commit the speaker to the proposition, *i.e.* falling declaratives like (1a).

Oshima (2014) [4] further describes a rising-falling contour ↗↘ combining with *yo*, characterizing *yo*↗↘ as a version of *yo*↘ with an additional meaning of "asking for understanding or sympathy", as illustrated in (3) and (4).

Scenario: A suggests to go outside together

(3) S: Soto-wa samui yo(o)↗↘
outside-TOP cold SFP
"It's cold outside!"

Scenario: S is desparately looking for their own wallet

(4) S: Saifu-ga mitsukara-nai yo(o)↗↘
wallet-NOM be_found-NEG SFP
"I can't find my wallet!"

The question is whether this additional meaning is paralinguistic, or compositional like that of *yo* with other intonational patterns. I aruge that while there is a purely emotive component to these examples (also apparent in final lengthening), there is expressive meaning to *yo*↗↘ that can be formalized, and that this expressive meaning is also present in the English correspondents to (3) and (4).

## Expressive meaning in English intonation

Crucially, the English correspondent to Japanese *yo*↗↘ in (3) and (4) is a somehwat similar intoation pattern that is distributed over focused (or stress-bearing) lexical items and sentence-final intonation, as shown in (5) and (6) below.

(5) "(But) it's [cold]↗ outside↘. . . "

(6) "I [can't]↗ find my [wallet]↗↘. . . "

While the notation ↗ and ↘ is not to say that their prosodic realization is exactly the same as on Japanese *yo*, I argue that this is a non-coincidental similarity, as intonation in the English examples (5) and (6) carries the same meaning as *yo*↗↘ in their Japanese correspondents (3) and (4). Note that this intonation is distinct from sentence-final ↑ and ↓ shown in (1) — both (5) and (6) are assetions with a final ↓ (merged with ↘).

It should also be noted that emotive content akin to exasperation (which is potentially part of "asking for sympathy") is encoded by amplified rises and falls throughout the utterance, as well as final lengthening, in both Japanese and English. This is rather likely a (paralinguistic) expression of strong speaker emotions, which can be expressed by extralinguistic means, in contrast to the meaning of (*yo*)↗↘ proper.

That the lexical meaning of *yo*↗↘ from (3) and (4) is also present in the translations (5) and (6) is remarkable not least because English correspondents to *yo*↗ and *yo*↘ are hard to come by, if they exist at all. That is, if the lexical meaning of *yo*↗↘ is conveyed by ↗ on focus and final ↘ in English, then English intnoation is more "grammatical" than often assumed.

# The meaning of *yo*↘ and *yo*↗

Most proposals of formal analyses of *yo* do not bother with prosodic morphemes. When analyzed, they are mostly treated on par with sentence-final ↑ and ↓. On my view, while both are similar in that they resolve participant variables, ↗ and ↘ operate on a different level of meaning, namely that of modal thought (in the broad sense of *e.g.* Philips and Kratzer 2022 [5]), much like pragmatic particles or non-propositional negation.

## Premise and expectation management and *yo*

From observations in the literature on *yo*, it seems minimally necessary to make reference to speaker- and addressee orientation, and to premises that the participants entertain in their modal reasoning. I analyze *yo* as modifying context change potentials, *cf.* Heim (1983) [3] and, for an application to Japanese, Davis (2009) [1], proposing new conditions on input and output contexts, *cf.* Rieser (2020) [6]. To illustrate how I propose intonational morphemes resolve participant variables, consider again the (without resolution by sentence-final intonation) ambigious example (2), repeated here as (7).

Scenario: A suggests to buy paper cups for a party.

(7) S: kami koppu-wa mada takusan nokot-tei-ru yo{↗/↘}
paper cups-TOP still plenty left-RES-NPST SFP
"There are still plenty of paper cups left."

What both prosodic variants have in common is that in the input context, $\varphi$ ("There are still plenty of paper cups left.") is not taken into account as a premise by A, which S tries to change. The difference lies in whether S is sharing $\varphi$ in order to adjust A's expectations about S's own behavior (*yo*↘) or whether S is sharing $\varphi$ for A to adjust their behavior (*yo*↗). This can be captured by assuming that a variable in *yo* is resolved to S by ↘, and to A by ↗, indicating the target of context update.

### Formalism

- $\langle c, c' \rangle$ is a pair of input and output contexts.
- $\{\langle c, c' \rangle \mid \ldots\}$ is a CCP, the set of pairs of input and output contexts satisfying the conditions elided (...) here — an utterance can be felicitously made when it links contexts found in this set (or when the speaker believes this to be the case).
- $\Pi^c_X$ is the set of premises $\pi$ epistemically settled for agent $X$ (in context $c$), *i.e.* agent $X$ makes decitions and assumptions (modal reasoning) based on these premises.

- $\Xi^c_X$ is the set of premises $\xi$ which agent $X$ assumes to be the case under normal circumstances, but which are not (yet) epistemically settled (in context $c$). While $\Pi^c_X$ needs to be consistent, $\Xi^c_X$ can contain conflicting expectations.
- $\pi \rightsquigarrow \xi$ relates premises $\pi$ and expectations $\xi$ by defeasible implicature $\rightsquigarrow$, *i.e.* any agent is to expect $\xi$ from $\pi \wedge (\pi \rightsquigarrow \xi)$ unless $\neg\pi$ is epistemically settled.

### Meaning of *yo*

These definitions are sufficient to sketch the meaning of *yo* as a CCP presupposing that the prejacent is *not* a premise, and requiring an output context containing a premise that makes the prejacent expected. While this might seem like rather weak conditions, they are necessary to cover various uses of *yo* beyond the limited cases discussed here, which are all assertions. Asserting a prejacent requires it to be epistemically settled for the speaker, yielding the CCP in (8) for a *yo*-assertion. Note that this speech-act is undefined without a final ↘ or ↗ with are necessary to resolve the variable $X$.

(8) $[\![yo(\text{DECL}\downarrow(\varphi))]\!] = \{\langle c, c'\rangle \mid \varphi \in \Pi^c_S \wedge \varphi \notin \Pi^c_X \wedge \exists\pi \in \Pi^{c'}_X : \pi \rightsquigarrow \varphi\}$

This puts a stronger requirement on the input context $c$, namely that there is a discrepancy between the speaker's premises and that of the addressee. Note that, by definition, adding $\varphi$ as a premise also satisfies the output context requirement of making it expected (as $p \rightsquigarrow p$ is trivially true). Also note that premises, as grounds for expectations, are often evidential, and the assertion of $\varphi$ by S can thus serve as the required $\pi$ (grounds for A to expect $\varphi$, unless for A $\neg\varphi$ is epistemically settled).

Intonation resolves the part of $c$ to be updated: ↘ indicates update of the **shared** context (common ground), whereas ↗ indicates update of the **addresse**'s context only:

(9) a. $[\![yo \searrow (\text{DECL}\downarrow(\varphi))]\!] = \{\langle c, c'\rangle \mid \varphi \in \Pi^c_S \wedge \varphi \notin \Pi^c_{S,A} \wedge \exists\pi \in \Pi^{c'}_{S,A} : \pi \rightsquigarrow \varphi\}$
b. $[\![yo \nearrow (\text{DECL}\downarrow(\varphi))]\!] = \{\langle c, c'\rangle \mid \varphi \in \Pi^c_S \wedge \varphi \notin \Pi^c_A \wedge \exists\pi \in \Pi^{c'}_A : \pi \rightsquigarrow \varphi\}$

The difference is subtle, as expected for a fine pragmatic contrast. Whereas (9a) is compatible with a speaker intention of adding $\varphi$ to the common ground, with (9b) the speaker indicates that $\varphi$ is more relevant for the addressee than as common gound.

## Prosodic morphemes and asking for sympathy

What about the meaning of *yo* ↗↘? Can the claim that it is a variant of *yo* ↘"asking for understanding or sympathy" be supported compositionally, or is this additional meaning purely expressive, or even paralinguistic?

I propose that *yo* ↗↘ is a hybrid of *yo* ↗ and *yo* ↘, but not in the sense of sequential application. Like the former, it focuses on $\varphi$ not being a premise to the addressee, but like the latter, does not solely target addressee expectations in the output context:

Scenario: A suggests to go outside together

(10) S: Soto-wa samui yo(o)↗↘
outside-TOP cold SFP
"It's cold outside!"

(11) .$[\![yo \nearrow\searrow (\text{DECL}\downarrow(\varphi))]\!] = \{\langle c, c'\rangle \mid \varphi \in \Pi^c_S \wedge \varphi \notin \Pi^c_A \wedge \exists\pi \in \Pi^{c'}_{S,A} : \pi \rightsquigarrow \varphi\}$

By choosing this marked intonation over either ↘ or ↗, the speaker both decries the lack of shared awareness of $\varphi$ by the speaker, and indicates that this premise is **not** directly relevant to the addressee's goals, compatible with the nuance of seeking understanding or sympathy.

Note that such an interpretation of examples like (11) is not a direct, necessary consequence of their semantically (lexically) derived meaning, but involves pragmatic reasoning — the constraints that their semantic content imposes on the context, together with the changes that they implement on it, make such utterances a tool suitable to convey the pragmatic meaning they conventionally do in both Japanese and English.

### The ↗↘ prosodic morpheme in English

There is also a paralinguistic meaning component in this example, expressed by an intensified pitch contour and final lengthening, also present in the English translation repeated in (12). However, the meaning of *yo* ↗↘ is present in its entirety.

(12) "(But) it's [cold]↗ outside↘. . . "

There are two ways to think about this: either expressing the emotive content only is sufficient to implicate this meaning component, or English intonation is actually encoding "grammatical" meaning. I suggest that the latter is the case, not least because there is no clear mechanism to derive such rather complex meaning by implicature from a mere expression of a strong emotional attitude.

# References


[1] Davis, C.: Decisions, dynamics and the japanese particle yo. Journal of Semantics **26**(4), 329–366 (2009)

[2] Gunlogson, C.: True to form: Rising and falling declaratives as questions in English. Ph.D. thesis, UCSC (2003)

[3] Heim, I.: On the Projection Problem for Presuppositions. In: Formal Semantics: The Essential Readings, pp. 249–260. Wiley (1983)

[4] Oshima, D.Y.: On the functions of the japanese discourse particle yo in declaratives. In: Formal Approaches to Semantics and Pragmatics: Japanese and Beyond, pp. 251–271. Springer (2014)

[5] Phillips, J.S., Kratzer, A.: Decomposing modal thought. https://doi.org/10.31234/osf.io/g6tzc (2022)

[6] Rieser, L.: Deriving confirmation and justification—an expectative, compositional analysis of japanese ‘yo-ne’. In: Proceedings of the 34th Pacific Asia Conference on Language, Information and Computation. pp. 261–269 (2020)

[7] Xu, Y.: Prosody, tone and intonation. In: The Routledge handbook of phonetics, pp. 314–356. Routledge (2019)

**Towards a Semantics of the Javanese Speech Level System**

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**Speech Levels and Lexical Classes.** Javanese sentences can generally be assigned to one of three 'speech levels', called *ngoko* (N), *madya* (M), and *krama* (K). The *ngoko* speech level is canonically used towards intimates and addressees of similar status, while *krama* speech level is used toward addressees of higher status and low intimacy. The *madya* level serves as a "half-way house" (Wolff & Poedjosoedarmo 1982) between these two endpoints, canonically used in situations where the factors determining the choice of speech level are in conflict. The speech level of a sentence is formally marked by the choice of lexical items belonging to paradigms of suppletive alternants with identical truth-conditional content but differing in terms of the speech levels with which they are compatible. The following example from Clynes (1989) illustrates how distinct combinations of lexical alternants combine to determine the overall speech level:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (1) | *Bu* | *Siti* | *sampun* | *nedha* | *ingkang* | *menika.* | **Krama** |
| | *Bu* | *Siti* | *mpun* | *nedha* | *sing* | *niku.* | **Madya** |
| | *Bu* | *Siti* | *wis* | *mangan* | *sing* | *kuwi.* | **Ngoko** |
| | Ms. | Siti | already | eat | REL | that | |

"Bu Siti has already eaten that one."

In (1), the three alternants for 'already' are each compatible with only one of the levels, and thus the choice of any one of these alternants serves to unambiguously mark the speech level of the sentence as a whole. The same holds for the alternants for 'that'. The two alternants for 'eat', meanwhile, show a two-way contrast that divides sentences into either the *Ngoko* or non-*Ngoko* level, while the choice between the two alternants for the relative clause marker REL divides the resulting sentence into either *Krama* or non-*Krama*. The choice of alternant for one lexical item thus imposes restrictions on the choice of others, with the combination of these choices determining the speech level of the sentence as a whole.

**A Formal Semantics for Speech Levels.** Davis (2021), building on Clynes, derives the syntagmatic properties of the speech level system by dividing the lexical alternants into five classes, formalized in terms of two binary features, [±K] and [±N]. These features indicate the type of context (speech level) that the lexical item is compatible with: *krama* level is signaled by utterances whose lexical items collectively encode the features [+K,−N], *ngoko* level by [−K,+N], and *madya* by [+K,+N]. The five lexical classes are then categorized as follows: [+K,−N] items can be used only with the *krama* speech level, [+K] items with either *krama* or *madya* speech level, [+K,+N] items only with the *madya* speech level, [+N] items with both the *madya* or the *ngoko* speech level, and [−K,+N] items only with the *ngoko* speech level. This feature-based theory accounts for the syntagmatic combinatorics of the speech level system, but does not directly model the semantic/pragmatic properties of the speech levels. In this talk, I show how this feature-based morpho-syntactic account can be mapped to a semantic account that captures the syntagmatic properties of the system in terms of semantic (in)compatibility.

A number of researchers (Potts and Kawahara 2004, McCready 2019, Oshima 2019, a.o.) argue that honorific meanings should be modeled continuously. In the case of Javanese, I posit that "speech level" corresponds to three sub-intervals of the continuous interval [0,1], such that *Ngoko* = $[0, n]$, *Madya* = $[n, k]$, and *Krama* = $[k, 1]$, where $0 < n < k < 1$. The location on this interval is given by *SL*, a function from ordered pairs of entities to points on this interval. The value returned by this function depends (in some nebulous way) on relevant properties holding between these entities; in particular, their level of intimacy, relative status, relative age, etc. The features are now understood as making semantic requirements on the speech level holding between the speaker and addressee (encoded as either a presupposition or conventional implicature), as follows:

$[+N]$ requires that $SL(s, h) < k$
$[+K]$ requires that $SL(s, h) > n$
$[-N]$ requires that $SL(s, h) \nless k$ (i.e. $SL(s, h) \geq k$)
$[-K]$ requires that $SL(s, h) \ngtr n$ (i.e. $SL(s, h) \leq n$)

This approach has a number of consequences. First, negative feature values can be modeled as negation (e.g. $-K$ is just the negation of $+K$). Additionally, the syntagmatic constraints on different forms are derived semantically, since $+K$ and $-K$ make contradictory requirements of $SL(s, h)$, as do $+N$ and $-N$. It also provides an explanation for the non-existence of $[-N, -K]$ lexical items in the system: $-N$ requires $SL(s, h) \geq k$ and $-K$ requires $SL(s, h) \leq n$; since $k > n$, $-N$ and $-K$ cannot be simultaneously satisfied.

**Extension to Deferentials.** Many Javanese lexical items have an additional *deferential* alternant form that signals honorification of a grammatically-determined argument. For example, 'eat' has the deferential alternant *dahar*, which signals honorification of the grammatical subject (or the agent of eating). Deferential forms are compatible with all speech levels, and are thus orthogonal to the calculation of speech level. For example, the deferential *dahar* 'eat' can be substituted for any of the three forms in (1), as see in the following examples, built from those above by substituting the deferential alternant *dahar*, resulting in grammatical sentences in each of the three speech levels, as determined by the other lexical items in sentence:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (2) | *Bu* | *Siti* | *sampun* | **dahar** | *ingkang* | *menika.* | **Krama** |
| | *Bu* | *Siti* | *mpun* | **dahar** | *sing* | *niku.* | **Madya** |
| | *Bu* | *Siti* | *wis* | **dahar** | *sing* | *kuwi.* | **Ngoko** |
| | *Bu* | *Siti* | *already* | *eat* | *REL* | *that* | |

'Bu Siti already ate that one.' (+ the speaker honors Bu Siti)

While they are thus orthogonal to the speech level system itself, the semantics of deferentials can be handled straightforwardly by a simple modification to the semantics introduced earlier: While speech level distinctions are anchored to the contextual addressee, deferentials are anchored to some grammatically or lexically determined referent. For *dahar* 'eat', the semantics would require that $SL(s, x) > d$, for some lexically determined degree of honorification $d$, with $x$ resolved to the grammatical subject (or to the agent of eating); for the case at hand, this is resolved to the subject *Bu Siti*.

While appealing, I show that this simple approach to integrating semantics/pragmatics of speech levels and deferentials is untenable, by focusing attention on cases where the semantics of speech level and argument honorification interact, namely in cases where the grammatically determined anchor of a deferential alternant refers to the contextual addressee (e.g. in cases the sentences in (1) are being addressed to the referent of the subject NP, *Bu Siti*). I show that the account sketched above leads to problematic predictions in such cases, building on the description of **?**, according to whom the Ngoko and Krama speech levels can be further subdivided by into two sublevels, determined by whether deferentials are used for the addressee:

- Ngoko 1: Ngoko speech level, no use of deferentials targeting the addressee (can be used for third person referents).
- Ngoko 2: Ngoko speech level, regular use of deferentials targeting the addressee.
- Krama 1: Krama speech level, no use of deferentials targeting the addressee.
- Krama 2: Krama speech level, regular use of deferentials targeting the addressee.

If deferentials rely on the same "honorific function" that speech level features do ($SL$ in this talk), it isn't clear how (or whether) the pattern described by Uhlenbeck can be modeled. The use of addressee-targeting deferentials, under this simple view, should raise the speech level above what it would be without addressee-targeting deferentials. For this to work at the Krama speech level, *dahar* should require that $SL(s, x) > k'$, with $x$ resolved to the addressee, and $k' > k$ (where $k$ is the 'floor' for Krama speech level). But Ngoko speech level requires $SL(s, h) < n$. Since $n < k$, this should make Ngoko speech level incompatible with addressee-targeting deferentials, contrary to fact.

In the full talk I discuss further implications of this problematic interaction, and consider (a) how this problem might be resolved, and (b) how this interaction behaves in the honorific systems of other languages.

**References.** Clynes, A. 1989. Speech Styles in Javanese and Balinese: A Comparative Study. Davis, C. 2021. Deriving Categorial and Continuous Properties of Javanese Speech Levels. Errington, J. 1985. Language and Social Change in Java. McCready, E. 2019. The semantics and pragmatics of honorification: Register and social meaning. Oshima, D. 2019. The logical principles of honorification and dishonorification in Japanese. Poedjosoedarmo, S. 1969. Wordlist of Javanese Non-Ngoko Vocabularies. Potts, C. & S. Kawahara. 2004. Japanese honorifics as emotive definite descriptions. Robson, S. & S. Wibisono. 2002. Javanese English Dictionary. Uhlenbeck, E. M. 1970. The use of respect forms in Javanese. Wolff, J. & S. Poedjosoedarmo. 1982. Communicative Codes in Central Java.

# Semantic-pragmatic account of syntactic structures

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## 1. Introduction

This paper aims to show that the communicative organization plays a crucial role in the emergence of the syntactic structure of a sentence. The main purpose of language is communication, and communication is a dynamic process of information transfer. From dynamic semantic perspective, the meaning of a sentence is its context change potential, i.e. is procedural (Heim 1982). The speaker's intentions to convey certain information to the hearer split their mental content into a number of instructions to update the common ground. Being dependent on one another, the instructions form a tree, which is then realized as a syntactic tree of the sentence produced.

I approach the question in the well-established framework of Discourse Representation Theory (Kamp & Reyle 1993). I propose an extension to the theory, which explains the connection between semantic representation and syntactic structures.

## 2. Discourse Representation Theory

Discourse Representation Theory (DRT) employs a semantic representation layer called DRS (discourse representation structure). DRS represents the common ground and includes all the information conveyed by the discourse up to the present point in time. DRS consists of discourse referents (variables) and conditions on them (predicates). When the next sentence is processed, its representation is added to the main discourse DRS with the resolution of pronouns:

(1) A farmer bought a car

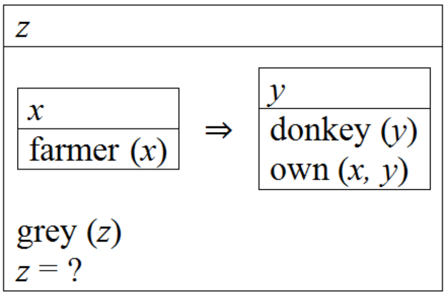
$$\begin{array}{|l|}\hline x,\ y \\ \hline \text{farmer}\ (x) \\ \text{car}\ (y) \\ \text{buy}\ (x,\ y) \\ \hline \end{array}$$

(2) A farmer bought a car. It was pink.

$$\begin{array}{|l|}\hline x,\ y,\ z \\ \hline \text{farmer}\ (x) \\ \text{car}\ (y) \\ \text{buy}\ (x,\ y) \\ \text{pink}\ (z) \\ z = y \\ \hline \end{array} \quad = \quad \begin{array}{|l|}\hline x,\ y \\ \hline \text{farmer}\ (x) \\ \text{car}\ (y) \\ \text{buy}\ (x,\ y) \\ \text{pink}\ (y) \\ \hline \end{array}$$

A DRS can also contain sub-DRSs, which are used to represent complex structures such as implication, negation, disjunction, etc. Nested DRSs form a hierarchy of subordination and accessibility. When searching for an antecedent of a pronoun we can look only into the current or superordinate DRSs. Subordinate DRSs are not accessible. That explains why sometimes no anaphoric links can be established.

(3) Every farmer owns a donkey. *It is grey.

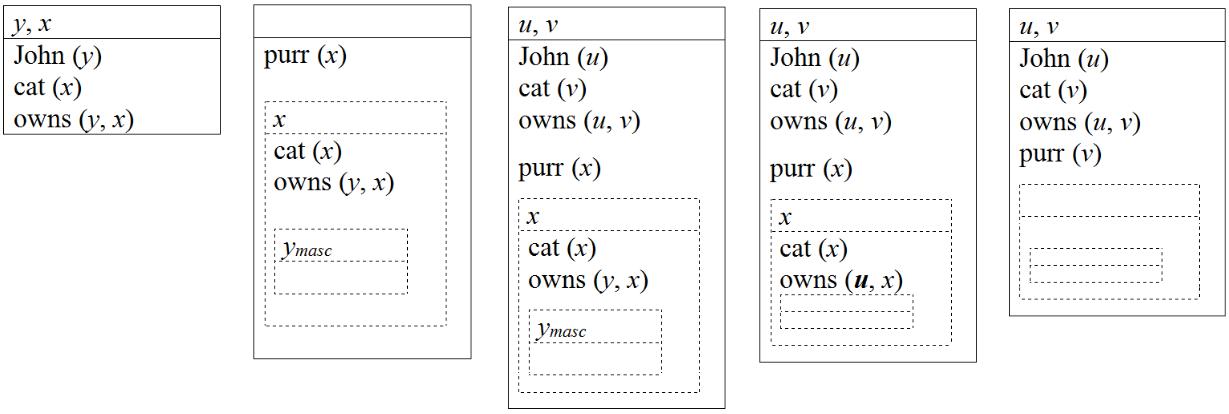



### 3. Binding theory of presupposition

Van der Sandt 1992 suggested that presupposition is a very similar phenomenon to anaphora. A presuppositional expression has to be resolved like a pronoun, i.e. bound to an antecedent. However, unlike pronouns, presuppositions contain a descriptive content, which must be matched with a potential antecedent. To represent such content, a special sub-DRS is used, which is called A-DRS.

Presupposition resolution is performed in two stages. First, a sentence DRS is created, which is called Preliminary DRS. It contains (yet unresolved) A-DRSs for each presupposition from the sentence. A-DRSs can be nested if presuppositions depend on one another. Second, the sentence DRS is merged into the main DRS and A-DRSs are resolved by finding antecedents for them through the accessibility hierarchy. Once the presuppositions are resolved, the A-DRSs are removed and the main DRS becomes Proper DRS.

(4) John has a cat. His cat purrs




If no antecedent is found, then the presupposition can be accommodated, because (unlike a pronoun) usually it has enough descriptive content to represent a meaningful relevant peace of information by itself.

### 4. Specific indefinites

Van Geenhoven 1998 noticed that specific indefinites are similar to presuppositions in some respect. Like presuppositions, they are interpreted not in the place where they appear but somewhere higher in the structure. The only difference is that they are normally accommodated rather than bound.

The following sentence has at least three different readings depending on the level where ‘a museum’ is interpreted (Karttunen 1976):

(5) Bill intends to visit a museum every day

Are specific indefinites a special type of presupposition?

### 5. Backgrounding

Guerts 2010 suggested to unify specificity with presupposition not by reducing the former to the latter but by subsuming them under a more general term – backgrounding. He points out that accommodation is a repair strategy and it would be strange to use it normally as specific indefinites do. Instead, he postulates The Buoyancy Principle:

- Backgrounded material tends to float up towards the main DRS.

In addition to presuppositions and specific indefinites, there can be other backgrounded material such as conventional implicatures (as defined by Potts 2005).

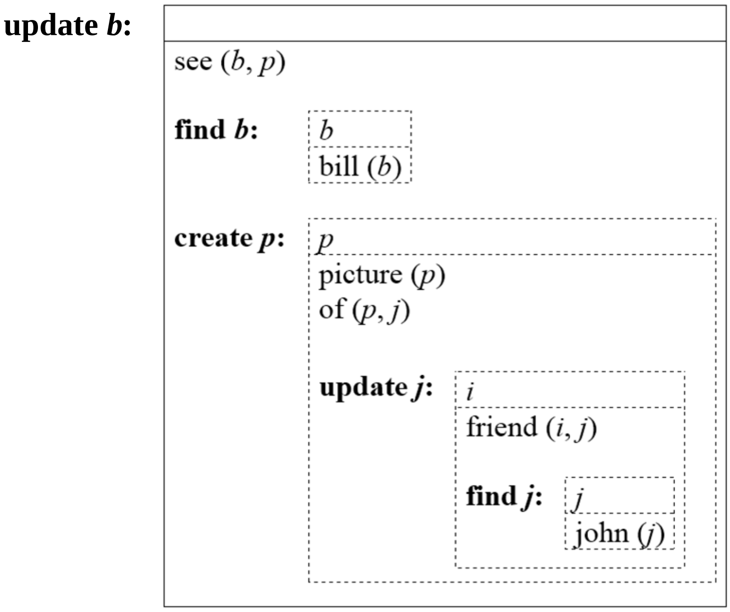
### 6. Instructional DRT

If we follow The Buoyancy Principle then we need to separate each backgrounded constituent within the DRS. We can continue using A-DRSs for that purpose, but they now have to be marked with their type, since, for example, specific indefinites are processed differently from presuppositions. The type of A-DRS represents its function:

- Propositional A-DRS serves to find a discourse referent
- Specificity A-DRS – to create a new discourse referent
- Conventional implicature A-DRS – to update an existing one

Supplied with a function and a principal discourse referent an A-DRS becomes an instruction to update the common ground (or the hearer's mental database). The sentence DRS itself can be treated as an instruction to update the topic referent of a sentence.

(6) Bill saw a certain picture of John, a friend of mine




Each backgrounded constituent corresponds to an A-DRS. The hierarchy of A-DRSs forms a tree, which mirrors the syntactic tree of the sentence. I suggest that this is not a coincidence and this is exactly how the syntactic tree is formed in the first place.

- The speaker intends to convey certain information to the hearer

- They split their knowledge into a set of instructions to find, create or update discourse referents in the common ground
- Being dependent on one another, they form a tree.
- The tree is then lexicalized and realized as a syntactic tree of the sentence

Mel'čuk 2001 introduced a notion of communicative dependency and noticed that the communicative dependency always mirrors the syntactic one: *"Comm-dependency is, so to speak, a way of 'foreseeing,' on the semantic level, the future syntactic dependencies"* (Mel'čuk 2001, chapter I, pt. 2.3.1.1). A sentence DRS with backgrounded A-DRSs is exactly a way of 'foreseeing' the future syntactic structure of the sentence.

The idea to represent the meaning of a sentence in procedural terms is not new and goes back at least to Winograd 1972. Davies & Isard 1972 suggest that a natural language understanding is done in two steps (similar to computer "understanding" of programming languages) – compilation and execution. There is a distinction between understanding an utterance and actually carrying it out.

These two steps correspond to two stages in the resolution process. On the first step we generate instructions, i.e. create Preliminary DRS of the sentence with A-DRSs inside. The second step consists in executing the A-DRS instructions against the common ground. This results in the updated Proper DRS of the discourse.

Therefore, we have two levels of representation. Preliminary DRS represents the procedural meaning of the sentence. It reflects the information structure and the future syntactic structure of the sentence. When building Preliminary DRS we do not use information from the common ground. It is context-independent. Yet it is context-sensitive, since execution against different common grounds can produce different results.

On the other hand, Proper DRS represents the knowledge generated after the execution of the instructions. It captures truth conditions, has model-theoretic interpretation and is a good candidate for representation of the mental content.

## 7. Applications

The modified version of DRT can potentially shed some light on the nature of island constraints. Goldberg 2006, developing ideas of Erteschik-Shir 1973, proposed the following rule:

- Backgrounded constituents are islands (BCI)

The present approach could explain why they are islands. Each backgrounded constituent corresponds to a separate instruction, which is separately executed. At the moment of its execution all discourse referents the instruction depends on must have already been found or created by other instructions. If that is not the case, i.e. if the set of instructions is inconsistent (e.g. because of vicious circles in the instruction dependencies), the set in not executable. Hence, the sentence is not interpretable.

It seems that it is exactly what happens at least to some syntactic islands. And it can explain the strong unacceptability of their violation. However, that is a topic for a separate paper.

## 8. Conclusions

Instructional DRT provides a unified account of backgrounded meaning within the DRT framework. It suggests how the syntactic structure of a sentence arises out of knowledge in our mind and why backgrounded constituents are syntactic islands.

### References


1. Davies, D. J. M., & Isard, S. D. (1972). Utterances as programs. Machine intelligence, 7, 325-339.
2. Erteschik-Shir N. 1973. On the nature of island constraints. PhD thesis, Dep. Foreign Lang. Linguist., MIT, Cambridge. 175 pp.
3. Geurts, B. (2010). Specific Indefinites, Presupposition and Scope. Presuppositions and Discourse: Essays Offered to Hans Kamp, 21, 125.
4. Goldberg AE. 2006. Constructions at Work: The Nature of Generalization in Language. Oxford, UK: Oxford Univ. Press
5. Heim, I. (1982). The semantics of definite and indefinite noun phrases.
6. Kamp, H., & Reyle, U. (1993). From discourse to logic: Introduction to modeltheoretic semantics of natural language, formal logic and discourse representation theory.
7. Karttunen, L. (1976). Discourse referents. In Notes from the linguistic underground (pp. 363-385). Brill.
8. Mel'čuk, I. A. (2001). Communicative organization in natural language. John Benjamins.
9. Potts, C. (2004). The logic of conventional implicatures (Vol. 7). OUP Oxford.
10. Van der Sandt, R. A. (1992). Presupposition projection as anaphora resolution. Journal of semantics, 9(4), 333-377.
11. Van Geenhoven, V. (1998). Semantic incorporation and indefinite descriptions: Semantic and syntactic aspects of noun incorporation in West Greenlandic. CSLI publications.
12. Winograd, T. (1972). Understanding natural language. Cognitive psychology, 3(1), 1-191.

# Semantics of Propositional Attitudes in Type-Theory of Algorithms

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## 1 A Brief Overview

Human natural language (NL) is notorious for various kinds of ambiguities. Among the most difficult ambiguities for computational handling of NL, are expressions with multiple occurrences of quantifiers, which contribute to quantifier scope ambiguities.

Far more difficult for computational handling are NL expressions having occurrences of so-called attitude components designating knowledge, believes, statements, and similar semantic information. Often, the syntactic complement of an attitude lexeme is a sentential expression (see the examples below). The sentential complement may have subexpressions that designate semantic components, which are semantical parts of the attitudinal information (i.e., in the scope of the attitude). For example, an agent $a$ can use a sentence $\Phi$ with a major (head) word occurring in it, which is an attitude lexeme $L$ having attitudinal syntactic arguments, e.g., subexpressions $\Psi_1$ and $\Psi_2$. The expression $\Psi_1$ can designate an agent $a_1$. On its turn, $\Psi_2$ can have a syntactic component $B$ that designates a semantic object $b$. The expression $B$ can be:

(1) $a_1$'s description of $b$: thus, the semantics of $B$ is in the semantic scope of $L$; or

(2) $a$'s description of $b$: thus, while $b$ is a semantic component of the semantic information designated by $\Psi_2$, the relevant semantics of $B$ is outside of the semantic scope of $L$.

Furthermore, the attitude expressions create the so-called oblique text in which the attitude expressions do not preserve semantic equivalence under replacement of equivalent attitude components.

The first formal representation of NL attitudes was by Montague [6], along with the quantifier scope ambiguities, by the notions of *extension* and *intension*, and using extra syntactic disambiguation of NL expressions. That solution was adopted by some generalisations of Montague grammars. The problem has been largely open, due to its purely semantic nature and complexity, without direct syntactic appearance.[1]

In this presentation of the paper, I extend the type-theory $\mathrm{L}^{\lambda}_{\mathrm{ar}}$ of algorithms, to cover algorithmic semantics of some of the major attitude expressions, their semantic underspecification, and deriving reductions of specifications in contexts.

*Syntax of Type-Theory of Algorithms.* For introductions to Type-Theory $\mathrm{L}^{\lambda}_{\mathrm{ar}}$ of Algorithms, its syntax, denotational and algorithmic semantics, and reduction calculi,

[1] More details will be provided in the full paper.

e.g., see [7], and, for recent developments, see [1]–[5]. The syntax of $\mathrm{L}^{\lambda}_{\mathrm{ar}}$ can be briefly introduced by (Types) and (2a)–(2d):

$$\tau :\equiv \mathsf{e} \mid \mathsf{t} \mid \mathsf{s} \mid (\tau_1 \to \tau_2) \qquad \text{(Types)}$$

$$\widetilde{\tau} \equiv (\mathsf{s} \to \tau), \quad \tau \in \mathit{Types} \qquad \text{(abbreviation for state-dependency)}$$

The language of $\mathrm{L}^{\lambda}_{\mathrm{ar}}$ has, for all types $\tau$, $\mathsf{Consts}_{\tau}$ and two kinds of variables: $\mathsf{PureV}_{\tau}$, for binding by $\lambda$ and logic quantifiers, and $\mathsf{RecV}_{\tau}$, for saving calculated denotations.

$$\begin{aligned}
A :\equiv\ & \mathsf{c}^{\tau} : \tau \mid x^{\tau} : \tau && (\text{for } \mathsf{c}^{\tau} \in \mathsf{Consts}_{\tau},\ x^{\tau} \in \mathsf{PureV}_{\tau} \cup \mathsf{RecV}_{\tau}\ ) && \text{(2a)}\\
& \mid B^{(\sigma \to \tau)}(C^{\sigma}) : \tau && (\textit{application term}) && \text{(2b)}\\
& \mid \lambda(v^{\sigma})\,(B^{\tau}) : (\sigma \to \tau) && (\lambda\textit{-term}) && \text{(2c)}\\
& \mid \big[A_0^{\sigma_0} \ \mathsf{where}\ \{\, p_1^{\sigma_1} := A_1^{\sigma_1}, \ldots, p_n^{\sigma_n} := A_n^{\sigma_n}\,\}\big] : \sigma_0 && (\textit{recursion term}) && \text{(2d)}
\end{aligned}$$

## 2 Algorithmic Syntax-Semantics of Propositional Attitudes

In this paper, I disregard rendering verbal inflections, e.g., for event time, since that is outside of its major topic.

I shall present a possibility for algorithmic syntax by $\mathrm{L}^{\lambda}_{\mathrm{ar}}$ of verbs designating propositional attitudes. It is with respect to their corresponding algorithmic semantics. I shall consider only verbs taking sentences as complements, e.g.:

$$\mathsf{ToScope} : (\widetilde{\mathsf{t}} \to (\mathsf{s} \to \widetilde{\mathsf{t}})), \quad \mathcal{C} : (\mathsf{t} \to \widetilde{\mathsf{t}}) \qquad \text{(operator constants)} \qquad \text{(3a)}$$

$$\tau_{pa} \equiv (\widetilde{\mathsf{t}} \to (\widetilde{\mathsf{e}} \to \widetilde{\mathsf{t}})) \qquad \text{(3b)}$$

$$\begin{aligned}
&\text{claim (that)} \xrightarrow{\mathsf{render}} \mathit{claim} : \tau_{pa}, \quad \text{state (that)} \xrightarrow{\mathsf{render}} \mathit{state} : \tau_{pa},\\
&\text{believe (that)} \xrightarrow{\mathsf{render}} \mathit{believe} : \tau_{pa}, \ \text{know (that)} \xrightarrow{\mathsf{render}} \mathit{know} : \tau_{pa}, \ \ldots
\end{aligned} \qquad \text{(3c)}$$

At first, I shall express the concepts of the algorithmic semantics of sentential attitudes, by an example, as a representative of a large class of verbal attitudes. I present the concept of verbal attitudes, which are context dependent. The scope of the semantic components is underspecified without any specific context.

$$\textsf{Jim believes that Mary's sister is happy.} \xrightarrow{\mathsf{render}} A \qquad \text{(4a)}$$

$$A \equiv \mathit{believes}\Big(\mathsf{ToScope}\big(\mathit{happy}[\mathit{mary's}(\mathit{sister})]\big)(s_c)\Big)(\mathit{jim}) : \widetilde{\mathsf{t}} \qquad \text{(4b)}$$

$$\begin{aligned}
\Rightarrow \mathit{believes}(q)(j) \ \mathsf{where}\ \{\, & q := \mathsf{ToScope}\big(\mathit{happy}[\mathit{mary's}(\mathit{sister})]\big)(s_c),\\
& j := \mathit{jim}\,\}
\end{aligned} \qquad \text{(4c)}$$

Here, $s_c \in \mathsf{RecV}_{\mathsf{s}}$ is a variable for states, and $\dot{s_c} \in \mathbb{T}_{\mathsf{s}}$ is a state of using the given sentence, e.g., called an *utterance*, in a technical usage. It provides a context by a valuation function $g \in G$ applied on the state variable $s_c$, $g(s_c) = \dot{s_c}$, or by a function called the agent's (e.g., the speaker's), references, in (5a):

$$\langle \dot{s_c}, \textsf{Jim believes that Mary's sister is happy.}\rangle \xrightarrow{\mathsf{render}} A_1 \qquad \text{(5a)}$$

$$A_1 \Rightarrow \mathit{believes}(q)(j) \;\mathsf{where}\; \{\, q := \mathsf{ToScope}\Big(\mathit{happy}[\mathit{mary's}(\mathit{sister})]\Big)(s_c),\; j := \mathit{jim} \,\} \tag{5b}$$

$$\Rightarrow \mathit{believes}(q)(j) \;\mathsf{where}\; \{\, q := \mathsf{ToScope}\Big(\mathit{happy}(m) \;\mathsf{where}\; \{\, m_s := \mathit{mary's}(\mathit{sister}) \,\}\Big)(s_c),\; j := \mathit{jim} \,\} \equiv A_2 \tag{5c}$$

The scoping operator $\mathsf{ToScope}$ applies to the term rendering the sentence complement of the attitude verb. There are two ways to apply $\mathsf{ToScope}$, each creating its own scope of the algorithmic closure $\mathcal{C}$:

$$A_2 \Rightarrow_{\mathsf{cf}} A_3 \equiv \mathit{believes}(q)(j) \;\mathsf{where}\; \{\, q := \mathcal{C}\big(\mathit{happy}(m)(s_r) \;\mathsf{where}\; \{\, m_s := m's(p),\; m := \mathit{mary},\; p := \mathit{sister} \,\}\big),\; j := \mathit{jim} \,\} \quad \text{(de-dicto)} \tag{6a}$$

$$A_2 \Rightarrow_{\mathsf{cf}} A_4 \equiv \mathit{believes}(q)(j) \;\mathsf{where}\; \{\, q := \mathcal{C}\big(\mathit{happy}(m)(s_r)\big),\; m_s := m's(p),\; m := \mathit{mary},\; p := \mathit{sister},\; j := \mathit{jim} \,\} \quad \text{(de-re)} \tag{6b}$$

In $A_3$, (6a), the operator $\mathsf{ToScope}$ has been applied in $q$ of (5c)by keeping the assignment $m_s := \mathit{mary's}(\mathit{sister})$ in the scope of $\mathcal{C}$, and thus, in the scope of the attitude *believe*. The result is $A_3$, which is the de-dicto meaning, i.e., in $j$'s believe, $j$ refers to the individual $m_s$ as Mary's syster, represented by $m_s := \mathit{mary's}(\mathit{sister})$ inside the believe scope.

The term $A_4$, in (6b), is the de re meaning of the NP "Mary's sister". The user of the sentence (5a) provides the reference to $m_s$, by $m_s := \mathit{mary's}(\mathit{sister})$, and the believe of $j$ does not provide this description of $m_s$, by referring directly to the individual $m_s$.

Note that the context of use $s_c$ provides the state $s_r$, in which the attitude proposition is supposed to, i.e., believed to hold.

By the following pattern example (7a), I demonstrate the anaphoric pronouns with respect to the attitude scope in the algorithmic semantics of $\mathrm{L}^{\lambda}_{\mathrm{ar}}$:

$$\langle s_c, \text{Jim}_j \text{ claims that Mary robbed him}_j \rangle \xrightarrow{\mathsf{render}} A \tag{7a}$$

$$A \equiv \mathfrak{c}\Big(\mathsf{ToScope}[\mathit{robbed}(j)(\mathit{mary})](s_c)\Big)(j) \;\mathsf{where}\; \{\, j := \mathit{jim},\; \mathfrak{c} := \mathit{claim} \,\} \tag{7b}$$

$$\Rightarrow \cdots \Rightarrow \mathfrak{c}(q)(j) \;\mathsf{where}\; \{\, q := \mathsf{ToScope}[\mathit{robbed}(j)(\mathit{mary})](s_c),\; j := \mathit{jim},\; \mathfrak{c} := \mathit{claim} \,\} \equiv T \tag{7c}$$

$$\Rightarrow \mathfrak{c}(q)(j) \;\mathsf{where}\; \{\, q := \mathsf{ToScope}[\mathit{robbed}(j)(m) \;\mathsf{where}\; \{m := \mathit{mary}\}](s_c),\; j := \mathit{jim},\; \mathfrak{c} := \mathit{claim} \,\} \equiv T_0 \tag{7d}$$

$$\Rightarrow_{\mathsf{cf}} \mathfrak{c}(q)(j) \;\mathsf{where}\; \{\, q := \mathcal{C}[\mathit{robbed}(j)(m)(s_r) \;\mathsf{where}\; \{m := \mathit{mary}\}],\; j := \mathit{jim},\; \mathfrak{c} := \mathit{claim} \,\} \equiv T_1 \tag{7e}$$

In (7d)–(7e), $\mathsf{ToScope}$ keeps all assignments of the sentential term (which is the complement of the attitude) inside the scope expressed by $\mathcal{C}$. By (7e), the reference to the individual $m$, by the name and the corresponding constant $mary$, is in the claim of Jim.

In (8a)–(8b), the operator $\mathsf{ToScope}$ moves the assignments $m := mary$ outside the attitude closure by $\mathcal{C}$. By the alternative reductions (8b), Jim's claim does not include the assignment, which is in the term, but outside of the subterm representation of the claim itself, e.g., the proper name "Mary" refers to the individual $mary$ by the user of the sentence (7a):

$$\begin{aligned} A \Rightarrow \mathfrak{c}(q)(j) \text{ where } \{\, & q := \mathsf{ToScope}[robbed(j)(m) \text{ where } \{m := mary\}](s_c), \\ & j := jim,\ \mathfrak{c} := claim\,\} \equiv T \end{aligned} \tag{8a}$$

$$\begin{aligned} T \Rightarrow_{\mathsf{cf}} \mathfrak{c}(q)(j) \text{ where } \{\, & q := \mathcal{C}[robbed(j)(m)(s_r) \text{ where } \{\}], \\ & m := mary,\ j := jim,\ \mathfrak{c} := claim\,\} \equiv T_2 \end{aligned} \tag{8b}$$

## 3 The General Algorithmic Pattern

In this section, I shall present a general pattern for algorithmic semantics of attitude verbs via a memory (recursion) variable $\mathfrak{c}$ that can be instantiated by any specific representative of a suitable set of attitude expressions. Note that, $\phi, \psi$ are meta-variables for NL expressions, while $A, B$ can be recursion variables, and thus, the rendering expression in (9b) is an underspecified $\mathrm{L}^{\lambda}_{\mathrm{ar}}$ term; $A, B$ can be suitably instantiated:

$$\begin{aligned} &\text{For any } \phi \xrightarrow{\mathsf{render}} A : \widetilde{\mathsf{t}}, \quad \text{attitude expression } \psi \xrightarrow{\mathsf{render}} B : \tau_{pa} \\ &\text{and fresh variables } \mathfrak{c} \in \mathsf{RecV}_{\tau_{pa}},\ s_c \in \mathsf{RecV}_{\mathsf{s}} \end{aligned} \tag{9a}$$

$$\psi \text{ (that) } \phi \xrightarrow{\mathsf{render}} \mathfrak{c}\big(\mathsf{ToScope}(A)(s_c)\big) \text{ where } \{\, \mathfrak{c} := B \,\} \tag{9b}$$

The algorithmic syntax-semantics of the operator $\mathsf{ToScope}$ is via reductions calculus:

(1) $\mathsf{ToScope}$ allows the term in its argument to be reduced, e.g., to its canonical form
(2) In its final stage (e.g., in (6a) or (6b)), the operator $\mathsf{ToScope}$ closes an attitude scope, by selection of some of the assignments in its propositional argument, depending on the state $s_c$. Simultaneously, $\mathsf{ToScope}$ transforms the selected scoping into an algorithmically closured term, by the operator $\mathcal{C}$ of algorithmic closure
(3) Simultaneously, $\mathsf{ToScope}$ moves the other assignments into the external recursion.

The reduction rules of $\mathrm{L}^{\lambda}_{\mathrm{ar}}$ are extended, e.g., by adding the following rules:

**Compositionality**

$$\text{If } A \Rightarrow A' \text{ then } \mathsf{ToScope}(A) \Rightarrow \mathsf{ToScope}(A') \tag{S-comp}$$

$$\text{If } A \Rightarrow A' \text{ then } \mathcal{C}(A) \Rightarrow \mathcal{C}(A') \tag{$\mathcal{C}$-comp}$$

**The Bekič-Scott Rule (B-S)** (a generalization for including attitudes) Given that, for all $i = 1, \ldots, n$, $j = 1, \ldots, m$, $p_i \neq q_j$ and $q_j$ does not occur freely in $A_0$, $A_i$, then:

$$\begin{aligned} & A_0 \text{ where } \{\, p := \big(B_0 \text{ where } \{\, \overrightarrow{q} := \overrightarrow{B} \,\}\big), \overrightarrow{p} := \overrightarrow{A} \,\} \\ \Rightarrow\ & A_0 \text{ where } \{\, p := B_0, \overrightarrow{q} := \overrightarrow{B},\ \overrightarrow{p} := \overrightarrow{A} \,\} \end{aligned} \tag{B-S}$$

$$\begin{aligned} & A_0 \text{ where } \{\, p := \mathsf{ToScope}\big(B_0 \text{ where } \{\, \overrightarrow{c} := \overrightarrow{C}, \overrightarrow{q} := \overrightarrow{B} \,\}\big)(s_c), \\ & \qquad \overrightarrow{p} := \overrightarrow{A} \,\} \\ \Rightarrow\ & A_0 \text{ where } \{\, p := \mathcal{C}\big(B_0(s_r) \text{ where } \{\, \overrightarrow{c} := \overrightarrow{C} \,\}\big), \\ & \qquad \overrightarrow{q} := \overrightarrow{B},\ \overrightarrow{p} := \overrightarrow{A} \,\} \end{aligned} \tag{B-S-att}$$

A similar clause is added to the head rule for the attitude closure.
Conclusion: Assume that $A, X$ are such that:
(1) $A \equiv A_0 \text{ where } \{\, \overrightarrow{p} := \overrightarrow{A} \,\} \equiv A_0 \text{ where } \{\, p_1 := A_1, \ldots, p_n := A_n \,\}$ $(n \geq 0)$
(2) $X(Y)$ is an attitude expression, e.g., $X \in \mathsf{Consts}$, or $X \equiv p \in \mathsf{RecV}$ for such
(3) $X(Y)$ occurs in $A_0$ or $\overrightarrow{A}$, $Y$ is the scope-creating argument $Y$ of $X$.
It holds that: If $Y \xrightarrow{\mathsf{render}} T$ and $p_i := \mathsf{ToScope}(T)(s)$,
then $p_i$ ($p_i \in \mathsf{RecV}$) occurs in the scope-creating argument $Y$.

*In the Full Paper.* I introduce the extended $\mathrm{L}^{\lambda}_{\mathrm{ar}}$ covering attitude expressions, along with logic operators and pure quantifiers, by extended reduction calculus. I provide information on other approaches to the NL attitudes and motivate the extended $\mathrm{L}^{\lambda}_{\mathrm{ar}}$.

## References


1. Loukanova, R.: Gamma-Reduction in Type Theory of Acyclic Recursion. Fundamenta Informaticae **170**(4), 367–411 (2019). URL https://doi.org/10.3233/FI-2019-1867
2. Loukanova, R.: Gamma-Star Canonical Forms in the Type-Theory of Acyclic algorithms. In: J. van den Herik, A.P. Rocha (eds.) Agents and Artificial Intelligence. ICAART 2018, *Lecture Notes in Computer Science*, vol. 11352, pp. 383–407. Springer International Publishing, Cham (2019). https://doi.org/https://doi.org/10.1007/978-3-030-05453-3_18
3. Loukanova, R.: Type-Theory of Acyclic Algorithms for Models of Consecutive Binding of Functional Neuro-Receptors. In: A. Grabowski, R. Loukanova, C. Schwarzweller (eds.) AI Aspects in Reasoning, Languages, and Computation, vol. 889, pp. 1–48. Springer International Publishing, Cham (2020). URL https://doi.org/10.1007/978-3-030-41425-2_1
4. Loukanova, R.: Logic Operators and Quantifiers in Type-Theory of Algorithms. In: D. Bekki, K. Mineshima, E. McCready (eds.) Logic and Engineering of Natural Language Semantics, pp. 173–198. Springer Nature Switzerland, Cham (2023). https://doi.org/https://doi.org/10.1007/978-3-031-43977-3_11
5. Loukanova, R.: Restricted Computations and Parameters in Type-Theory of Acyclic Recursion. ADCAIJ: Advances in Distributed Computing and Artificial Intelligence Journal **12**(1), 1–40 (2023). URL https://doi.org/10.14201/adcaij.29081
6. Montague, R.: The Proper Treatment of Quantification in Ordinary English. In: J. Hintikka, J. Moravcsik, P. Suppes (eds.) Approaches to Natural Language, vol. 49, pp. 221–242. Synthese Library. Springer, Dordrecht (1973). URL https://doi.org/10.1007/978-94-010-2506-5_10
7. Moschovakis, Y.N.: A Logical Calculus of Meaning and Synonymy. Linguistics and Philosophy **29**(1), 27–89 (2006). URL https://doi.org/10.1007/s10988-005-6920-7

# When children are more pragmatic than adults: Norwegian children's comprehension of contextualized absolute adjectives

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Adjectives like *straight* (known as **maximum standard absolute gradable adjectives**, henceforth **absolute adjectives** for short) can have both a precise ("literal") (*perfectly straight*) and an imprecise ("non-literal") (*straight enough*) interpretation. Their precise interpretation has been claimed to be part of the adjective's semantic meaning (Kennedy, 2007; Syrett et al., 2010; Aparicio et al., 2015; i.a.). The imprecise interpretation is seen as a pragmatic phenomenon that arises after setting a contextual threshold for tolerance (see Lasersohn, 1999; Leffel et al., 2016). How and when do we learn to set this threshold in order to decide whether people are speaking precisely or imprecisely?

It could be the case that as a form of pragmatic reasoning, imprecise interpretations develop over time, with young children first showing a preference for literal interpretations, similarly to what has been found for other pragmatic phenomena (e.g., Noveck, 2001).

Alternatively, it could be that children show the opposite trajectory. Firstly, it is reasonable to assume that there is a prevalence of contexts that favor imprecise interpretations (how many things around a child are perfectly straight?). Secondly, Lee & Kurumada (2020) showed that second language adult learners can reason about the intentions of a speaker in order to learn the precise meaning of a novel absolute adjective despite receiving only imprecise input. It could therefore be that children first develop an imprecise interpretation of *straight*, and only with time (i.e., after multiple exposures to imprecise input) are able to bootstrap the precise, semantic meaning of the absolute adjective.

The current study tests these two hypotheses using a paradigm based on the landmark study by Syrett et al. (2010), who investigated children's understanding of gradable adjectives. They asked participants (3, 4, 5-year-olds and adult controls) to select *the straight wire* when presented with two different objects. If neither of the objects could be described as a referent of the utterance*,* they could choose neither. When children had to select between two objects that did not have the maximal degree of the relevant property (i.e., neither of the wires was straight), they preferentially selected *the straighter wire,* that is, they preferred an imprecise interpretation*.* Adults overwhelmingly selected neither of the pictures, consistent with a precise, semantic understanding of the adjective *straight.* This study was limited to a single item (*full jar*, in Experiment 1, and *straight wire* in Experiment 2), tested only 10 participants per age bracket, and did not discuss a possible developmental trajectory. Importantly, the imprecise picture used represented a large deviation from the standard (i.e., the wire was bent). It is uncertain how these results translate to the interpretation of more common, conventional uses of imprecision (e.g., an only slightly bent line being referred to as *straight*).

We therefore set out to replicate and extend the findings of Syrett et al. (2010). In a pre-registered experiment, we tested 100 native speakers of Norwegian ages 3-8 along with 33 adults. In the experiment, participants saw 12 critical items (using 6 different absolute adjectives) and 12 fillers on a tablet screen. In each trial, participants heard an instruction to select a picture. They then saw a set of three pictures including an incorrect referent, a target referent (depicting either a precise, imprecise or incorrect control picture in each condition) and a red X, signifying that neither of the two pictures was the correct referent (See Figure 1). Participants were told in advance that they should select the red X if neither of the two images complied with the spoken instruction. The Experiment had CONDITION (three levels: precise, imprecise, control), AGE (continuous predictor measured in days) and their interaction as fixed effects. The dependent variable was whether participants selected the target picture (coded as 1) or the red X (coded as 0). Instances of selecting the distractor image (less than 2% of the data) were discarded.

We fitted a mixed-effects, 'maximal' logistic regression model to the data, which included random intercepts and slopes for both factors and their interaction by items and random intercepts and a slope term for the factor CONDITION by subjects. The results suggest a different developmental trajectory for imprecise relative to precise interpretations: There was an interaction between CONDITION (precise vs. imprecise levels) and AGE (z-value= 2.4, $p<0.05$), suggesting that, with age, children were less likely to tolerate imprecise interpretations and increasingly preferred precise ones (see Figure 2). A post-hoc test (with matched number of participants per group) comparing adults to the youngest 33 children showed that adults were significantly less likely to tolerate imprecision ($p< 0.05$), whereas there was no significant difference in their acceptance for precise referents.

Overall, our findings suggest that children behave more pragmatically than adults when understanding imprecision, and that only with age do they become less tolerant of imprecise interpretations of absolute adjectives. This could be indicative of differences in the lexical representation of absolute adjectives between children and adults: It could be the case that children's lexical entry is underspecified for precision (i.e., that their representation of absolute adjectives does not contain the requirement that the adjective's argument possess the maximal quantity of the relevant property). Only with repeated exposure to different usages of the adjectives can they bootstrap the precise meaning, in line with the suggestion of Lee and Kurumada (2022).

Another alternative is that children do have a precise representation of absolute adjectives but are simply more tolerant of imprecision, as suggested by Syrett et al. (2010). We are currently conducting further studies investigating the contextualized interpretation of absolute adjectives in order to test between these possible alternatives.

**Figure 1: The three possible visual displays shown to participants.**

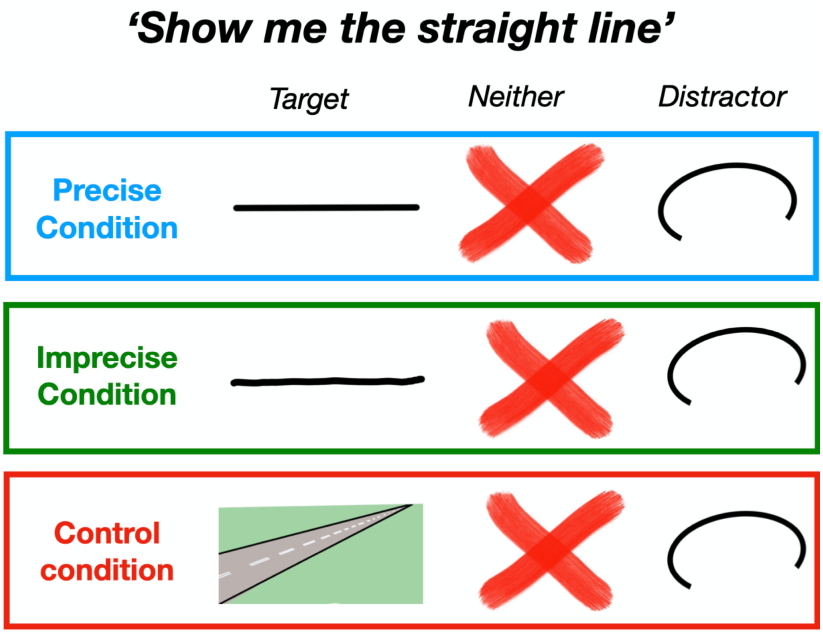
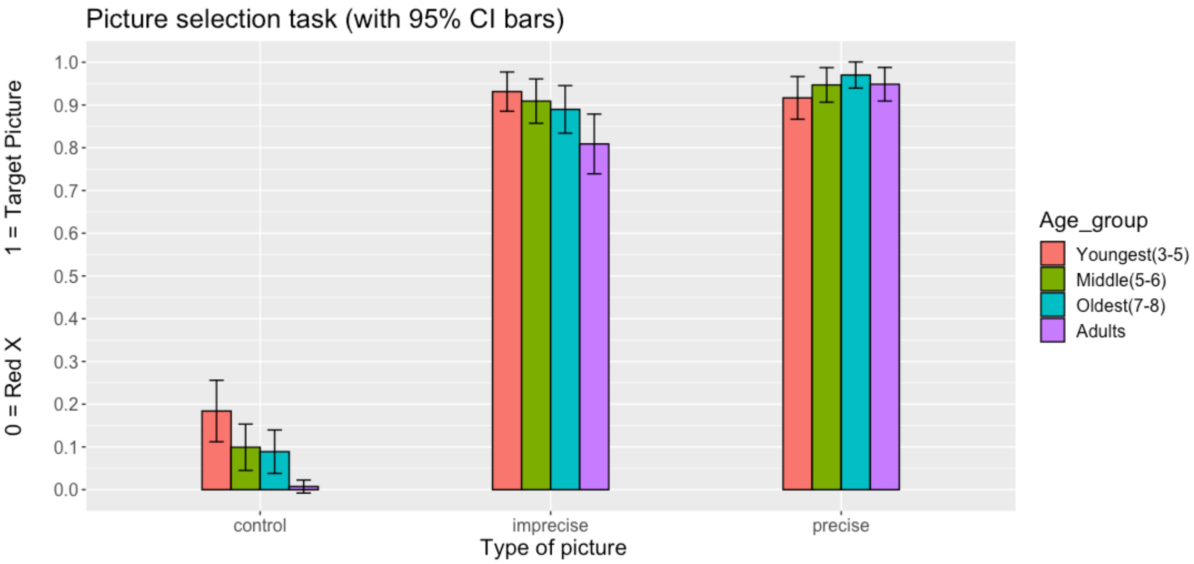


**Figure 2: Results of the picture selection task.**





**References**

Aparicio, H., Xiang, M., & Kennedy, C. (2016). Processing gradable adjectives in context: A visual world study. In *Semantics and Linguistic Theory* (Vol. 25, pp. 413-432).

Kennedy, C. (2007). Vagueness and grammar: The semantics of relative and absolute gradable adjectives. *Linguistics and philosophy*, *30*(1), 1-45.

Lasersohn, P. (1999). Pragmatic halos. *Language*, 522-551.

Lee, C., & Kurumada, C. (2021). Learning Maximum Absolute Meaning Through Reasoning About Speaker Intentions. Language Learning, 71(2), 326-368.

Leffel, T., Xiang, M., & Kennedy, C. (2016). Imprecision is pragmatic: Evidence from referential processing. In *Semantics and linguistic theory* (Vol. 26, pp. 836-854).

Noveck, I. A. (2001). When children are more logical than adults: Experimental investigations of scalar implicature. *Cognition*, *78*(2), 165-188.

Syrett, K., Kennedy, C., & Lidz, J. (2010). Meaning and context in children's understanding of gradable adjectives. *Journal of semantics*, *27*(1), 1-35.

**An Inquisitive-Semantics perspective on NPI licensing: the cases of *only* and *any more***

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**Overview.** I explore an Inquisitive-Semantics perspective on NPI licensing. Starting from the basic assumptions that (i) NPIs are indefinites, (ii) indefinites invoke alternatives (i.e., inquisitiveness, see Ciardelli et al. 2018), (iii) but NPIs are referentially too vague to maintain specific referents and project inquisitiveness to a higher, sentential level (see Giannakidou 2011, 2017), I propose that NPI licensing essentially involves canceling the inquisitiveness introduced by NPIs along sentence derivation. I show how this idea provides a new account for two related groups of phenomena: *only* and *any more*.

**1. Introduction: English *only* is an NPI licencer.** The classical view is that NPIs require to be licensed by a downward-entailing (DE) operator (see (1) for an illustration).

(1) Negation is a DE operator (i.e., $\forall p \forall q[p \subseteq q \rightarrow \neg q \subseteq \neg p]$), which licenses NPI *any*
   a. #Mary ate any vegetable. (Degradedness due to the lack of a licencer)
   b. Mary didn't eat any vegetable. (Negation serves as a licencor for *any*)

However, it has been observed that although *only* is not a DE operator, it licenses NPIs like *any* (see (2)). According to Ladusaw (1979), an *only*-sentence like (2) includes a positive presupposition (see (3a)) and a negative assertion (see (3b)), and it is rather this negative assertion, which includes a DE operator *no*, that licenses an NPI.

(2) Only Mary ate any vegetable. (*only* serves as a licencor for *any* (cf. (1a)))
(*Only* is not a DE operator: Only Mary ate vegetables $\not\models$ Only Mary ate kale.)

(3) a. Presupposition of (2): Mary ate some vegetables. $\rightsquigarrow$ **Positive**
   b. Assertion of (2): No one who is not Mary ate any vegetables. $\rightsquigarrow$ **Negative**

von Fintel (1999) raises questions on how to analyze the positive component in (3a) and fit *only* into the classical DE-ness-based theory on NPI licensing. He proposes the notion of Strawson-DE: we check the entailment between *Only Mary ate vegetables* and *Only Mary ate kale* with an additional assumption that they are both true.

Intuitively, our natural acceptance for a sentence like (2) should have nothing to do with whether we accept the assumption that Mary ate a specific kind of vegetable.

**2. Inspiration from cross-linguistic *only*-like expressions.** Korean '*pakk-ey* + NEG' and French '*ne ... que*' contribute a meaning similar to English *only*, and intriguingly, these constructions already contain an explicit use of negation (see (4) and (5)).

(4) Korean construction *pakk-ey* + NEG

30-pwun pakk-ey an ca-ss-ta
30-min. outside-to NEG sleep-PST-DEC

'I only slept for 30 minutes.'

(5) French construction *ne ... que*

Jean n' aime que Marie.
John NEG love that Mary

John only loves Mary.

In particular, in Korean '*pakk-ey* + NEG', the morpheme *pakk* literally means 'outside'. Thus a literal translation of (4) is 'outside of 30 minutes, I didn't sleep'. This morpheme *pakk* in (4) suggests the hidden compositional details behind the meaning of *only*.

Basically, *only* is similar to additive particles like *another* and *other* (see (6)) in that their uses all involve the existence of a contextually salient base item (here *Lucy* in (6)).

(6) a. Lucy came. {Another person / Other people} also came.
b. Lucy came. {Another person / Other people} (*also) didn't come.

In (6), the availability of a contextually salient base item licenses the use of additive particle (*a*)*nother*, but not the use of *also* (see (6b)). This contrast between (*a*)*nother* and *also* indicates that (*a*)*nother* requires just the existence of a base item in the same domain as (*a*)*nother* (*person*), while *also* seems to further require event parallelism.

Evidently, similar to (*a*)*nother*, *pakk* in (4) also requires the existence of a base item in the same domain, here *30-pwun* ('30 minutes'). Then similar to (*a*)*nother* and different from *also*, Korean '*pakk-ey* + NEG' requires no event parallelism (between *30-pwun* and *pakk*). Rather it seems that there is an opposition between the base item part *30-pwun* ('30 minutes') and *pakk* (≈ extra time beyond the 30 minutes), thus giving rise to the meaning of *only*: I didn't sleep beyond 30 minutes, (in opposite to the base item part).

In this sense, for (2), *only Mary* can be decomposed into (i) negation, (ii) additive part *other*, and (iii) the base item *Mary* (see (7a)). The negation component *no one* in (7a) can be further decomposed into (i) a negation operator *not* and (ii) *any* (see (7b)).

(7) Only Mary ate (any) vegetable.
a. ⇝ **No one other than Mary** ate (any) vegetable.
b. ⇝ **Not any one other than** Mary ate (any) vegetable.

This decompositional view on *only* is crucially different from Ladusaw (1979)'s view (sketched out in (3)) in two ways.

First, there is no positive component like (3a). Even if *only*-sentences themselves suggest or presuppose or even entail a contrast between the base item part (e.g., *Mary* in (2)/(7)) and the additive part (e.g., other people), the base item part does not introduce a discourse referent like *some vegetable* (see (3a)). This can also be confirmed by (8). In (8a), the pronoun *it* does not have a salient discourse referent to refer back to (cf. (8b)).

(8) a. People other than Mary didn't read any book. *?She read it.
b. People other than Mary didn't read one book. She read it.

Second, instead of just considering Mary and other people distinct (see (3b)), the decompositional view in (7) actually assumes an ordering between the base item part and the additive part. This ordering assumption is conceptually and empirically welcome.

On the one hand, within English, this ordering assumption relates the use of *only* on a domain of entities to its use on a domain of scalar values (see (9)).

(9) She is only 5′ tall. ⇝ She is not more than 5′ tall (or not any taller than 5′).

On the other hand, this ordering assumption further makes another group of cross-linguistic NPI phenomena parallel to the case of *only*. As illustrated in (10)–(12), English *any more*, Korean *te isang* ('any more'), and Chinese *zài* ('again') all (i) include an additive component and (ii) require a typical NPI-licensing operator like negation.

(10) a. She is *(not) any taller than 5′.
b. She has *(not) any more interest in house work.

(11) a. John-un te isang chayk-ul ilk-ci anh-ass-ta
John-TOPIC more above book-ACC read-COMP NEG-PAST-DECL
'John did not read books any more.' (With the licensing of negation)

b. * John-un te isang chayk-ul ilk-ess-ta
John-TOPIC more above book-ACC read-PAST-DECL
Intended translation: 'John read books any more.' (Licensing is needed.)

(12) Mary *(bù) zài gěi Bill dǎ-diànhuà
Mary NEG again towards Bill make-a-phone-call
'Mary no longer calls Bill.' Additive particle *zài* ('again') requires licensing.

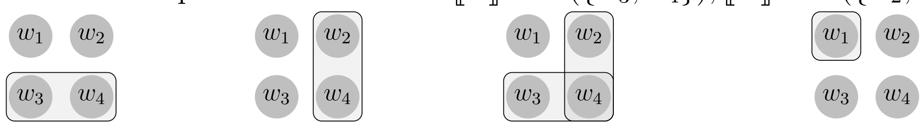
This group of *any-more* constructions in (10)–(12) is similar to the case of *only* in that (i) they all involve an **additive part** that goes beyond the base item part and (ii) it is exactly with regard to this additive part (not the base item part) that NPI licensing is required and takes place. These *any-more* constructions in (10)–(12) are actually exactly the same as Korean *pakk-ey* in (4). English *only* is slightly different from them in that *only* contains a hidden negation operator, while in the use of Korean *pakk-ey* in (4) and *any-more* constructions in (10)–(12), the negation operator is explicit.

**3. Proposal.** Given that (i) the use of *only* and *any more* involves a base item part and an additive part, and that (ii) NPI licensing only involves the additive part, NPI licensing phenomena with regard to *only* and *any more* should not be largely different from the simplest NPI licensing case illustrated by (1b). Inquisitive Semantics (Ciardelli et al. 2018) provides a natural account for these licensing phenomena. Within this framework,

(13) a. An *information state* $s$ (of type $\langle st \rangle$) is a set of possible worlds, i.e., $s \subseteq W$.
b. An *issue* $I$ is a non-empty, downward-closed set of information states.
c. The maximal elements of an issue $I$ are called the *alternatives* in $I$.
d. The set of alternatives in $I$ is written as $\mathsf{alt}(I)$.
e. The *informative content* of an issue is the union of its alternatives, i.e., $\mathsf{info}(I) = \bigcup\{\alpha \mid \alpha \in \mathsf{alt}(I)\}$.

Thus a proposition $\varphi$ is lifted from a set of possible worlds to a set of sets of possible worlds. A proposition $\varphi$ is (i) *inquisitive* iff $|\mathsf{alt}(\varphi)| > 1$ (see '$A$ or $B$' in (14)) and (ii) *non-inquisitive* iff $|\mathsf{alt}(\varphi)| = 1$ (see '$A$', '$B$', and 'not ($A$ or $B$)' in (14)).

(14) Illustrations of Inquisitive Semantics: $[\![A]\!] = \mathcal{P}(\{w_3, w_4\})$, $[\![B]\!] = \mathcal{P}(\{w_2, w_4\})$

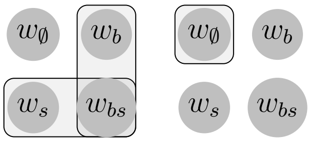



$\mathsf{alt}([\![A]\!]) = \{\{w_3, w_4\}\}$ — $[\![A]\!]$: non-inquisitive
$\mathsf{alt}([\![B]\!]) = \{\{w_2, w_4\}\}$ — $[\![B]\!]$: non-inquisitive
$\mathsf{alt}([\![A \text{ or } B]\!]) = \{\{w_3, w_4\}, \{w_2, w_4\}\}$ — $[\![A \text{ or } B]\!]$: inquisitive
$\mathsf{alt}([\![\text{not } (A \text{ or } B)]\!]) = \{\{w_1\}\}$ — $[\![\text{not}(A \text{ or } B)]\!]$: non-inquisitive

Within Inquisitive Semantics, some syntactic conditions are sufficient for non-inquisitivity. As shown in (17), negating a proposition $\varphi$ guarantees that the potential inquisitiveness of $\varphi$ does not project further. Thus for an *only*-sentence (see (2) and (7b)), explicit and implicit NPIs work like indefinites and introduce inquisitiveness (see (16)), but since NPIs are referentially vague and cannot maintain discourse referents, their inquisitiveness needs to be cancelled. Negation satisfies this requirement, for multiple NPIs at the same time.

In this account, I actually assume that the potential inquisitiveness and its cancellation do not involve the base item part, but only the additive part. In this sense, whether/what Mary ate is backgrounded, and thus, not under discussion or involved in inquisitiveness.

(15) Negation removes the inquisitiveness introduced by NPIs:




$[\![$(16)$]\!]$ $[\![$(17)$]\!]$

(16) $[\![$*any one other than Mary* ate *any vegetable*$]\!]$
$= \{\{w \mid \text{Bill ate carrots in } w\}, \{w \mid \text{Sue ate cabbage in } w\}, \ldots\}$

(17) Negation cancels the inquisitiveness of NPIs:
$[\![\text{NEG}]\!] \stackrel{\text{def}}{=} \lambda P_{\langle st,t\rangle}.\{\{w \mid w \notin \mathsf{info}(P)\}\}$

**4. Extension: in a domain of scalar values.** The above analysis in (15)–(17) is about inquisitiveness and its cancellation in a domain of entities. Such an analysis can be extended to a domain of scalar values, like a domain of degrees (or intervals) or times. In these domains of scalar values, I assume that the additive part *any more* introduces alternatives that are indefinite, referentially vague, positive differences (e.g., *exactly 1"* in (18), *about 3 mins* in (19)). The rest of the story is the same as in the domain of entities.

(18) She is not any taller than 5′. (see (10a))
$[\![$She is *any taller than 5'*$]\!] = \{\{w \mid \text{She is exactly 1" taller than 5' in } w\},$
$\{w \mid \text{She is between 2" and 3" taller than 5' in } w\}, \ldots\}$

(19) John did not read books {any more / any longer}. (see (11) and (12))
$[\![$John read books *any longer*$]\!] = \{\{w \mid \text{John read books at about 3 mins after } t_0\}, \ldots\}$

A further extension is about a new trend in using English *many*. Some native speakers find (20a) degraded, and according to their intuition, the use of *many* requires negation (see (20b)). Thus for these speakers, *many* contains a hidden *any* and works as an NPI (see (21)). Presumably, this decompositional analysis makes *many* parallel to *any-more* constructions in a domain of degrees and explains the NPI licensing requirement of *many*.

(20) a. %I have many books. (Some native speakers don't accept this sentence.)
b. I don't have many books.

(21) $[\![$many$]\!] = [\![$(any) more than a contextual threshold$]\!]$

**5. Discussion.** Compared to existing views on NPIs, the current proposal has a few benefits. First, compared with the classical DE-ness-based theory, the current proposal not only explains how to license NPIs, but also why NPIs require licensing. The fundamental driving force behind these NPI phenomena is the tension between their indefinite-like behavior in invoking alternatives and their inability to project inquisitiveness further.

Second, the current proposal also explains why cross-linguistically, an NPI often behaves as a free choice item (FCI). Under Inquisitive Semantics, not only negating a proposition $\varphi$ guarantees that the potential inquisitiveness of $\varphi$ does not project further, making $\varphi$ the antecedent of a conditional also cancels inquisitiveness. As shown in (22), FCI phenomena can be considered (wh)-unconditionals: the distinction among the alternative resolutions to the issue of the antecedent is not preserved at the entire sentence level.

(22) a. If you see any unicorn, you will feel happy.

$\rightsquigarrow$ Whatever unicorns you see, you will feel happy. *wh*-unconditional

b. Please greet any unicorn you see. $\rightsquigarrow$ If you see any unicorn, greet them.

Third, the current analysis does not rely on the assumption that there is a hidden *even* in NPIs (see Lahiri 1998). The *even*-based analysis for NPIs is usually based on the additivity and/or the likelihood component in *even*, but the existence of these components in *even* is much challenged in recent works on *even* (see Greenberg 2016; Zhang 2022).

Fourth, the current analysis for *only* relies on a distinction between a salient base item and an additive part. The contextual salience in making this distinction might be able to explain another puzzle in the literature on NPIs (see (23) and Crnič 2014).

(23) a. Exactly 2 students in my class read any book. $\rightsquigarrow$ only 2 (+ additional)
$\rightsquigarrow$ Except for 2 students in my class, not anyone else read any book.
b. #Exactly 20 students in my class read any book. $\not\rightsquigarrow$ ?only 20 (+ additional)
$\rightsquigarrow$ ??Except for 20 students in my class, not anyone else read any book.

## References


Ciardelli, Ivano, Jeroen Groenendijk, and Floris Roelofsen. 2018. *Inquisitive semantics*. Oxford University Press. https://doi.org/10.1093/oso/9780198814788.001.0001.

Crnič, Luka. 2014. Against a dogma on NPI licensing. In *The art and craft of semantics: A festschrift for Irene Heim*, ed. Luka Crnič and Uli Sauerland, volume 1, 117–145. https://lukacrnic.com/pdfs/dogma.pdf.

von Fintel, Kai. 1999. NPI licensing, Strawson entailment, and context dependency. *Journal of semantics* 16:97–148. https://doi.org/10.1093/jos/16.2.97.

Giannakidou, Anastasia. 2011. Negative and positive polarity items. In *Semantics: An International Handbook of Natural Language Meaning*, ed. Claudia Maienborn, Klaus von Heusinger, and Paul Portner, volume 2, 1660–1712. de Gruyter. https://doi.org/10.1515/9783110255072.

Giannakidou, Anastasia. 2017. Polarity in the semantics of natural language. In *Oxford Research Encyclopedia of Linguistics*. OUP. https://doi.org/10.1093/acrefore/9780199384655.013.7.

Greenberg, Yael. 2016. A novel problem for the likelihood-based semantics of *even*. *Semantics and Pragmatics* 9:2:1–28. https://doi.org/10.3765/sp.9.2.

Ladusaw, William. 1979. Polarity Sensitivity as Inherent Scope Relations. Doctoral Dissertation, The University of Texas at Austin. https://www.proquest.com/docview/302988920.

Lahiri, Utpal. 1998. Focus and negative polarity in Hindi. *Natural Language Semantics* 6:57–123. https://doi.org/10.1023/A:1008211808250.

Zhang, Linmin. 2022. The presupposition of *even*. In *Semantics and Linguistic Theory*, volume 32, 249–269. https://doi.org/10.3765/salt.v1i0.5355.

## On the *Ye/Haishi* Alternation in Mandarin Concessive Conditionals

Shao-Yu Huang & I-Ta Hsieh

In Mandarin, the counterpart of the English concessive conditional *even if*, such as *even if Zhangsan did not come, Lisi would still come*, is expressed with the morpheme *jiusuan* ahead the antecedent and an additive particle *ye* 'also' or *haishi* 'still' in the consequent (see (1)).

(1) *jiùsuàn Zhāngsān bù lái Lǐsì yě/haíshì huì lái.*
even-if p.n. NEG come, p.n. also/still will come
'Even if Zhangsan didn't come, Lisi would come.'

This research is focused on the alternation between *ye* and *haishi* in this construction.

### 1. The *ye/haishi* alternation

At first glance, *ye* and *haishi* seemingly alternate freely (see (2)).

(2) A: *If the next goal is not scored, the Taiwanese team will lose*.
B: *jiùsuàn xià yī qíu jìn-le, táiwān duì* ***yě/háishì*** *huì shū.*
even-if next one ball enter-PFV Taiwan team also/still will lose
'Even if the next goal were scored, the Taiwanese team would lose.'

However, there are cases in which only the use of *haishi* is felicitous, e.g., (3).

(3) [*Context*: *Wang and Li are going to attend Chen's wedding, and they have three ways to get to the venue: the bus, MRT and taxi. Among these three ways, the bus takes the most time, the MRT comes second, and the taxi takes the least. Now, the wedding is going to begin just in ten minutes; meanwhile, Wang and Li just leave home, and are talking about which way they should take while rushing to the venue.* ***W***: *The wedding is about time to begin; if we take bus or the MRT, we will definitely be late.* ***L***: *How about taking a taxi?* ***W***: *Well...,*]

*jiùsuàn dā jìchéngchē, wǒmen* ***#yě/háishì*** *huì chídào.*
even-if take taxi 1. PL also/still will late
'Even if we take a taxi, we will be late.'

Two types of *even-if* concessive conditionals, the factive and the non-factive, have been differentiated in previous literatures (Pollock 1976, Lycan 1991, Guerzoni and Lim 2007, and others). Nevertheless, the contrast between the *jiusuan*-conditionals in (2) and (3) cannot be attributed to such a distinction, for in both cases, the speaker is committed to the truth of the consequent. We suggest that this observed contrast has to do with the size of the alternative set and may be accounted with *Maximize Presupposition!* (Heim 1991, Sauerland 2008, and others) and pruning on the alternatives (Fox & Katzir 2011, Chierchia 2013, and others).

### 2. Semantics of concessive conditionals

Mandarin *jiusuan*-conditionals, just like their English *even-if* counterparts,show focus-sensitivity and scalarity of likelihood; (3) expresses that (i) it is the least likely, compared to other alternatives, that Wang and Li will be late if they take a taxi, and (ii) it is true that if they take a taxi, they will be late. Following Guerzoni & Lim (2007), we assume that, as shown in (4), (i) is a presupposition and (ii) is (part of) the assertion; we also assume that the part in the antecedent, in focus associated with *jiusuan*, can be a constituent (e.g., (3), with *a taxi* in focus) or the polarity operator (i.e., AFF/NEG); in the latter case, the alternative set is $\{$*if p then q, if* $\neg p$ *then q*$\}$.

(4) $[\![jiusuan]\!]^{w}(p_{<s,t>})(q_{<s,t>})$ is defined only if:
**(i)** $\forall p' \in \mathrm{ALT}(p)[p' \neq p \rightarrow [\lambda w'.\ \mathrm{Sim}_{w'}(p) \subseteq q] <_{\mathrm{likelihood},c} [\lambda w'.\ \mathrm{Sim}_{w'}(p') \subseteq q]]$
where $\mathrm{Sim}_{w}(p)=\{w': p(w')$ and $w'$ is the most similar to $w\}$, and $c$ is the context set
if defined, then **(ii)** $[\![jiusuan]\!]^{w}(p_{<s,t>})(q_{<s,t>})=\mathrm{True}$ iff $\forall p'_{<s,t>}[p' \in \mathrm{ALT}(p) \rightarrow \mathrm{Sim}_{w}(p') \subseteq q]$

## 3. Adding in additive particles

It has been assumed that English *even* introduces an existential additive presupposition; For instance, *even if p, q* presupposes that in the alternative set there is some $p' \neq p$ such that if $p'$ then $q$. Given the presence of the additive particles, *ye* and *haishi*, we assume that in a *jiusuan*-conditional the additive presupposition is carried out by the two particles. The presuppositions from them, we assume, differ in their quantificational force: *ye* presupposes that there is some alternative $p' \neq p$ such that $p'$ is true (see (5)), *haishi* presupposes that for every alternative $p' \neq p$ such that $p'$ is true (see (6)). Hence, the additive presupposition triggered by *haishi* is stronger than that by *ye*. According to those assumptions, a *jiusuan*-conditional is parsed as in (7) at LF.

(5) $[\![ye]\!]^{w}(p_{<s,t>})$ is defined only if:
$\exists q \in \mathrm{ALT}(p)[q \neq p$ and $q(w)=1]$
if defined, $[\![ye]\!]^{w}(p_{<s,t>})=1$ iff $p(w)=1$

(6) $[\![haishi]\!]^{w}(p_{<s,t>})$ is defined only if:
$\forall q \in \mathrm{ALT}(p)[q \neq p \rightarrow q(w)=1]$
if defined $[\![haishi]\!]^{w}(p_{<s,t>})=1$ iff $p(w)=1$

(7) [ [*jiusuan p*]$_1$ [ *ye/haishi* [ *pro*$_1$ *q* ]]], where *pro* is a covert sentential pronoun.

Accordingly, in a *jiusuan*-conditional [*jiusuan p*, *ye/haishi q*], *ye* triggers a presupposition that there is some $p' \in \mathrm{ALT}(p)$ such that $p' \neq p$ and if $p'$ then $q$, whereas *haishi* triggers a presupposition that for all $p' \in \mathrm{ALT}(p)$ such that $p' \neq p$, if $p'$ then $q$.

## 4. Solution to the *ye/haishi* alternation

We assume that *ye* and *haishi* are for a lexical scale of presuppositionality, <*ye*, *haishi*>, just like <*believe*, *know*>, <*a*, *the*>, <∅, *too*> (Chemla 2008). Along with the characterizations above, the alternation of *ye/haishi* in (2)-(3) may be accounted for by appealing to *Maximize Presupposition!* (Heim 1991, Percus 2006, Sauerland 2008, Chemla 2008; a.o.).

(8) ***Maximize Presupposition!*:**

If $p$ and $q$ are contextually equivalent alternatives, and the presuppositions of $q$ are stronger than those of $p$ and are met in the context of utterance $c$, then one must use $q$.

4.1 The use of *haishi* in (3)

While *ye* and *haishi* give rise to presuppositions with different quantificational force, a *jiusuan*-conditional with *ye*, given the alternative set A, is equivalent to its counterpart with *haishi*. This results from the truth conditions in (4) (see (4, (ii))): for [*jiusuan p*, [*ye/haishi q*]] to be true, it is required that *if p then q* and all the other alternatives *if p' then q* are true. Given this truth-conditional equivalence, (8) then correctly predicts that in a *jiusuan*-conditional like (3), *haishi*, which triggers a stronger presupposition than *ye*, must be used. This also predicts that *haishi* may be used in a *jiusuan*-conditional like (2).

4.2 The optionality in (2)

While (8) predicts that *haishi* must be used in *jiusuan*-conditionals, in some cases, such as (2), the use of *ye* is not blocked. We suggest that in this case the use of *ye* may be salvaged by '**truncating**' the lexical scale <*ye*, *haishi*> and removing *haishi* from being a competitor of *ye*. This is along with the same spirit to 'alternative pruning' suggested in Fox and Katzir (2011), Chierchia (2013) and others. Without *haishi* as its alternative, the use of *ye* is not subject to *Maximize Presupposotion!* (8) and hence is felicitous.

4.3 Restrictions on lexical scale truncation

The fact that the use of *ye* is infelicitous in (3) suggests that removing *haishi* from being the lexical alternative to *ye* is forbidden, which further suggests that the appeal to lexical scale truncation should be constrained. We suppose that lexical scale truncation is subject to the constraint in (10), according to which the key notion to account for the contrast in (2)-(3) in this respect is **relevance**, and furthermore make an assumption to define the relevance between competing sentences: **presuppositional relevance**. Below, (10) states that a lexical scale can be truncated only if the pair of competing alternatives generated by it are presuppositionally irrelevant in the context $c$, and (9) states that two competing alternatives are presuppositionally irrelevant in $c$, if their domains are equivalent in $c$. In the other words, a stronger lexical alternative can be removed from being the competitor of the weaker one, only if the competing sentence with it has a domain equivalent to that of the sentence with its competitor in $c$.

(9) Presuppositional relevance:

Given a context $c$, a sentence $S$, a lexical alternative scale $<\alpha, \beta>$, where β carries a stronger presupposition than $\alpha$,

$[_S \ldots \alpha \ldots]$ and $[_S \ldots \beta \ldots]$ are presuppositionally relevant in $c$ iff:

$\{w \in c: w \in dom([\![[_S \ldots \beta \ldots]]\!])\} \subset \{w \in c: w \in dom([\![[_S \ldots \alpha \ldots]]\!])\}$;

[$_S$ … $\alpha$ …] and [$_S$ … $\beta$ …] are **presuppositionally irrelevant** in $c$ iff:
{w∈c: w∈dom(⟦[$_S$ … $\beta$ …]⟧)}={w∈c: w∈dom(⟦[$_S$ … $\alpha$ …]⟧)}.
(⊂ means 'a proper subset of'.)

(10) Constraint on the lexical scale truncation:
Given a context $c$ and a lexical alternative scale <$\alpha$, $\beta$>, where β carries a stronger presupposition than $\alpha$, $\beta$ may be removed from being the competitor of α in a sentence $S$ iff [$_S$ … $\alpha$ …] and [$_S$ … $\beta$ …] are presuppositionally irrelevant in $c$.

4.4 The contrast in the alterantion of *haishi/ye* between (2) and (3)

In (2), the contextually salient alternative set to the assertion, namely {*if p then q, if ¬p then q*}, has two elements. Moreover, according to (5) and (6), *haishi* and *ye* are quantifiers over a subset of the alternative set: the subset exactly excluding the assertion. Since there is only one $\neg p \rightarrow q$ alternative in such a subset in (2), the *jiusuan*-conditionals with *haishi* and with *ye*, either by universal or existential quantification, both presupposes $\neg p \rightarrow q$ in the context; namely, they have equivalent domains and are presuppositionally irrelevant therein. Therefore, *ye* and *haishi* conform with the constraint (10) in (2B), so that lexical scale truncation can apply to them. In (2), as a consequence, the use of *ye* is not subjected to *Maximize Presupposition!* and it is thus in free alternation with *haishi*.

In (3), on the other hand, the contextually salient alternative set {*if p then q*, *if p' then q*, *if p" then q*} (i.e., *taking bus, taking the MRT* and *taking a taxi*) has three elements. Namely, the subset that *haishi* and *ye* quantify over in (3) is a set of plural elements instead of a singleton set. In such a context, the *jiusuan*-conditional with *ye*, by the existential quantification, presupposes a disjunction of the alternatives, i.e., $(p' \rightarrow q) \vee (p'' \rightarrow q)$, whereas that with *haishi*, by the universal quantification, presupposes a conjunction $(p' \rightarrow q) \wedge (p'' \rightarrow q)$. Given these two presuppositions, the *jiusuan*-conditional with *haishi* certainly has a domain as a proper subset of that of its counterpart with *ye*, and therefore being presuppositionally relevant to the counterpart according to (9). Consequently, since truncation is not licensed in (3), the use of *ye* is subjected to *Maximize Presupposition!* and its alternation with *haishi* is accordingly blocked, as we have explained in 4.1.

## 5. Implications

The analyses suggested above carry two implications that competitions may be subjected to presuppositional relevance, and that violations to *Maximize Presupposition!* may be ameliorated with truncation of the lexical alternative scale in question, which is subject to constraints about the relevance.

**References**:

Chemla, Emmanuel. An Epistemic Step for Anti-Presuppositions, Journal of Semantics, Volume 25, Issue 2, May 2008, Pages 141–173.

Chierchia, Gennaro. Logic in Grammar : Polarity, Free Choice, and Intervention. First edition. Oxford: Oxford University Press, 2013. Print.

Fox, D. & Katzir, R. (2011). On the characterization of alternatives. Nat Lang Semantics 19, 87–107. https://doi.org/10.1007/s11050-010-9065-3

Guerzoni, E., & Lim, D. (2007). Even if, factivity and focus. Proceedings of Sinn Und Bedeutung, 11, 276-290.

Heim, I. (1991). Artikel und Definitheit. In Semantik: Ein internationales Handbuch der zeitgenössischen Forschung, ed. Arnim von Stechow and Dieter Wunderlich, 487–535. Mouton de Gruyter

Ippolito, M. (2007). On the meaning of some focus-sensitive particles. *Nat Lang Semantics* 15, 1–34.

Ivlieva, Natalia. (2011). Obligatory Implicatures and Grammaticality. 381-390. 10.1007/978-3-642-31482-7_39.

Kratzer, A. (1991a) Conditionals, in von Stechow and Wunderlich (1991), pp. 651–656.

Lycan, William G. "'Even' and 'Even If.'" *Linguistics and Philosophy* 14, no. 2 (1991): 115–50.

Percus, Orin (2006), 'Antipresuppositions'. In A. Ueyama (ed.), Theoretical and Empirical Studies of Reference and Anaphora: Toward the Establishment of Generative Grammar as an Empirical Science. Report of the Grant-in-Aid for Scientific Research (B), Japan Society for the Promotion of Science. 52–73.

Sauerland, Uli. (2008) "Implicated Presuppositions". The Discourse Potential of Underspecified Structures, edited by Anita Steube, Berlin, New York: De Gruyter, pp. 581-600. https://doi.org/10.1515/9783110209303.4.581

Schlenker, P. *Maximize Presupposition* and Gricean reasoning. *Nat Lang Semantics* **20**, 391–429 (2012). https://doi.org/10.1007/s11050-012-9085-2

Singh, R. (2011). "Maximize Presupposition!" and local contexts. Natural Language Semantics, 19(2), 149–168. http://www.jstor.org/stable/43550285

Tellings, Jos. (2017). "Still" as an additive particle in conditionals. Semantics and Linguistic Theory. 27. 1-21.

# Two Places Where We Need Plug-negation in Update Semantics

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***Synopsis.*** This study investigates presuppositions in disjunction and argues that we need Plug-negation, the negation that filters presuppositions, in two places. One is the negation that appears in the local contexts of the disjuncts, and the other is the negation that appears in exhaustifying disjunction.

***Presuppositions in disjunction and negation.*** Karttunen (1973) observes that in disjunction $p \vee q_\pi$, where the second disjunct $q$ presupposes $\pi$, the presupposition $\pi$ is projected to the global context except when $\neg p$ entails $\pi$. This is exemplified by the contrast in (1), where the use of ***stop*** presupposes that Jonathan used to run regularly. This presupposition is projected to the entire disjunction in (1a), but not in (1b) because the negation of the first disjunct entails the presupposition.

(1) a. Either Jonathan hates exercising, or he **stopped** runnnig regularly.
    b. Either Jonathan never ran regularly, or he **stopped** running regularly.

Karttunen further observes that negation projects the presupposition of its prejacent. This is shown in (2), where both the affirmative and the negative sentences presuppose Jonathan used to run regularly.

(2) a. Jonathan **stopped** running regularly.
    b. Jonathan didn't **stop** running regularly.

***Presuppositions in Update Semantics.*** Under Propositional Update Semantics (PUS; Veltman 1996; Beaver 2001: Ch.6; see also Groenendijk et al. 1996), the above two observations are analyzed in the following way. In PUS, a proposition $p$ updates a state $s$, defined as a set of worlds $w$, to the subset of $s$ where $p$ is true (3a). When $p$ has a presupposition $\pi$, this update is defined only if $s[\pi] = s$, i.e., $\pi$ is true in all $w \in s$ (3b). Negation of any proposition $\phi$ is then defined as (3c), where $\neg\phi$ subtracts the worlds in $s$ where $\phi$ is true. Notice that the definedness condition of negation inherits that of its prejacent, $\phi$. It explains why (2b), roughly analyzed as $s[\neg\texttt{Jonathan\_stop\_running\_regularly}_\pi]$, projects the presupposition $\pi$. For the update to be defined, Jonathan used to run regularly in every $w \in s$.

(3) a. $s[p] := \{w \in s \mid p(w) = 1\}$
    b. $s[p_\pi] := \{w \in s \mid p(w) = 1\}$, defined only if $s[\pi] = s$, undefined otherwise.
    c. $s[\neg\phi] := s / s[\phi]$, defined only if $s[\phi]$ is defined.
    d. $s[\phi \vee \psi] := s[\phi] \cup s[\neg\phi][\psi]$

Disjunction then is defined as (3d), which sums up the updates $s[\phi]$ and $s[\neg\phi][\psi]$. There, the second disjunct $\psi$ updates the input under 'the local context' $\neg\phi$ – it only considers the $\neg\phi$-worlds. Thus, when $\psi$ has a presupposition $\pi$, it is only required that every $\neg\phi$-worlds in $s$ makes $\pi$ true. This definition explains the presupposition projections in (1b). In $p \vee q_\pi$, where $\neg p$ entails $\psi$, the presupposition is true in all the $\neg p$-worlds. Thus, $s[\neg p][q_\pi]$ is always defined, and the presupposition is not projected. (The definition predicts that, when $\neg p$ does not entail $\pi$, the disjunction presupposes $\neg p \rightarrow \pi$, which is weaker than the presupposition observed in (1a). This is called *proviso problem*, and almost all dynamic systems (e.g., Heim 1982; Groenendijk & Stokhof 1991; Groenendijk et al. 1996; a.m.o.) inherit it, except for some versions of DRT (Kamp & Reyle 1993; van der Sandt 1992). Solving it is beyond the scope of this study. See Mandelkern (2016) for an ovierview.)

***Two definitions of negation.*** The definition of negation in (3c) emulates the particular definition of negation in trivalent logic, represented as (4a), which I call *Hole-Negation* (after Karttunen's

(1973) *presupposition hole*.) This is not the only definition possible. Another option is what I call *Plug-negation*, represented as (4b). $-p$ is true iff $p$ is false *or undefined*, so it does *not* project the presupposition of $\pi$. The Plug-negation can be translated into a PUS definition as in (5). $s[-\phi]$ collects every $w \in s$ such that $\phi$ is *undefined, or defined and false*.

(4) a. Hole Negation ($\neg$)

| $p$ | $\neg p$ |
|---|---|
| 1 | 0 |
| 0 | 1 |
| * | * |

b. Plug-Negation ($-$)

| $p$ | $-p$ |
|---|---|
| 1 | 0 |
| 0 | 1 |
| * | 1 |

(5) $s[-\phi] = \{w \in s \mid w \text{ does not subsist in } \{w\}[\phi]\}$,

where $w$ subsists in $s[\phi]$ iff $s[\phi]$ is defined as $w \in s[\phi]$

The purpose of this study is to claim that, despite the validity of the definition in (3c) for the negation that is phonologically realized in sentences (like English *not*), we need the Plug-negation in (5) for some of the negations that are not phonologically realized, namely the negation in the local context of disjuncts and the negation in exhaustification.

***The need of Plug-negation 1: symmetrical presupposition filtering.*** A recent experimental study by Kalomoiros & Schwarz (2021) reveals that presupposition filtering effect observed in (1) is symmetric: in $p_\pi \vee q$, where $p$ has presupposition $\pi$, the presupposition is filtered when the negation of $q$ entails $\pi$. Thus, (6) does not presuppose that Jonathan used to run regularly.

(6) Either Jonathan **stopped** running regularly or he never used to run regularly.

In order to have a fully generalized definition, the update by disjunction in (3d) must be revised as (7), where NEG will be either the Hole-negation ($\neg$) or the Plug-negation ($-$).

(7) $s[p \vee q] := s[\text{NEG}\, q][p] \cup [\text{NEG}\, p][q]$

I demonstrate that filling $\neg$ in the places of NEG does not converge to the desired result. For clarity, consider the update by $p_\pi \vee q$ w.r.t. the state $s$ in (8a) where the $\pi$ holds in every non-$q$ world ($w_{2,p\pi}$ represents that $p$, $\pi$ and nothing else is true in $w_2$.) Although the presupposition should not be projected there, the definition in (8b) predicts that it is. The lefthand side of the union (8c) does not pose any problem. It first eliminates from $s$ the worlds where $q$ is false. Since $\pi$ is true in every non-$q$ world by assumption, the further update by $p_\pi$ is defined. However, the righthand side of the union (8d) is not defined. This is because $s[\neg p_\pi]$ is defined only if $s[p_\pi]$ is defined. The condition is not met in $s$, and the entire update by the disjunction is also undefined. In fact, the update is only defined if $\pi$ is true in every $w \in s$, i.e., $\pi$ must be presupposed by the disjunction. It goes against the observation in (6).

(8) a. $s = \{w_{1,p\pi q}, w_{2,p\pi}, w_{3,q}, w_{4,\pi}\}$
b. $s[p_\pi \vee q] := s[\neg q][p_\pi] \cup s[\neg p_\pi][q]$
c. $s[\neg q][p_\pi] = \{w_{2,p\pi}\}$
d. $s[\neg p_\pi][q] = \text{undefined}$

Consider the update of the same state $s$ by the disjunction defined as (9a) with the Plug-negation. The lefthand side of the union works as above, but this time, the righthand side is also defined. $s[-p_\pi]$ eliminates $w \in s$ where $p_\pi$ is defined and true, resulting in the new state which contains the worlds where $p_\pi$ is undefined or false, as in (9c). The update proceeds as (9d). Crucially, under this definition of disjunction, the presupposition $\pi$ is not projected, deriving the correct result. It reveals that the local context of disjunction in PUS must be defined with the Plug-negation.

(9) a. $s[p_\pi \vee q] := s[-q][p_\pi] \cup s[-p_\pi][q]$
b. $s[-q][p_\pi] = \{w_{2,p\pi}\}$
c. $s[-p_\pi] = \{w_{3,q}, w_{4,\pi}\}$
d. $s[-p_\pi][q] = \{w_{3,q}\}$

***The need of Plug-negation 2: Obligatory exclusivity of disjunction and exhaustification.*** Logically, $p \vee q$ is true when $p \wedge q$ is true. Nevertheless, natural language utterances of disjunction often imply that the conjunctive counterpart is false, i.e., the utterance is strengthened to exclusive disjunction $(p \vee q) \wedge \neg(p \wedge q)$ (Chierchia 2004 for an overview). For example, (10a) implies (10b).

(10) a. John will dance or Mary will sing.
b. It is not the case that John will dance *and* Mary will sing.

Although the implication is usually cancellable, and (10a) can be followed up by saying '... *maybe both*,' the strengthening is obligatory for some forms of disjunction (Spector 2014). This is the case for English '*either* ... *or* ...', French '*soit* ... *soit* ...', and Japanese '... *ka* ... *ka dochiraka*,' just name a few. Thus, English (11a) and Japanese (11b) both *entail* (10b), and the follow-up '... *maybe both*' is infelicitous.

(11) a. ***Either*** John will dance ***or*** Mary will sing.
b. *John-ga odoru* ***ka*** *Mary-ga utau* ***ka dochiraka*** *da.*
John-NOM will.dance or Mary-NOM will.sing or either COP

Spector (2014) proposes, in the static and bivalent system, that these forms of disjunction lexically contain the 'exhaustification operator' EXH (Chierchia 2006, 2013 and the references therein), which, applied to disjunction, induces the strengthening to exclusive disjunction. In Spector's paper, NEG in (12) is the familiar bivalent negation.

(12) $\text{EXH}(p \vee q) \rightsquigarrow (p \vee q) \wedge \text{NEG}(p \wedge q)$

Supposing that conjunction $p \wedge q$ induces a successive update by the conjuncts, $s[p][q]$, the exhaustified disjunction is translated into the PUS definition in (13). (Sudo (2023) proposes a different definition for a first-order extension of the definition. For the purpose of this paper, the definition in (13) suffices, but it is worth noting that the following discussion also applies to Sudo's definition.) Again, I will demonstrate that NEG must be the Plug-negation.

(13) $s[\text{EXH}(p \vee q)] := s[p \vee q][\text{NEG}(p \wedge q)]$

In order to see what we should obtain, observe that (14) does not presuppose that Jonathan used to run regularly. This is another instance of the symmetrical filtering discussed above. Given the proposal by Spector (2014) on obligatory exhaustification, any theory should predict that the symmetrical filtering is preserved after the application of EXH.

(14) ***Either*** Jonathan **stopped** running regularly ***or*** he never ran regularly.

Consider first the update by (14) under the definition with the Hole-negation in (15a). Suppose the state $s$ where the negation of $q$ entails the presupposition $\pi$, as in (15b), and that the update by disjunction is defined with the Plug-negation, as established above. We then already know that the update by disjunction results in (15c), the union of (9b) and (9d). The negated conjunction $\neg(p_\pi \wedge q)$ updates this state. But for this update to be defined, $s[p_\pi \wedge q]$ must be defined by the definition of $\neg$, which in turn means that $s[p_\pi]$ is defined. This is not the case because $\pi$ is false in $w_3$. In fact, the update is defined if we eliminate $w_3$ from the initial state $s$, but that would mean that $\pi$ must be true in all the worlds in $s$. Thus, the definition of EXH with the Hole negation requires that $\pi$ must be presupposed, contrary to fact.

(15) a. $s[\textsc{Exh}(p_\pi \vee q)] := s[p_\pi \vee q][\neg(p_\pi \wedge q)]$

b. $s = \{w_{1,p\pi q}, w_{2,p\pi}, w_{3,q}, w_{4,\pi}\}$

c. $s[p_\pi \vee q] = \{w_{2,p\pi}, w_{3,q}\}$

Consider next the definition with the Plug-negation in (16a). The update by the disjunction stays the same as above, but this time, the exhaustification part $[-(p_\pi \wedge q)]$ turns out to be vacuous. The computation proceeds as in (16d), it checks for each $w \in s'$, where $s' = \{w_{2,p\pi}, w_{3,q}\}$, whether $w$ subsists in $\{w\}[p_\pi][q]$; if $w$ subsists in $\{w\}[p_\pi][q]$, then $w$ is eliminated from $s'$. However, since no world $w \in s'$ subsists in $\{w\}[p_\pi][q]$, no world is eliminated from $s'$. ($w_{2,p\pi}$ does not subsist because $\{w_{2,p\pi}\}[p_\pi][q] = \emptyset$; $w_{3,q}$ does not subsist because $\{w_{3,q}\}[p_\pi][q]$) is undefined.) Crucially, unlike the definition with the Hole negation, the presupposition $\pi$ is not projected. It reveals that the negation in exhaustification must be defined with the Plug-negation.

(16) a. $s[\textsc{Exh}(p_\pi \vee q)] := s[p_\pi \vee q][-(p_\pi \wedge q)]$

b. $s = \{w_{1,p\pi q}, w_{2,p\pi}, w_{3,q}, w_{4,\pi}\}$

c. $s[p_\pi \vee q] = \{w_{2,p\pi}, w_{3,q}\} = s'$

d. $s[p_\pi \vee q][-(p_\pi \wedge q)] = \{w \in s' \mid w \text{ does not subsist in } \{w\}[p_\pi][q]\} = \{w_{2,p\pi}, w_{3,q}\}$

***Conclusion.*** In this study, I show that the negation in the local context of disjunction and the negation in exhaustification must be defined as the Plug-negation. Recall that the negation typically realized in natural language sentences, like English *not*, is defined (correctly) as the Hole negation. Thus, the result of this study reveals that the negations in the two investigated circumstances must be defined differently from the negations in sentences.

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**References**

Beaver, D. (2001). *Presupposition and Assertion in Dynamic Semantics*. CLSI.

Chierchia (2004). *Scalar implicatures, polarity phenomena and the syntax/pragmatics interface* (Edited by Belletti ed.)., (pp. 39–103). Oxford University Press.

Chierchia, G. (2006). Broaden Your Views: Implicatures of Domain Widening and the "Logicality" of Language. *Linguistic Inquiry*, *37*(4), 535–590. Publisher: The MIT Press.

Chierchia, G. (2013). *Logic in Grammar: Polarity, Free Choice, and Intervention*. Oxford, UK: Oxford University Press.

Groenendijk, J. & Stokhof, M. (1991). Dynamic Predicate Logic. *Linguistics and Philosophy*, *14*(1), 39–100. Publisher: Springer.

Groenendijk, J., Stokhofand, M., & Veltman, F. (1996). Coreference and modality. In S. Lappin (Ed.), *Handbook of Contemporary Semantic Theory* (pp. 179–216). Blackwell.

Heim, I. (1982). *The Semantics and Definite and Indefinite Noun Phrases*. PhD thesis, Umass Amherst.

Kalomoiros, A. & Schwarz, F. (2021). Presupposition projection from disjunction is symmetric. In *Proceedings of LSA*, (pp. 556– 571).

Kamp, H. & Reyle, U. (1993). *From Discourse to Logic*. Dordrecht: Kluwer.

Karttunen, L. (1973). Presuppositions of compound sentences. *Linguistic Inquiry*, *4*, 169–193.

Mandelkern, M. (2016). A note on the architecture of presupposition. *Semantics and Pragmatics*, *9*.

Spector, B. (2014). Global positive polarity items and obligatory exhaustivity. *Semantics and Pragmatics*, *7*.

Sudo, Y. (2023). Scalar implicatures with discourse referents: a case study on plurality inferences. *Linguistics and Philosophy*.

van der Sandt, R. A. (1992). Presupposition projection and anaphora resolution. *Journal of Semantics*, 333–377.

Veltman, F. (1996). Defaults in update semantics. *Journal of Philosophical Logic*, *25*(3), 221–261.

## The Japanese negative polarity item *hitotsu* 'even': An event semantics approach

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### 1 Introduction

The Japanese classifier *tsu* is a classifier for counting separable inanimate entities. When combined with the numeral *hito* 'one' and the scalar particle *mo* 'even' (i.e., *hito-tsu-mo* [one-CL-even] 'even 1-CL'), it functions as a negative polarity minimizer:

(1) Sora-ni-wa kumo-ga hito-tsu-mo nai.
sky-LOC-TOP cloud-NOM one-CL-even NEG.exist
'There is not even a single cloud in the sky.'

Sawada (2006) observes that *hitotsu* can also be utilized as a scalar particle, in which *hitotsu* itself is interpreted as 'even', as shown in (2):

(2) Taro-wa aisatsu-hitotsu {shi-nai /*suru}.
Taro-TOP greeting-even do-NEG /do
'Taro does not even say hello.'

*Aisatsu* 'greeting' in (2) is not a kind of noun that can be counted by the classifier *tsu* (i.e., **aisatu-o hito-tsu* [greeting-ACC one-CL] '1 greeting'). This type of *hitotsu* is a negative polarity item (NPI) because its positive counterpart of the sentence becomes ill-formed as in (2). In this paper, I will compare *hitotsu* as a scalar particle with ordinary scalar particles, such as *sae* 'even'/*mo* 'even', and argue that the scalar particle NPI *hitotsu* 'even' imposes a semantic restriction that the noun *hitotsu* attaches to must be non-specific and interpreted as the theme of an event. It will be shown that, unlike ordinary scalar particles, the scalar particle *hitotsu* 'even' cannot be thought of as a sentential operator and that it belongs to a new type of EVEN that is sensitive to an event (thematic role).

### 2 Previous studies

Several studies have been conducted on the one-classifier minimizer in Japanese. Nakanishi (2006) observes that in Japanese, there is a type of one-classifier minimizer that does not utilize the scalar particle *mo*, as shown in (3) (see also Kataoka 2010 ):

(3) Alan-wa kooen-de [inu i-ppiki]$_F$ mi-nakat-ta.
Alan-TOP park-at dog one-CL see-NEG-PST
'Alan didn't see any dog(s) at the park.' (Nakanishi 2006)

Nakanishi (2006) assumes that in (3), there is a focus on *inu i-ppiki* [dog one-CL] 'one dog', which can trigger a set of alternatives consisting of animals (e.g., cat, rabbit) whose numbers are greater than or equal to 1 (i.e., one dog, two dogs, one cat, two cats). She then posits a hidden sentential operator EVEN, which takes scope over an entire proposition (based on the idea of scope theory).[1] Note that *piki* here is a classifier that still counts the number of NP.

From a functional perspective, Sawada (2006) discusses the difference between the classifier-based minimizers, like (3) and (4), and the scalar particle *hitotsu*, like (2) and (5), and claims that *hitotsu* in (2) and (5) has been grammaticalized from *hito-tsu* 'one-classifier' to a scalar particle:

[1]Following Nakanishi (2006), Ochi (2016) assumes that the postnominal classifier phrase (1-CL) contains a null focus head and provided a syntactic account. Ogawa (2022) also provides a syntactic account but he assumes that the post nominal classifier phrase is grammaticalized to the head of FocP based on the tendency that it cannot associate with the scalar particle *mo*.

(4) Sora-ni-wa kumo hito-tsu nai. (classifier)
sky-LOC-TOP cloud one-CL NEG.exist
'There is not even a single cloud in the sky.'

(5) Hanako-wa okyaku-san-ni ocha-hitotsu dasa-nai. (scalar particle)
Hanako-TOP visitor-HON-to tea-even provide-NEG
'Hanako does not even serve tea to her guests.' (*ocha* = theme)

In (1) and (4), *hito-tsu* is a numeral classifier because it is concerned with the number of clouds, and the sentence conveys that there are no clouds at all. By contrast, *hitotsu* in (2) and (5) is not concerned with the number of an NP; rather, it functions as 'even' and focuses on an act (see also Nabeshima (2003)). For example, (2) is conveying that Taro cannot even greet people (let alone do other more desirable acts).

Note that some classifier-based minimizers can behave like EVEN while maintaining the classifier status. For example, Sawada (2006) observes that in some cases, sentences with *i-ppai* '1-cup' can be ambiguous between an event-scale reading (= focusing on an event) (which is similar to the reading provided by the scalar particle *hitotsu*) and a numerical reading (= focusing on a number) (see also Sakamoto 2002).

(6) Taro-wa biiru i-ppai nom-e-nai.
Taro-TOP beer one-CL drink-can-NEG
Quantity reading: Taro cannot drink even one glass of beer.
Event-scale reading: Taro cannot even drink beer.
(Based on Sawada (2006: 162), slightly modified)

*I-ppai* in the event-scale reading in (6) is similar to *hitotsu* in (7). It functions as "even":

(7) Taro-wa biiru hitotsu nom-e-nai.
Taro-TOP beer even drink-can-NEG
'Taro cannot even drink beer.' (Based on Sawada (2006: 162))

Sawada (2006) analyzes *i-ppai* in the event-scale reading in (6) as a scalar particle while considering it as a classifier. Although Sawada's observation is intuitively correct, he does not provide any formal analysis. Furthermore, he does not discuss the difference between the scalar particle *hitotsu* 'even' and ordinary scalar focus particles. In this paper, we will first focus on the grammaticalized scalar particle *hitotsu* and analyze its meaning and distribution patterns based on the idea of event semantics. Afterward, we will consider the case of classifier-based minimizers that behave like scalar particles and examine their relationship with the scalar particle *hitotsu*.

## 3 Some constraints on the meaning and distribution patterns of the NPI *hitotsu* 'even'

Let us first consider the difference between the scalar particle *hitotsu* and the ordinary scalar particles such as *sae* 'even'. Syntactically, the scalar particle *hitotsu* 'even' is a particle just like any other scalar particle. This is supported by the fact that an accusative marker cannot attach to the NPI *hitotsu* (i.e., * *aisatsu hitotsu-o* 'greeting even-ACC', **aisatsu sae-o* 'greeting even-ACC'). (Note: The ordinary classifier *hito-tsu* '1-classifier' allows the accusative marker (e.g. *pen hito-tsu-o* 'pencil 1-CL-ACC')).

However, there are several clear differences between the typical scalar particle and the NPI *hitotsu* 'even'. First, unlike the regular scalar particle *sae* 'even', the scalar particle *hitotsu* cannot combine with a specific noun (e.g., proper name) as in (8), nor can it combine with a demonstrative phrase as in (9):

(8) Taro-{(de)-sae /*hitotsu} {shaken-ni ukara-nakat-ta / warawa-nakat-ta}.
Taro-even /even exam-DAT pass-NEG-PST / laugh-NEG-PST
'Even Taro didn't pass the exam/Even Taro didn't laugh.' (Taro = individual)

(9) * Hanako-wa okyaku-san-ni sono ocha-hitotsu dasa-nai. (scalar particle)
Hanako-TOP visitor-HON-to that tea-even provide-NEG
'Hanako does not even serve that tea to her guests.' (*ocha* = theme)

Second, structurally, the NPI *hitotsu* cannot appear in an adjunct (PP) position as in (10):

(10) Kono ishi-wa kureen-de-{sae / *hitotsu} mochiage-rare-nai.
this stone-TOP crane-with-even / even lift.up-can-NEG
'This stone cannot even be lifted by a crane.' (*kureen* 'crane' = instrumental)

Note that although the NPI *hitotsu* attaches to a non-specific noun, it makes a contrast with a verb phrase (VP). For example in (11), *hitotsu* is contrasting "to sing a song" with other activities, such as "to perform a play", and in (12), *hitotsu* is contrasting *ocha-o dasu* 'to serve tea" and *aisatsu suru* 'to greet':

(11) Mary-wa joyuu-nanoni uta-hitotsu uta-e-nai.
Mary-TOP actress-despite song-even sing-can-NEG
'Hanako can't even [sing a song]$_F$ despite being an actress.'

(12) Taro-wa okyaku-san-ni [ocha-o dasu]-dokoroka aisatsu-hitotsu shi-nakat-ta.
Taro-TOP visitor-HON-to tea-ACC serve-let.alone greeting-even do-NEG-PST
'Taro did not even [greet]$_F$ his guests, let alone [serve tea] to them.'

## 4 Analysis

How can we explain the above facts? In this paper, I argue that the scalar particle *hitotsu* is sensitive to event-kind and it makes a contrast among events denoted by a VP. More specifically, based on the idea of Neo-Davidsonian event semantics, I propose that the NPI *hitotsu* has the following meaning ($C$ is a contextually determined set):

(13) $[\![\text{hitotsu}_{NPI}]\!] = \lambda k \lambda P \lambda x \lambda y \lambda e : \forall R \in C[R \neq P(k) \rightarrow P(k)(x)(y)(e) >_{likely} R(x)(y)(e)].$
$P(k)(x)(y)(e)$ (where $k$ = a kind nominal $\wedge$ $k$ = a theme of the event predicate $P$)

In prose, *hitotsu* takes a kind-denoting noun $k$ (of type $e$), a predicate $P$, individuals $x$ and $y$, and an event $e$ and presupposes that for all $R$ that are in the contextually determined set $C$, if $R$ is distinct from $P(k)$, then $P(k)(x)(y)(e)$ is more likely than $R(x)(y)(e)$. Note that the first argument $k$ is a kind nominal, and it is a theme of the event predicate $P$. Note also that here I have assumed that *hitotsu* takes two individuals in order to analyze examples involving predicates that take goal arguments, such as (5). However, if the given predicate is a simple transitive verb (e.g., (11)), the number of arguments taken by *hitotsu* is reduced.[2]

[2]There are also cases wherein a sentence with the scalar particle *hitotsu* is contrasting two individuals:

(i) Taro-wa okyaku-san-ni [shokuji]-dokoroka [ocha]-hitotsu dasa-nakat-ta.
Taro-TOP visitor-HON-to food-let.alone tea-even serve-NEG-PST
'Taro did not even serve [tea], let alone [food], to his guests.'

I assume that, even in this case, the scalar particle *hitotsu* is contrasting two events, i.e., "to serve" tea and "to serve food". That is, the predicate in $R$ is the same as $P$. Another possibility is to posit a different lexical item for *hitotsu* dedicated to invidivual comparison.

The following figure shows the logical structure of (5):

(14) Logical structure of (5)

$$\neg\exists e : \forall R \in C[R \neq (\lambda y\lambda z\lambda e'.\text{provide}(e') \wedge \text{agent}(e') = z \wedge \text{theme}(e') = \text{tea} \wedge \text{goal}(e') = y) \rightarrow$$
$$(\text{provide}(e) \wedge \text{agent}(e) = \text{Hanako} \wedge \text{theme}(e) = \text{tea} \wedge \text{goal}(e) = \text{the-visitor}) >_{likely} R(\text{the-visitor})(\text{Hanako})(e)].$$
$$\text{provide}(e) \wedge \text{agent}(e) = \text{Hanako} \wedge \text{theme}(e) = \text{tea} \wedge \text{goal}(e) = \text{the-visitor}$$

$$\exists e : \forall R \in C[R \neq (\lambda y\lambda z\lambda e'.\text{provide}(e') \wedge \text{agent}(e') = z \wedge \text{theme}(e') = \text{tea} \wedge \text{goal}(e') = y) \rightarrow$$
$$(\text{provide}(e) \wedge \text{agent}(e) = \text{Hanako} \wedge \text{theme}(e) = \text{tea} \wedge \text{goal}(e) = \text{the-visitor}) >_{likely} R(\text{the-visitor})(\text{Hanako})(e)].$$
$$\text{provide}(e) \wedge \text{agent}(e) = \text{Hanako} \wedge \text{theme}(e) = \text{tea} \wedge \text{goal}(e) = \text{the-visitor}$$

NEG
$\lambda V.\neg V$

Hanako

$$\lambda y\lambda e : \forall R \in C[R \neq (\lambda y\lambda z\lambda e'.\text{provide}(e') \wedge \text{agent}(e') = z \wedge \text{theme}(e') = \text{tea} \wedge \text{goal}(e') = y) \rightarrow$$
$$(\text{provide}(e) \wedge \text{agent}(e) = y \wedge \text{theme}(e) = \text{tea} \wedge \text{goal}(e) = \text{the-visitor})$$
$$>_{likely} R(\text{the-visitor})(y)(e)].$$
$$\text{provide}(e) \wedge \text{agent}(e) = y \wedge \text{theme}(e) = \text{tea} \wedge \text{goal}(e) = \text{the-visitor}$$

okyaku-san-ni
'visitor'

$$\lambda x\lambda y\lambda e : \forall R \in C[R \neq (\lambda y\lambda z\lambda e'.\text{provide}(e') \wedge \text{agent}(e') = z$$
$$\wedge\ \text{theme}(e') = \text{tea} \wedge \text{goal}(e') = y) \rightarrow$$
$$(\text{provide}(e) \wedge \text{agent}(e) = y \wedge \text{theme}(e) = \text{tea} \wedge \text{goal}(e) = x) >_{likely} R(x)(y)(e)].$$
$$\text{provide}(e) \wedge \text{agent}(e) = y \wedge \text{theme}(e) = \text{tea} \wedge \text{goal}(e) = x$$

$$\lambda P\lambda x\lambda y\lambda e : \forall R \in C[R \neq P(\text{tea}) \rightarrow$$
$$P(\text{tea})(x)(y)(e) >_{likely} R(x)(y)(e)].$$
$$P(\text{tea})(x)(y)(e)$$

dasu 'serve'
$$\lambda x\lambda y\lambda z\lambda e'.\text{provide}(e') \wedge \text{agent}(e') = z$$
$$\wedge\ \text{theme}(e') = x \wedge \text{goal}(e') = y$$

ocha
'tea'

hitotsu
$$\lambda k\lambda P\lambda x\lambda y\lambda e : \forall R \in C[R \neq P(k) \rightarrow$$
$$P(k)(x)(y)(e) >_{likely} R(x)(y)(e)].$$
$$P(k)(x)(y)(e)$$

**Pseudo-incorporation**: The phenomenon of the NPI *hitotsu* can be considered as a kind of pseudo-incorporation. Carlson (2003) argues that some indefinite internal objects undergo verb incorporation in order to form an event-kind (what Carlson calls an event-type). Although there is no movement operation in the sentence with the NPI *hitotsu*, we can consider that the NPI *hitotsu* semantically connects the noun that it attaches to and the predicate and forms an event-kind.

The idea of pseudo-incorporation naturally captures the NPI *hitotsu*'s constraint that the noun that *hitotsu* combines with must be a kind nominal and must be non-specific ((8)-(9)). In the literature of pseudo-incorporation, it is observed that the incorporated nominals lack determiners and are discourse opaque. In accordance with the mapping hypothesis of Diesing (1992), Carlson (2003) argues that VP is the domain of a context-free interpretive mechanism specifying an event-type, and noun phrases that depend on time, worlds, truth, and context to get evaluated (i.e., proper names, definite descriptions, indexicals) are not able to combine with verbs at the VP level. Assuming that NPI *hitotsu* creates pseudo-incorporation, it then makes sense to have constraints on NPs.

The pseudo-incorporation approach also provides a natural explanation why the NPI *hitotsu* has the constraint that its first argument must function as a theme. Generally, only internal arguments undergo incorporation, so the thematic role of arguments tends to be a theme (see Gehrke (2019) for a recent overview of event-kinds). (The historical factor that *tsu* in *hitotsu* was a classifier for counting objects seems also to be relevant.)

**Ambiguity in the classifier-based minimizer**: Then, how can we analyze the meaning of a classifier-based minimizer that can trigger both a quantity reading and an event-scale reading (=6)?

(15) Taro-wa biiru i-ppai nom-e-nai.
Taro-TOP beer one-CL drink-can-NEG
Quantity reading: 'Taro cannot drink even [one]$_F$ glass of beer.')
Event-scale reading: 'Taro cannot even [drink beer]$_F$.'
(Based on Sawada (2006: 162), slightly modified)

I would like to consider that in the event-scale reading, *i-ppai* behaves just like the scalar particle *hitotsu* 'even' expect that it additionally restricts the first argument, namely, *k* is a liquid that can be counted by *ppai* 'cup':

(16) $[\![\text{i-ppai}_{even.NPI}]\!] = \lambda k \lambda P \lambda x \lambda y \lambda e : \forall R \in C[R \neq P(k) \rightarrow P(k)(x)(y)(e) >_{likely} R(x)(y)(e)].$ $P(k)(x)(y)(e)$ (where $k$ = a kind nominal $\wedge$ $k$ = liquid that can be counted by cups $\wedge$ $k$ = a theme of the event predicate $P$)

By contrast, in the case of the quantity reading, *i-ppai* is a regular classifier phrase. It seems possible to consider that the meaning of EVEN is triggered by a null scalar particle. [3]

## 5 Conclusion and discussion

In the studies of the semantics of EVEN, various approaches have been proposed, but they tend to assume that EVENs are sentential operators. For example, in the scope-based unitary approach (e.g., Karttunen & Peters 1979; Wilkinson 1996; Nakanishi 2006), EVEN has a wide scope with respect to negation and construes a negative proposition as the least likely among the alternatives, as shown in (13a). By contrast, the so-called lexical ambiguity theory (e.g., Rooth 1985; Rullmann 1997; Giannakidou 2007) assumes that in addition to the positive EVEN, there is an NPI EVEN situated below negation. Usually, it is assumed that the NPI EVEN takes the proposition without negation and construes it as the most likely among the alternatives, as in (17b):

(17) (LF structure of "John did not invite even [Bill]$_F$.")
  a. EVEN [NOT [John invited [Bill]$_F$ ] ]
  b. NOT [EVEN$_{NPI}$ [John invited [Bill]$_F$ ] ]

Although they differ in their assumptions about logical structure, in both approaches, EVEN is considered as an operator that takes a proposition as its argument.

However, the phenomenon of the scalar particle *hitotsu* strongly suggests that there is also a non-sentential EVEN in natural language that is sensitive to thematic roles/events. This paper provides a new perspective on the variations in meaning and distribution patterns of EVEN.

[3]The quantity reading of (15) can be paraphrased by (i), where the object *biiru* combines with the accusative marker and *mo* is attached to *i-ppai*, forming an adverb phrase:

(i) Taro-wa biiru-o i-ppai-mo nom-e-nai.
Taro-TOP beer-ACC one-CL-even drink-can-NEG
'Taro cannot drink even one glass of beer.'

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## References

Carlson, Greg. 2003. Weak indefinites. In Martine Coene & Yves D'Hulst (eds.), From NP to DP volume 1: The syntax and semantics of noun phrases, 195–210. Amsterdam/New York: John Benjamins.

Diesing, Molly. 1992. Indefinites. Cambridge, Mass: MIT Press.

Gehrke, Berit. 2019. Event kinds. In Rob Truswell (ed.), The oxford handbook on event structure, 205–233. Oxford: Oxford University Press.

Giannakidou, Anastasia. 2007. The landscape of even. Natural Language & Linguistic Theory 25(1). 39–81. https://doi.org/10.1007/s11049-006-9006-5.

Karttunen, Lauri & Stanley Peters. 1979. Conventional implicature. In C. K. Oh & D. A. Dinneen (eds.), Syntax and semantics. vol. 11. presupposition, 1–56. New York: Academic Press.

Kataoka, Kiyoko. 2010. Hiteikyokusei to tougoteki jouken [Negative polarity and syntactic condition]. In Ikumi Imani Yoshihiko Kato, Akiko Yoshimura (ed.), Hitei to gengo riron [Negation and linguistic theory], 118–140. Tokyo: Kaitakusha.

Nabeshima, Kojiro. 2003. "... hitotsu ... nai" koobun ni tsuite: Nihongo ni okeru koubun bunpou kenkyuu no ichirei to shite [On the "... *hitotsu* ... *nai*" construction: A case study of Construction Grammar approach to Japanese]. In Conference handbook of the Society of Japanese Grammar, 83–92.

Nakanishi, Kimiko. 2006. Focus, numerals, and negative polarity items in Japanese. Unpublished ms., Ochanomizu University.

Ochi, Masao. 2016. Numeral classifiers, negative polarity, and movement to the nominal periphery. Nanzan Linguistics 11. 35–56.

Ogawa, Yoshiki. 2022. Grammaticalization from minimizer to focus marker as upward reanalysis along the nominal spine. Studia Linguistica 77(2). 258–306.

Rooth, Mats. 1985. *Association with focus*. Amherst, MA: University of Massachusetts at Amherst dissertation.

Rullmann, Hotze. 1997. Even, polarity, and scope. Papers in experimental and theoretical linguistics 4. 40–64.

Sakamoto, Chika. 2002. Suuryooshi "hitotsu" no imi to yoohoo: N hitotsu v nai koubun o chooshin ni [The meaning and use of the quantifier *hitotsu*: With special reference to "n *hitotsu* v *nai*" construction]. In Conference handbook of the 124th meeting of the Linguistic Society of Japan, 30–41.

Sawada, Osamu. 2006. From classifier construction to scalar construction: The case of the Japanese N *hitotu* V nai and N 1-classifier V *nai* constructions. In Naomi McGloin & Junko Mori (eds.), Japanese/Korean Linguistics 15, 161–172.

Wilkinson, Karina. 1996. The scope of *even*. Natural Language Semantics 4(3). 193–215. https://doi.org/10.1007/BF00372819.

# Argumentative meaning

## Semantics with a purpose

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In this talk, I will elaborate on *argumentative meaning*, defined as the part of natural language meaning which is related to how speakers use language as a means for persuading their audience to adopt certain beliefs. After delineating the contours of a theory of argumentation within language and offering a justification for such a theory, I will focus on two aspects: the notion of argumentative goal, and the hypothesis that lexical meaning can be characterized in terms of the goals an expression can be used for.

The idea that natural language is used for persuasion has a long and rich history in most philosophical traditions, dating at least as far back as ancient Egypt (Hutto 2002). Typical argumentation studies have thus focused on questions about the validity of arguments, typically trying to separate fallacies from acceptable arguments (Hamblin 1970), on coming up with a taxonomy of argumentation schemes, or on evaluating the role of the speaker and their audience in the evaluation of the argument. More recently, some authors have defended the central role of argumentation in human cognition (Sperber et al. 2010; Mercier and Sperber 2011). The idea that argumentation is an essential part of conversation also dovetails with considerations about *grounding*: the (non-trivial) process by which information becomes explicitly shared between the participants in a conversation (Clark 1996; Ginzburg 2012).

Among these works, the theory of *argumentation within language* (AwL) posits that parts of the linguistic code are dedicated to its argumentative function (Anscombre and Ducrot 1983; Winterstein 2023). Its central observation is that expressions that convey the same descriptive content can nevertheless be used in different contexts, and for different, sometimes opposed, purposes. Typical examples of such expressions are proximal adverbs like *almost* and *barely* (Amaral 2007; Jayez and Tovena 2008), as illustrated in (1).

(1) Get me another drink.
  a. I'm (*almost*) done with mine.
  b. #I'm *barely* done with mine.

Even though *almost* commits its speaker to the negation of its prejacent, it can be used for the same conclusion as its prejacent in (1), cf. (1-a). In contrast, though *barely* does commit its speaker to the truth of its prejacent, it allows the speaker for opposite conclusions (1-b).

Within AwL, the interpretation of any utterance is thus done in the light of the *argumentative goal* targeted by the speaker. This goal can be explicit, though it often remains implicit, and part of the interpretation process involves recovering what is the most likely goal of the speaker. In several respects, that notion of argumentative goal can be likened to that of *Question Under Discussion* (QUD), as used in some approaches to discourse semantics (Roberts 1996). I will discuss these similarities, and highlight what sets the two notions apart. Essentially, QUD are related to a descriptive perspective on language, i.e. that language is used to determine the state of the world. Argumentative goals are however not neutral: they reflect a particular answer to a QUD, and one which might not be fully supported by descriptive facts. The case of proximal adverbs will again be used to illustrate these differences, in particular the question of the *projection* of the prejacent. We will revisit propositions such as those of Simons et al. (2010) about what defines projective and *at-issue* content. Specifically, we will propose that instead of considering the relationship of conveyed content to the QUD, a characterization in terms of the relationship to the goal of the speaker is more adequate.

To conclude, I will discuss proposals about the lexical roots of argumentative goals. One hypothesis within various versions of AwL is that lexical meaning is defined as the set of argumentative goals an expression can be used for, understood either as the *argumentative topoi* that an item can enter in (Anscombre 1995), or as a direct relationship between linguistic expressions (Carel 2011; Ducrot 2016). I will focus on how these proposals dovetail with other aspects of lexical meaning, and on computational perspectives about how to observe such argumentative meaning in practice.

## References


Amaral, Patricia. 2007. "The meaning of approximative adverbs: Evidence from European Portuguese." PhD diss., The Ohio State University.

Anscombre, Jean-Claude. 1995. "Topique or not topique: formes topiques intrinsèques et formes topiques extrinsèques." *Journal of Pragmatics* 24:115–141.

Anscombre, Jean-Claude, and Oswald Ducrot. 1983. *L'argumentation dans la langue.* Liège, Bruxelles: Pierre Mardaga.

Carel, Marion. 2011. *L'Entrelacement argumentatif. Lexique, discours et blocs sémantiques.* Paris: H. Champion.

Clark, Herbert H. 1996. *Using language.* Cambridge: Cambridge University Press.

Ducrot, Oswald. 2016. "La théorie des blocs sémantiques." *Verbum* XXXVII (1–2): 53–65.

Ginzburg, Jonathan. 2012. *The interactive stance. Meaning for conversation.* Oxford: Oxford University Press.

Hamblin, Charles Leonard. 1970. *Fallacies.* London: Methuen.

Hutto, David. 2002. “Ancient Egyptian Rhetoric in the Old and Middle Kingdoms.” *Rhetorica* 20 (3): 213–233. https://doi.org/10.1525/rh.2002.20.3.213.

Jayez, Jacques, and Lucia Tovena. 2008. “Presque and almost: how argumentation derives from comparative meaning.” In *Empirical Issues in Syntax and Semantics,* edited by Olivier Bonami and Patricia Cabredo Hofherr, 7:1–23. CNRS.

Mercier, Hugo, and Dan Sperber. 2011. “Why do humans reason? Arguments for an argumentative theory.” *Behavioural and Brain Sciences* 34:57–111.

Roberts, Craige. 1996. “Information Structure in Discourse: Towards an Integrated Formal Theory of Pragmatics.” In *OSU Working Papers in Linguistics,* vol. 49: Papers in Semantics, 91–136. Jae Haek Yoon / Andreas Kathol.

Simons, Mandy, Judith Tonhauser, David Beaver, and Craige Roberts. 2010. “What projects and why.” In *Proceedings of Semantics and Linguistic Theory (SALT) 20,* 309–327. CLC Publications.

Sperber, Dan, Fabrice Clément, Christophe Heintz, Olivier Mascaro, Hugo Mercier, Gloria Origgi, and Deirdre Wilson. 2010. “Epistemic Vigilance.” *Mind & Language* 25 (4): 359–393.

Winterstein, Grégoire. 2023. *Argumentative semantics – Meaning with a purpose.* Under contract. Oxford University Press.

# Additively-Semiordered-Qualitative-Conditional-Probability-Theoretic Foundations of Logic of Probabilistic Indiscriminability (Extended Abstract)

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## 1. Motivation

*Vagueness* is a ubiquitous feature that we can recognize from many expressions in *natural languages*. It can invite a serious problem in the field of *(formal) philosophy of language*: the *Sorites Paradox*. We would like to specify the sort of Sorites Paradox that we tackle in this talk. Graff (2001, p.907) characterizes such an observational predicate as "looks-red", "sounds-loud" and "tastes-sweet" as follows: A predicate is *observational* iff its applicability to an object, given a fixed context of evaluation, depends only on the way that object appears. Observational predicates can generate a special kind of Sorites Paradox in the following sense: In a sorites series for a *nonobservational* predicate like "tall" (not "looks-tall"), to justify its use, there must be some *difference in height* between any adjacent two members in the series. On the other hand, it is plausible to think that we can arrange a sorites series for *observational* predicates that does not have this feature because the relevant perceptual indiscriminability relation can be *nontransitive*. In a sorites series for an observational predicate like "looks-red", if the relevant perceptual indiscriminability relation is nontransitive, then there can a series of color patches grading from red to yellow in which there is *no difference in appearance* between any adjacent two patches in the series. This version of Sorites Paradox generated by observational predicates is called the *Phenomenal Sorites Paradox*. On the basis of Raffman (2000, p.159) and Hardin (1988), we can classify perceptual indiscriminability into at least three categories: 1. *o-Indiscriminability*: Two objects are *occurrently indiscriminable (o-indiscriminable)* for an examinee at at a time $t$ iff an examiner makes a single-case judgment that these objects look the same to the examinee at $t$. 2. *d-Indiscriminability*: Two objects are *dispositionally indiscriminable (d-indiscriminable)* for an examinee in a given context iff an examiner makes a judgment that the objects would look the same to the examinee if she were to compare them in the context. 3. *p-Indiscriminability*: Two objects are *probabilistically indiscriminable (p-indiscriminable)* for an examinee iff an examiner makes a probabilistic (statistic) judgment based on *relative frequency* through enough trials that the objects look the same to the examinee. Numerous studies (e.g., Raffman (2000), Graff (2001), Keefe (2011)) have been made on the Phenomenal Sorites Paradox on $d$-Indiscriminability. But only few attempts with a notable exception of Hardin (1988) have so far been made at the Phenomenal Sorites Paradox on $p$-Indiscriminability despite its importance. In this talk, we would like to focus on $p$-Indiscriminability. In order to distinguish Hardin's from our viewpoint about $p$-Indiscriminability, we introduce the conceptions of global and bounded rationality: The standard model of economics is based on *global rationality* that requires an *optimising behavior*. But according to Simon (1982), cognitive and information-processing constrains on the capabilities of agents, together with the complexity of their environment, render an *optimising behavior* an *unattainable ideal*. Simon dismisses the idea that agents should exhibit global rationality and suggests that they in fact exhibit *bounded rationality* that allows a *satisficing behavior*. If an examinee has only a *limited* ability of discrimination, she may be considered to be only *boundedly rational*. If an examinee is *boundedly rational*, one possible explanation for the Phenomenal Sorites Paradox on $p$-Indiscriminability is that the *nontransitivity* of $p$-Indiscriminability results from the fact that she *cannot generally* discriminate very close quantities. The psychophysicist Fechner (1860) explains this inability by the concept of a *threshold of discrimination*, that is, *just noticeable difference* (*JND*). Given a measure function $f$ that an examiner could assign to a boundedly-rational examinee for an object $a$, its JND $\delta$ is the *lowest intensity increment* such that $f(a) + \delta$ is recognized to be higher than $f(a)$ by the examinee. We can consider the notion of noticing a JND from a *probabilistic* point of view. The Phenomenal Sorites Paradox on $p$-Indiscriminability is as follows:

**Example 1 (Phenomenal Sorites Paradox on $p$-Indiscriminability)** • *Patch 1 looks red to an examinee.* • Tolerance Principle*: For any $i, j$ with $1 \le i, j \le 100$, if an examiner makes a probabilistic judgment that Patch $i$ looks the same as Patch $j$ to the examinee, then if Patch $i$ looks red to the latter, then Patch $j$ looks red to her.* • *Patch 1 is indiscriminable from Patch 2 for her.* • *Patch 2 is indiscriminable from Patch 3 for her.* ⋯ • *Patch 99 is indiscriminable from Patch 100 for her.* • *Therefore, Patch 100 looks red to her.*

The *aim* of this talk is to propose a new version of logic —$\dot{\text{L}}$ogic of $\dot{p}$-$\dot{\text{I}}$ndiscriminability (LPI)—that makes it possible to reason in terms of $p$-Indiscriminability without the Phenomenal Sorites Paradox. Indeed Hardin (1988) discusses the Phenomenal Sorites Paradox on $p$-Indiscriminability in terms of JNDs, but he argues that $p$-Indiscriminability can theoretically have enough precision of to be *transitive*. So his viewpoint can be considered to be *globally rational*. On the other hand, in this talk, from a *boundedly-rational and logical* point of view, we argue that $p$-Indiscriminability is nontransitive. Suzuki (2016) proposes a version of logic (OPL) that makes it possible to reason in terms of $p$-Indiscriminability without the Phenomenal Sorites Paradox. OPL is a *first-order* logic the model of which is based on a forced-choice-pair-comparison qualitative probability relation. On the other hand, in this talk, we would like to demonstrate that a *propositional* logic can make it possible to fully express reasoning in terms of $p$-Indiscriminability without the Phenomenal Sorites Paradox. In fact, LPI is a propositional logic the model of which is based on an additively-semiordered qualitative conditional probability relation. In both OPL and LPI, a *representation theorem* in *measurement theory* (cf. Krantz et al. (1971)) plays such an essential role that, in OPL, $p$-Indiscriminability relation symbol is given its semantics by a forced-choice-pair-comparison qualitative probability relation in a model and this relation is represented by a function with a threshold by means of a representation theorem whereas, in LPI, $p$-Indiscriminability relation symbol is given its semantics by an additively-semiordered qualitative conditional probability relation in a model and this relation is represented by a conditional probability measure with a threshold by means of a representation theorem. OPL is *not complete* because the *first-order undefinability* of an essential property (i.e., $\sim^*$-Connectedness) of the model of OPL is proved, whereas LPI is *complete*.

## 2. Representation Theorem

On the basis of Domotor (1969, 1994), we can prove the following theorem in which $\delta$ is interpreted to mean a *normalized JND*:

**Theorem 1 (Representation)** *Suppose that $W$ is a nonempty* finite *set of possible worlds, and that $\mathscr{F}$ is the Boolean algebra of subsets of $W$, and that $\succ_w$ is a quaternary relation relative to $w \in W$ on $\mathscr{F}$, and that $(A,B) \sim_w (C,D)$ is defined as $(A,B) \nsucc_w (C,D)$ and $(C,D) \nsucc_w (A,B)$, and that $\mathscr{F}_0 := \{A : A \in \mathscr{F}$ and $(A,W) \nsucc_w (\varnothing, W)\}$. Then there exists a finitely additive conditional probability measure $P_w : \mathscr{F} \times \mathscr{F}_0 \to \mathbb{R}$ relative to $w \in W$ and $\delta \in \mathbb{R}$ satisfying, for any $A, C \in \mathscr{F}$ and any $B, D \in \mathscr{F}_0$, $(A,B) \succ_w (C,D)$ iff $P_w(A,B) \ge P_w(C,D) + \delta$, where $0 < \delta \le 1$ and $P_w(A,B)$ is a probability relative to $w$ of $A$ on the condition of $B$ iff the following conditions are met:* • Nontriviality*: $(W,W) \succ_w (\varnothing, W)$.* • Irreflexivity*: Not $((A,B) \succ_w (A,B))$, for any $A \in \mathscr{F}$ and any $B \in \mathscr{F}_0$.* • Cancellation*: $(A,B) \sim_w (A \cap B, B)$ for any $A \in \mathscr{F}$ and any $B \in \mathscr{F}_0$.* • Dominance*: For any $A, B, C \in \mathscr{F}$ and any $D, E \in \mathscr{F}_0$, if $A \subseteq B$, then if $(C,D) \succ_w (B,E)$, then $(C,D) \succ_w (A,E)$.* • Addition*: For any $A_1, \ldots, A_n, C_1, \ldots, C_n, E_1, \ldots, E_n, G_1, \ldots, G_n \in \mathscr{F}$ and any $B_1, \ldots, B_n, D_1, \ldots, D_n, F_1, \ldots, F_n, H_1, \ldots, H_n \in \mathscr{F}_0$, if, for any $i < n$, $((A_i, B_i) \succ_w (C_i, D_i)$ and $(E_i, F_i) \nsucc_w (G_i, H_i))$, then if $(A_n, B_n) \succ_w (C_n, D_n)$, then $(E_n, F_n) \succ_w (G_n, H_n)$, given that*

$$\bigcup_{1 \le i_1 < \cdots < i_k \le n} (((A_{i_1} \cap B_{i_1}) \cup (G_{i_1} \cap H_{i_1})) \cap \cdots \cap ((A_{i_k} \cap B_{i_k}) \cup (G_{i_k} \cap H_{i_k})))$$
$$= \bigcup_{1 \le i_1 < \cdots < i_k \le n} (((C_{i_1} \cap D_{i_1}) \cup (E_{i_1} \cap F_{i_1})) \cap \cdots \cap ((C_{i_k} \cap D_{i_k}) \cup (E_{i_k} \cap F_{i_k})))$$

*holds for any $k$ with $1 \le k \le n$.* • Multiplication*: For any $A_1, \ldots, A_n, B_1, \ldots, B_n \in \mathscr{F}_0$, if, for any $k$ with $1 \le k \le n-1$, $(B_{k+1}, \bigcap_{0 \le i \le k} B_i) \nsucc_w (\bigcap_{0 \le i \le k} B_i, B_0)$, then if, for any $k$ with $0 < k \le n$, $(A_k, \bigcap_{0 \le i < k} A_i) \succ_w (B_k, \bigcap_{0 \le i < k} B_i)$, then $(\bigcap_{0 \le i \le n} A_i, A_0) \succ_w (\bigcap_{0 \le i \le n} B_i, B_0)$.*

**Remark 1 (Addition and Multiplication)** Addition *and* Multiplication *are the qualitative versions of the addition and multiplication laws of conditional probability, respectively.*

## 3. Logic of Probabilistic Indiscriminability ($LPI$)

We define the language $\mathscr{L}_{\mathsf{LPI}}$ of $\mathsf{LPI}$ as follows:

**Definition 1 (Language)** • *Let* $\mathscr{S}$ *denote a set of sentential variables and a* qualitative conditional probability relation symbol $>$ *a quaternary sentential operator. The language* $\mathscr{L}_{\mathsf{LPI}}$ *of* $\mathsf{LPI}$ *is given by the following BNF grammar:*
$\varphi ::= s \mid \top \mid \neg\varphi \mid \varphi \wedge \psi \mid (\varphi, \psi) > (\chi, \tau)$
*such that* $s \in \mathscr{S}$. • $\bot, \vee, \to$ *and* $\leftrightarrow$ *are introduced by the standard definitions.* • $\varphi \approx \psi$ *(*$\varphi$ is $p$-indiscriminable from $\psi$*)* $:= \neg((\varphi, \varphi \vee \psi) > (\psi, \varphi \vee \psi)) \wedge \neg((\psi, \varphi \vee \psi) > (\varphi, \varphi \vee \psi))$. • *The set of all well-formed formulae of* $\mathscr{L}_{\mathsf{LPI}}$ *is denoted by* $\Phi_{\mathscr{L}_{\mathsf{LPI}}}$.

**Remark 2 (Not Absolute But Conditional)** *The reason why we introduce a qualitative not absolute but conditional probability relation symbol is to make it possible to express s-indiscriminability between* $\varphi$ *and* $\psi$ *on the condition that* $\varphi \vee \psi$.

We define a structured model $\mathfrak{M}$ of $\mathsf{LPI}$ as follows:

**Definition 2 (Model)** $\mathfrak{M}$ *is a triple* $(W, \rho, V)$ *in which* • $W$ *is a nonempty* finite *set of possible worlds.* • $\rho$ *is an* additively-semiordered qualitative conditional probability space assignment *that assigns to each* $w \in W$ *an additively-semiordered qualitative conditional probability space* $(W, \mathscr{F}, \succ_w)$ *in which* $\succ_w$ *is an additively-semiordred qualitative conditional probability relation relative to* $w \in W$ *on* $\mathscr{F}$ *that satisfies all of* Nontriviality*,* Irreflexivity*,* Cancellation*,* Dominance*,* Addition*, and* Multiplication *of Theorem 1.* • $V$ *is a truth assignment to each* $s \in \mathscr{S}$ *for each* $w \in W$.

We provide $\mathsf{LPI}$ with the following truth definition at $w \in W$ in $\mathfrak{M}$, define the truth in $\mathfrak{M}$, and then define validity as follows:

**Definition 3 (Truth and Validity)** • *The notion of* $\varphi \in \Phi_{\mathscr{L}_{\mathsf{LPI}}}$ *being true at* $w \in W$ *in* $\mathfrak{M}$*, in symbols* $(\mathfrak{M}, w) \vDash_{\mathsf{LPI}} \varphi$*, is inductively defined as follows:* $(\mathfrak{M}, w) \vDash_{\mathsf{LPI}} s$ *iff* $V(w)(s) = \text{true}$. $(\mathfrak{M}, w) \vDash_{\mathsf{LPI}} \top$. $(\mathfrak{M}, w) \vDash_{\mathsf{LPI}} \neg\varphi$ *iff* $(\mathfrak{M}, w) \nvDash_{\mathsf{LPI}} \varphi$. $(\mathfrak{M}, w) \vDash_{\mathsf{LPI}} \varphi \wedge \psi$ *iff* $(\mathfrak{M}, w) \vDash_{\mathsf{LPI}} \varphi$ *and* $(\mathfrak{M}, w) \vDash_{\mathsf{LPI}} \psi$. $(\mathfrak{M}, w) \vDash_{\mathsf{LPI}} (\varphi, \psi) > (\chi, \tau)$ *iff* $([\![\varphi]\!]^{\mathfrak{M}}, [\![\psi]\!]^{\mathfrak{M}}) \succ_w ([\![\chi]\!]^{\mathfrak{M}}, [\![\tau]\!]^{\mathfrak{M}})$*, where* $[\![\varphi]\!]^{\mathfrak{M}} := \{w' \in W : (\mathfrak{M}, w') \vDash_{\mathsf{LPI}} \varphi\}$ *and* $[\![\varphi]\!]^{\mathfrak{M}}, [\![\chi]\!]^{\mathfrak{M}} \in \mathscr{F}$ *and* $[\![\psi]\!]^{\mathfrak{M}}, [\![\tau]\!]^{\mathfrak{M}} \in \mathscr{F}_0$. • *If* $(\mathfrak{M}, w) \vDash_{\mathsf{LPI}} \varphi$ *for any* $w \in W$*, we write* $\mathfrak{M} \vDash_{\mathsf{LPI}} \varphi$ *and say that* $\varphi$ *is true in* $\mathfrak{M}$. • *If* $\varphi$ *is true in any model* $\mathfrak{M}$*, we write* $\vDash_{\mathsf{LPI}} \varphi$ *and say that* $\varphi$ *is valid.*

The next corollary follows from Definitions 1 and 3.

**Corollary 1 (Truth Condition of $\varphi \approx \psi$)** $(\mathfrak{M}, w) \vDash_{\mathsf{LPI}} \varphi \approx \psi$ *iff* $([\![\varphi]\!]^{\mathfrak{M}}, [\![\varphi]\!]^{\mathfrak{M}} \cup [\![\psi]\!]^{\mathfrak{M}}) \sim_w ([\![\psi]\!]^{\mathfrak{M}}, [\![\varphi]\!]^{\mathfrak{M}} \cup [\![\psi]\!]^{\mathfrak{M}})$.

Then the next corollary follows from Theorem 1 and Corollary 1.

**Corollary 2 (Truth Conditions by Probability Measure)** *There exists* $P_w : \mathscr{F} \times \mathscr{F}_0 \to \mathbb{R}$ *and* $\delta \in \mathbb{R}$ *with* $0 < \delta \leq 1$ *satisfying* • $(\mathfrak{M}, w) \vDash_{\mathsf{LPI}} (\varphi, \psi) > (\chi, \tau)$ *iff* $P_w([\![\varphi]\!]^{\mathfrak{M}}, [\![\psi]\!]^{\mathfrak{M}}) \geq P_w([\![\chi]\!]^{\mathfrak{M}}, [\![\tau]\!]^{\mathfrak{M}}) + \delta$. • $(\mathfrak{M}, w) \vDash_{\mathsf{LPI}} \varphi \approx \psi$ *iff* $P_w([\![\psi]\!]^{\mathfrak{M}}, [\![\varphi]\!]^{\mathfrak{M}} \cup [\![\psi]\!]^{\mathfrak{M}}) - \delta < P_w([\![\varphi]\!]^{\mathfrak{M}}, [\![\varphi]\!]^{\mathfrak{M}} \cup [\![\psi]\!]^{\mathfrak{M}}) < P_w([\![\psi]\!]^{\mathfrak{M}}, [\![\varphi]\!]^{\mathfrak{M}} \cup [\![\psi]\!]^{\mathfrak{M}}) + \delta$.

**Remark 3 (From Symbol to Relation and From Relation to Measure)** *p-Indiscriminability relation symbol is given its semantics by an additively-semiordered qualitative conditional probability relation in* $\mathfrak{U}$ *and this relation is represented by a conditional probability measure with a threshold by means of Corollary 2.*

We now return to Example 1. Hyde (2018) classifies responses to the Sorites Paradox in the following four types: 1. denying that logic applies to soritical expressions, 2. denying some premises, 3. denying the validity of the argument, and 4. accepting the paradox as sound. Assume that such a model of LPI for Example 1 as $\mathfrak{U} := (W, \rho, V)$ (based on Definition 2) is given, where: • $W := \{w_i\}_{1 \le i \le 100}$, • $w_i$ denotes the world where the $i$-th Patch, for any $i$ with $1 \le i \le 100$, grading from red to yellow is shown to an examinee, • $s_i$ is the sentence that Patch $i$ is shown to her, • $t_i$ is the sentence that Patch $i$ looks red to her, • $V(w_i)(s_i) = 1$ for any $i$ with $1 \le i \le 100$, • $V(w_i)(t_i) = \begin{cases} 1 & \text{if } 1 \le i \le 50 \\ 0 & \text{if } 51 \le i \le 100, \end{cases}$ • $\rho$ is an additively-semiordered qualitative conditional probability space assignment that assigns to each $w \in W$ an additively-semiordered qualitative conditional probability space $(W, \mathscr{F}, \succ_w)$ where $\succ_w$ is an additively-semiordred qualitative conditional probability relation relative to $w \in W$ on $\mathscr{F}$ that represents the relative frequency through enough trials for an examiner to make a judgment about the examinee, • $([\![s_i]\!]^{\mathfrak{U}}, [\![s_i]\!]^{\mathfrak{U}} \cup [\![s_{i+1}]\!]^{\mathfrak{U}}) \sim_{w_i} ([\![s_i]\!]^{\mathfrak{U}}, [\![s_{i+1}]\!]^{\mathfrak{U}} \cup [\![s_{i+1}]\!]^{\mathfrak{U}})$ ($s_i$ is $p$-indistinguishable from $s_{i+1}$), for any $i$ with $1 \le i \le 99$, • There exists $P_w : \mathscr{F} \times \mathscr{F}_0 \to \mathbb{R}$ with $\delta \in \mathbb{R}$ with $0 < \delta \le 1$ satisfying $(\mathfrak{U}, w) \vDash_{\mathsf{LPI}} s_i \approx s_{i+1}$ iff $P_{w_i}([\![s_{1+i}]\!]^{\mathfrak{M}}, [\![s_i]\!]^{\mathfrak{M}} \cup [\![s_{i+1}]\!]^{\mathfrak{U}}) - \delta < P_{w_i}([\![s_i]\!]^{\mathfrak{U}}, [\![s_i]\!]^{\mathfrak{U}} \cup [\![s_{i+1}]\!]^{\mathfrak{U}}) < P_{w_i}([\![s_{i+1}]\!]^{\mathfrak{U}}, [\![s_i]\!]^{\mathfrak{M}} \cup [\![s_{i+1}]\!]^{\mathfrak{U}}) + \delta$. When $\mathfrak{U}$ is given, we have the following proposition:

**Proposition 1 (Falsity of Tolerance Principle on $p$-Indiscriminability)** $\mathfrak{U} \nvDash_{\mathsf{LPI}} \bigwedge_{1 \le i,j \le 100} ((s_i \approx s_j) \to ((s_i \to t_i) \to (s_j \to t_j)))$.

**Proof** *When we set $i, j$ to 50 and 51 respectively in $\mathfrak{U}$, both $s_i \approx s_j$ and $s_i \to t_i$ are true, but $s_j \to t_j$ is false.*□

**Remark 4 (Bounded Rationality and Avoidance of Paradox)** *The reason why $s_j \to t_j$ can be false when both $s_i \approx s_j$ and $s_i \to t_i$ are true is as follows: Because the truth condition of $s_i \approx s_j$ is given by an additively-semiordered qualitative conditional probability relation that represents a conditional probability with a JND $\delta$ which can express the limited ability of a boundedly-rational examinee, not all implications (e.g., $t_i$) of $s_i$ agree with those (e.g., $t_j$) of $s_j$. In this way, Proposition 1 reveals that* LPI *can* avoid *the Phenomenal Sorites Paradox on p-Indiscriminability by embodying a* response 2 *above.*

$p$-Indiscriminability have the following general property:

**Proposition 2 (Nontransitivity of $p$-Indiscriminability)** $\nvDash_{\mathsf{LPI}} ((\varphi \approx \psi) \land (\psi \approx \chi)) \to (\varphi \approx \chi)$.

The proof system of LPI consists of the following:

**Definition 4 (Proof System)** • *All tautologies of classical propositional logic,* • *Proof-Theoretic Counterpart of* Nontriviality*:* $(\top, \top) > (\bot, \top)$, • *Proof-Theoretic Counterpart of* Irreflexivity*:* $(\psi \not\leftrightarrow \bot) \to \neg((\varphi, \psi) > (\varphi, \psi))$, • *Proof-Theoretic Counterpart of* Cancellation*:* $(\psi \not\leftrightarrow \bot) \to ((\varphi, \psi) \approx (\varphi \land \psi, \psi))$,
• *Proof-Theoretic Counterpart of* Addition*:*

$$\bigwedge_{1 \le i \le n} \Big( ((\psi_i, \top) \not\approx (\bot, \top)) \land ((\tau_i, \top) \not\approx (\bot, \top)) \land ((\eta_i, \top) \not\approx (\bot, \top)) \land ((\nu_i, \top) \not\approx (\bot, \top)) \Big)$$
$$\to \Bigg( \bigwedge_{1 \le k \le n} \Bigg( \bigvee_{1 \le i_1 < \cdots < i_k \le n} (((\varphi_{i_1} \land \psi_{i_1}) \lor (\mu_{i_1} \land \nu_{i_1})) \land \cdots \land ((\varphi_{i_k} \land \psi_{i_k}) \lor (\mu_{i_k} \land \nu_{i_k})))$$
$$\leftrightarrow \bigvee_{1 \le i_1 < \cdots < i_k \le n} (((\chi_{i_1} \land \tau_{i_1}) \lor (\zeta_{i_1} \land \eta_{i_1})) \land \cdots \land ((\chi_{i_k} \land \tau_{i_k}) \lor (\zeta_{i_k} \land \eta_{i_k}))) \Bigg)$$
$$\to \Bigg( \bigwedge_{i<n} (((\varphi_i, \psi_i) > (\chi_i, \tau_i)) \land \neg((\zeta_i, \eta_i) > (\mu_i, \nu_i))) \to (((\varphi_n, \psi_n) > (\chi_n, \tau_n)) \to ((\zeta_n, \eta_n) > (\mu_n, \nu_n))) \Bigg) \Bigg)$$
,

• *Proof-Theoretic Counterpart of* Multiplication*:*

$$\bigwedge_{1\le i\le n}\left(((\varphi_i,\top)\not\approx(\bot,\top))\wedge((\psi_i,\top)\not\approx(\bot,\top))\right)\to\left(\bigwedge_{1\le k\le n-1}\neg\left((\psi_{k+1},\bigwedge_{0\le i\le k}\psi_i)>(\bigwedge_{0\le i\le k}\psi_i,\psi_0)\right)\right.$$
$$\left.\to\left(\bigwedge_{0<k\le n}((\varphi_k,\bigwedge_{0\le i<k}\varphi_i)>(\psi_k,\bigwedge_{0\le i<k}\psi_i))\to((\bigwedge_{0\le i\le n}\varphi_i,\varphi_0)>(\bigwedge_{0\le i\le n}\psi_i,\psi_0))\right)\right),$$

• *Proof-Theoretic Counterpart of* Dominance*:*

$$\frac{(\tau,\top)\not\approx(\bot,\top)\qquad(\zeta,\top)\not\approx(\bot,\top)\qquad\varphi\to\psi}{((\chi,\tau)>(\psi,\zeta))\to((\chi,\tau)>(\varphi,\zeta))}\ ,$$

• *Modus Ponens.* • *A proof of $\varphi\in\Phi_{\mathscr{L}_{\mathsf{LPI}}}$ is a finite sequence of $\mathscr{L}_{\mathsf{LPI}}$-formulae having $\varphi$ as the last formula such that either each formula is an instance of an axiom or it can be obtained from formulae that appear earlier in the sequence by applying an inference rule.* • *If there is a proof of $\varphi$, we write $\vdash_{\mathsf{LPI}}\varphi$.*

**Remark 5 (Infinite Schema)** *The proof-theoretic counterparts of* Addition *and* Multiplication *are* infinite schemata *of axioms.*

On the basis of Gärdenfors (1975), we can prove the following theorems:

**Theorem 2 (Soundness)** *For any $\varphi\in\Phi_{\mathcal{L}_{\mathsf{LPI}}}$, if $\vdash_{\mathsf{LPI}}\varphi$, then $\models_{\mathsf{LPI}}\varphi$.*

**Theorem 3 (Completeness)** *For any $\varphi\in\Phi_{\mathcal{L}_{\mathsf{LPI}}}$, if $\models_{\mathsf{LPI}}\varphi$, then $\vdash_{\mathsf{LPI}}\varphi$.*

## 4. Cocluding Remarks

Suzuki (2016) proposed a version of logic OPL that makes it possible to reason in terms of $p$-Indiscriminability without the Phenomenal Sorites Paradox. OPL was a *incomplete first-order* logic. On the other hand, in this talk, we have demonstrated that a *complete propositional* logic LPI can make it possible to fully express reasoning in terms of $p$-Indiscriminability without the Phenomenal Sorites Paradox. The application of LPI to other types of Sorites Paradoxes would require further research.

## References

• Domotor, Z.: 'Probabilistic Relational Structures and Their Applications.' Technical Report No. 144, Institute for Mathematical Studies in the Social Sciences, Stanford University (1969). • Domotor, Z.: 'Qualitative Probabilities Revisited.' Humphreys, P. (ed.): Patrick Suppes: Scientific Philosopher, Vol.1. Kluwer, Dordrecht (1994) 197–238. • Fechner, G. T.: *Elemente der Psychophysik.* Breitkopf und Hartel, Leipzig (1860). • Gärdenfors, P.: 'Qualitative Probability as an Intensional Logic.' *Journal of Philosophical Logic* **4** (1975) 171–185. • Graff, D.: 'Phenomenal Continua and the Sorites.' *Mind* **110** (2001) 905–935. • Hyde, D.: 'Sorites Paradox.' Stanford Encyclopedia of Philosophy (2018). • Keefe, R.: 'Phenomenal Sorites Paradoxes and Looking the Same.' *Dialectica* **65** (2011) 327–344. • Krantz, D.H., et al.: *Foundations of Measurement, Vol. 1.* Academic Press, New York (1971). • Raffman, D.: 'Is Perceptual Indiscriminability Nontransitive?' *Philosophical Topics* **28** (2000) 153–175. • Simon, H. A.: *Models of Bounded Rationality, Vol. 1.* The MIT Press, Cambridge, Mass. (1982). • Suzuki, S.: 'Measurement-Theoretic Foundations of Observational-Predicate Logic.' In: Yang, S. C.-M. et al. (eds.): *Structural Analysis of Non-Classical Logics.* Springer-Verlag, Heidelberg (2016) 183–199.

# Additivity in Attention Semantics

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This presentation proposes a novel, Question under Discussion-based (Roberts 2012, Beaver et al. 2017) theory to explain known properties of additivity and its markers. Additivity (and its markers) has an inherent QUD-dependency. When and only when a given QUD is masked by the projecting alternatives of previous answers, identified with *attentions* in the sense of Westera (2022), and therefore asserting an additional answer is prohibited, additivity is activated (hence an additivity marker kicks in) so that the additional answer can be accepted in the ongoing discourse. Introducing the notion of attention as an underlying component of pragmatic and discourse-theoretic machinery will enable us to:

(1) a. understand in a unified way the effect of existential expressions upon both additivity and implicatures (the latter of which is what Westera (2022) intends to account for with the notion of attention),

b. to give a natural explanation of a known constraint of additivity that it is deactivated (markers are disallowed) when its prejacent is strictly stronger than its antecedent, and

c. to come to a particular theoretic standpoint in which additivity is not directly dependent on the denial or the aversion of (covert) exhaustivity / scalar implicature (such as in Krifka 1998, Sæbø 2004), but rather, additivity and implicatures are both derived from attention and relevant mechanisms.

This presentation will focus mainly on the Japanese additivity marker *mo*. Nevertheless, at least (1b) will benefit other languages as well.

**What activates additivity (and obligates markers to appear)?** Krifka (1998) likens additive sentences to the contrastive topic-focus construction, in which the associate of additivity takes the role of contrastive topic (the B-accent role) and the additive marker itself is an "special emphasis" which "realize[s] an affirmative element explicitly" (p. 124). In particular, an additive marker is necessitated and licensed at the same time by a given context in which the speaker is already not "willing to assert" the prejacent (his *distinctiveness*, p. 122, (47)). An assertion is incompatible with pre-existing distinctiveness in the context, where an additive marker kicks in to rescue the assertion in a similar way to a VERUM operator.

However, canceling distinctiveness of the antecedent is not the only way to necessitate additivity (and its markers). Sæbø (2004) has succeeded in constructing examples in which distinctiveness is not rooted in the context but in the prejacent itself. Besides, whether it is identified with exhaustivity or ignorance (it is notable that both Krifka (1998) and Sæbø (2004) are vague about this difference) or is originated from either the prejacent and the antecedent(s), distinctiveness is actually **not** the source of obligatory additivity. Below is a demonstrating contrastive pair of dialogues (2) and (3) between the three people Q, A, and B:

(2) Q: dare-ga pasuwādo-o sit-tei-masu-ka?
who-NOM password-ACC know-STATE-HON-Q

'Who knows the password?'

A: Tarō-tati-ga sit-tei-masu.
Taro-ASSOC-NOM know-STATE-HON

'Taro and his associates do.'

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B: Sonotōri. Hanako-{ # ga / mo } sit-tei-masu.
exactly Hanako-{ # NOM / ADD.NOM } know-STATE-HON
'Certainly. Hanako #(also) knows it.'

The assertion by B in (2) sounds self-contradicting unless *mo* is added because he endorses A's answer by *sonotōri* 'exactly' while he follows it by an assertion which does not respect the endorsement he made. On the other hand, if A mixes an indefinite *dareka* 'someone' in her assertion:

(3) Q: dare-ga pasuwādo-o sit-tei-masu-ka?
who-NOM password-ACC know-STATE-HON-Q
'Who knows the password?'

A: Tarō-to dareka-ga sit-tei-masu.
Taro-and someone-NOM know-STATE-HON
'Taro and someone (else) do.'

B: Sonotōri-desu. Hanako-{ ga / mo } sit-tei-masu.
exactly-HON Hanako-{ NOM / ADD.NOM } know-STATE-HON
'Certainly. Hanako (also) knows it.'

There is a (not necessarily promptly accessible) interpretation of B's assertion in which he accepts A's answer and at the same time specifies the indefinite A has left unresolved. Both the informativity of A's assertion in (2) and that in (3) are made balanced, and in neither case does A's assertion generate crucial exhaustivity implicature which contradicts B's assertion. This indicates that neither exhaustivity nor ignorance decides whether additivity must be activated (hence linguistically marked), and that it is indefinites that are determinative.

Sæbø (2004) argues that what necessitates additivity marking is distinctiveness branching out of the prejacent itself rather than previous assertions, and that an additivity marker introduces a concealed conjunction (see also Ahn 2015) so that no distinctiveness will grow from the prejacent. His proposal is not satisfactory, either, because

- the obligatoriness of additive marking is still there even if distinctiveness (as exhaustivity) is suppressed by expressions such as *at least*,
- the difference between (2) and (3) still remains unaddressed,
- the logical independence requirement (exemplified in (8) later) remains unexplained, and
- the "contextual effect" (Shudo 2002) of additivity is left unaccounted.

Indefinites are known to open up (local) questions or alternative sets that feed subsequent semantic and pragmatic mechanisms. Among them are the free choice implicature (Fox 2007, Bar-Lev & Fox 2020, Westera 2022), the interaction with conditionals (Ciardelli, Zhang & Champollion 2018), and (re)calculation of the saliency of following potential (covert) QUDs (Tönnis 2022). This presentation attempts to formulate this nature in Westera's (2022) theory of Attention Pragmatics. (It is better called Attention Semantics since the attention dimension is part of a denotation, which belongs to semantics.)

**Proposal** We construct a discourse semantic/pragmatic theory which

- is based on a particular kind of state-based semantics (Anttila 2021, Aloni 2022) rejecting downward closedness (akin to Alternative Semantics (Rooth 1985) and exact truthmaker semantics, Fine 2017a,b, Moltmann 2020) to treat declarative and (inter)rogative propositions indinstinguishingly,
- admits the attention dimension (Westera 2022) as a secondary dimension, and
- incorporates a discourse management mechanism based on both Roberts (2012) and Farkas & Bruce (2009).

States (sets of possible worlds) are truthmakers in our theory. A state can either satisfy or falsify (or do nothing to) a proposition. A proposition is in turn characterized by a set of states which satisfy it and another set of states which falsify it. (Falsification is not considered in this presentation, though.) Classical logical constants are classified into “global” ones ($\text{⩕}$, $\text{⩖}$, $\forall\forall$, $\exists\exists$, $\Rightarrow$, $\mathbb{0}$, $\mathbb{1}$, $\text{⫬}$), which calculate on sets of states characterizing propositions, and “local” ones ($\wedge$, $\vee$, $\forall$, $\exists$, $\rightarrow$, $\top$, $\bot$, $\neg$), which operate on states directly. In particular, $\text{⩖}$ is the same as the one in Inquisitive Semantics (Ciardelli, Groenendijk & Roelofsen 2019). Closure operators such as $\uparrow(\cdot)$ (upward closure), $\downarrow(\cdot)$ (downward closure), and $(\cdot)^{\wedge}$ (local conjunction closure) are also made expressible in the semantic language.

A proposition $\alpha$ has another dimension in addition to the ordinary one about informativeness. It is the *attention dimension*, denoted by $\text{☼}\alpha$. The attention dimension of a proposition is syntactically derived from the former one, the processes of which is such that $\vee$ and $\exists$ are replaced with $\text{⩖}$ and $\exists\exists$ and foci and topics introduce a global restriction by $\Rightarrow$ on what alternatives should be filtered out (see (6c) below).

A proposition $\alpha$, whether it is inquisitive or not, can find its correspondent alternative(s) of a QUD $\kappa$, which is called $\alpha$’s *inquisitive projection* on $\kappa$, defined as $(\uparrow\alpha)\text{⩕}\kappa$, and abbreviated to $\alpha \rightrightarrows \kappa$. Note that as a logical matter, $\kappa \vDash \alpha \rightrightarrows \kappa$ always holds because of $\text{⩕}$’s nature of being the global conjunction. In this presentation, what is crucial for an assertion of a proposition $\alpha$ is its attentional content projected on the given QUD $\kappa$, namely $\text{☼}\alpha \rightrightarrows \kappa$.

A speaker can, and is expected, to make a discourse move (as specified by Farkas & Bruce 2009) whenever her turns come. Amongst the moves she can make a question (Question), answer to a question by assertion (Answer) and (automatically) request confirmations (Req-Cfm), totally confirm other’s assertions (Confirm), confirm the information parts of previous assertions while rejecting their attentions (Cfm-Info-Only), and totally reject previous assertions (Reject). Whenever all the discourse participants have endorsed an assertion, it is *pragmatically enabled*. A pragmatically enabled assertion triggers two independent pragmatic effects, namely (i) generating conversational implicatures and (ii) fixing the given QUD. Thus we are assuming here a Y-shape pragmatic model in which (i) and (ii) both branch out of the divergent point, that is, the informational and the attentional representation of a proposition.

(4) Westera’s (2022) bifurcated I-/A-maxims govern how conversational implicatures are generated (i). Let $\boldsymbol{M},s$ be a structure, $\alpha$ an asserted proposition, and $\kappa$ an immediate QUD given by the context of $\boldsymbol{M}$. The maxims adapted to our theory are:

a. I-Quality: $\boldsymbol{M},s \vDash \Box\alpha$ (the speaker believes $\alpha$)

b. I-Relation: $\boldsymbol{M},s \vDash \alpha \rightarrow ((\downarrow\kappa)\text{⩖}(\downarrow\sim\kappa))$
($\alpha$ confined by $s$ in a reductive answer, see Agha & Warstadt 2020)

c. I-Quantity: for each $t$ s.t. $\boldsymbol{M},t \vDash \kappa$ ($t$ s.t. it is an alt of $\kappa$):
either $\boldsymbol{M},s \vDash \alpha \rightarrow \downarrow\{t\}$ ($\alpha$ confined by $s$ “entails” the state $t$)
or $\boldsymbol{M},s \vDash \ \Box\{t\}$ (the speaker does not believe $t$)

d. A-Quality: for each $t$ s.t. $\boldsymbol{M},t \vDash \text{☼}\alpha \rightrightarrows \kappa$: $\boldsymbol{M},s \vDash \Diamond\{t\}$
(each alternative of $\text{☼}\alpha \rightrightarrows \kappa$ is possible for the speaker)

e. A-Relation: $\boldsymbol{M},s \vDash (\text{☼}\alpha \rightrightarrows \kappa) \rightarrow \top$ ($\text{☼}\alpha \rightrightarrows \kappa$ confined by $s$ is non-empty)

f. A-Quantity: for each state $t$ s.t. $\boldsymbol{M},t \vDash \kappa^{\wedge}$:
either $\boldsymbol{M},s \cap t \vDash \{s\} \wedge (\text{☼}\alpha \rightrightarrows \kappa)$
(the alt $t$ of the $\wedge$-closure of $\kappa$, when confined by $s$, is a member of $(\text{☼}\alpha \rightrightarrows \kappa)$ confined by $s$)
or $\boldsymbol{M},s \vDash \ \Diamond\{t\}$ ($t$ is not possible for the speaker)

(5) By (ii), a pragmatically enabled (Answer-ed, Req-of-Cfm-ed, and Confirm-ed) assertion of a proposition $\alpha$ restricts the given QUD $\kappa$ so that only those alternatives of $\kappa$ that also belong to $\text{☼}\alpha$ remain. Let us call the proposition that consists of those remnant alternatives the *remnant*

*QUD* of a question. Unlike Krifka (1998), the obligatoriness of additive marking does not hinge on implicatures (or his distinctiveness). Rather, it is the remnant QUD that is crucial.

An additive marker is required if and only if a pragmatically enabled previous answer masks away the prejacent. The marker makes the prejacent answerable again by “correcting” the attention content of the previous answer. Thus it is predicted that B’s assertion in (2) is infelicitous unless *mo* is added. A’s assertion has the informational and the attentional content described in (6b) and (6c) below. The attentional content is then projected on the given QUD (6a) to gain (6d). Note that (6d) is no longer inquisitive. This means that after A’s assertion is confirmed by B (by saying *Sonotōri-desu*), B can no longer assert Hanako’s knowing the password because this answer is not included in (6d) unless B uses *mo* to replace (6c) with (6e) to gain (6f).

(6) a. QUD: $\exists\exists x.\text{knowPW}(x)$
b. Info: InfoFocus(Taro,knowPW)
c. Attention: $(\exists\exists x.\text{knowPW}(x)) \Rightarrow \text{knowPW(Taro)}$
d. Att. projected on the QUD: $\uparrow(\text{Att.}) ⩕ \text{QUD}$ $(\equiv \text{knowPW(Taro)})$
e. Att. corrected by *mo*: $(\exists\exists x.\text{knowPW}(x)) \Rightarrow \text{ktp(Taro)} ⩖ \text{knowPW(Hanako)}$
f. The projection of the above on the QUD: $\uparrow(\text{Att.corrected}) ⩕ \text{QUD}$
$(\equiv \text{knowPW(Taro)} ⩖ \text{knowPW(Hanako)})$

The discourse moves that have happened are represented by the following QUD history tree:

(7) (Question, Q, (6a))
(Answer, A, (6b)) (Answer, B, Hanako knows it)
(Req-Cfm, A, )
(Cfm-Info-Only, B, rewrite (6c) to (6e))

On the other hand, *mo* is not necessary in (3) because the indefinite expression *dareka* leaves alternatives in the attention dimension of the proposition asserted by A. In other words, (6e) and (6f), instead of (6c) and (6d), is available for B. This is why Hanako’s knowing the password is not excluded, rendering *mo* unnecessary. Ignoring the attentional effect of *dareka* will make *mo* obligatory again.

**Further predictions: what validates additivity (and licenses markers)?** Recognizing attention as an underlying representation to restricting a given QUD into a remnant QUD (5) independent of implicature generation (4) has an unexpected benefit of explaining a particular constraint imposed on additivity. It is known that the prejacent of an additive marker must be logically independent of the antecedent (Krifka 1998: 121, *disputability*, Beaver & Clark 2008: p. 73, Theiler 2019: §3.4).

(8) Q: Who knows the password?
A: Taro does.
B: Sonotōri-desu.
exactly-HON
{ zen’in / Tarō-to-Hanako } -{ ga / # mo } sit-tei-masu.
{ everyone / Taro-and-Hanako } -{ NOM / # ADD.NOM } know-STATE-HON

‘Certainly. { Everyone / Taro and Hanako } (# also) know(s) it.’

Our attentional approach has a different take: *mo* is impossible in (8) because the prejacent of B’s informational content entails the remnant QUD (though it is no longer inquisitive) i.e. (6d) above. In this sense, the prejacent and the antecedent are no different. Thus *mo* is unnecessary, and unnecessity means lack of motivation. Unlike (3), there is no attention proffered from the previous answer which makes difference when ignored.

Beaver & Clark (2008: p. 73) think that additivity markers (i) “mark that the Current Question has already been partially answered,” (ii) “with the additional requirement that the pre-existing partial answer is not entailed by the prejacent.” For us, additive markers are designed to do more than just mark; additive markers must modify previous attentions in order to make an otherwise disallowed assertion possible. Both (i) and (ii) are derived from this amending nature.

After all, the QUD- or Information Structure-dependence of additivity has been a prevailing idea in the literature (Jasinskaja & Zeevat 2009 and Bade 2008 among others). Shudo (2002) observes and discusses other cases speaking for it where *mo* is unlicensed (in spite of the availability of existential presuppositions!) because the prejacent together with the antecedent proposition (i.e. the existential presupposition) fails to impose a non-vacuous “contextual effect” to the given QUD (p. 42, (33)) and underlying similar cases where the prejacent and the antecedent must be interpreted in a parallel manner relative to the given (inexact) QUD (pp. 76–78). Our theory covers her cases by connecting the attentions of prejacents and their antecedents with $\mathbin{\rotatebox[origin=c]{180}{$\mathbb{A}$}}$ and $\exists\exists$ and requiring its utility with regard to the given QUD is sufficient enough.

## References


Agha, Omar & Alex Warstadt. 2020. Non-resolving responses to polar questions: A revision to the QUD theory of relevance. en. In *Proceedings of Sinn und Bedeutung 24*, vol. 1, 17–34. Osnabrück University: Osnabrück University.

Ahn, Dorothy. 2015. The semantics of additive either. In *Proceedings of Sinn und Bedeutung 19*, 20–35.

Aloni, Maria. 2022. Logic and conversation: the case of free choice. en. *Semantics and Pragmatics* 15(5).

Anttila, Aleksi. 2021. *The logic of free choice: axiomatizations of state-based modal logics*. Universiteit van Amsterdam MA thesis.

Bade, Nadine. 2008. Obligatory implicatures and the presupposition of “too”. In Urtzi Etxeberria et al. (eds.), *Proceedings of Sinn und Bedeutung 18*, 42–59.

Bar-Lev, Moshe E. & Danny Fox. 2020. Free choice, simplification, and Innocent Inclusion. *Natural Language Semantics* 28(3). 175–223.

Beaver, David I et al. 2017. Questions under Discussion: where information structure meets projective content. *Annual Review of Linguistics* 3. 265–284.

Beaver, David I. & Brady Z. Clark. 2008. *Sense and sensitivity: how focus determines meaning*. en. Oxford: Wiley-Blackwell.

Ciardelli, Ivano, Jeroen Groenendijk & Floris Roelofsen. 2019. *Inquisitive semantics*. Oxford: Oxford University Press.

Ciardelli, Ivano, Linmin Zhang & Lucas Champollion. 2018. Two switches in the theory of counterfactuals: a study of truth conditionality and minimal change. *Linguistics and Philosophy* 41(6). Publisher: Springer Netherlands, 577–621.

Farkas, Donka F. & Kim B. Bruce. 2009. On reacting to assertions and polar questions. *Journal of Semantics* 27(1). 81–118.

Fine, Kit. 2017a. A theory of truthmaker content I: conjunction, disjunction and negation. en. *Journal of Philosophical Logic* 46(6). 625–674.

Fine, Kit. 2017b. A theory of truthmaker content II: subject-matter, common content, remainder and ground. en. *Journal of Philosophical Logic* 46(6). 675–702.

Fox, Danny. 2007. Free choice and the theory of scalar implicatures. In Uli Sauerland & Penka Stateva (eds.), *Presupposition and implicature in compositional semantics*, 71–120. London: Palgrave Macmillan.

Jasinskaja, Katja & Henk Zeevat. 2009. Explaining conjunction systems: Russian, English, German. In Arndt Riester & Torgrim Solstad (eds.), *Proceedings of Sinn und Bedeutung 13*, vol. 1, 231–245.

Krifka, Manfred. 1998. Additive particles under stress. In Devon Strolovitch & Aaron Lawson (eds.), *Proceedings of SALT 8*, 111–129. Ithaca, NY: Cornell University.

Moltmann, Friederike. 2020. Truthmaker semantics for natural language: Attitude verbs, modals, and intensional transitive verbs. en. *Theoretical Linguistics* 46(3-4). 159–200.

Roberts, Craige. 2012. Information structure in discourse: towards an integrated formal theory of pragmatics. *Semantics and Pragmatics* 5. 6.

Rooth, Mats. 1985. *Association with Focus*. University of Massachusetts PhD Thesis.

Sæbø, Kjell Johan. 2004. Conversational contrast and conventional parallel: Topic implicatures and additive presuppositions. *Journal of Semantics* 21(2). 199–217.

Shudo, Sachiko. 2002. *Presupposition and discourse: function of the Japanese particle mo*. en. New York & London: Routledge.

Theiler, Nadine. 2019. When additive particles can associate with wh-phrases. In M. Teresa Espinal et al. (eds.), *Proceedings of Sinn und Bedeutung 23*, vol. 2, 347–364.

Tönnis, Swantje. 2022. It is not the obvious question that a cleft addresses. en. In Aybüke Özgün & Yulia Zinova (eds.), *Language, Logic, and Computation: 13th International Tbilisi Symposium, TbiLLC 2019, Batumi, Georgia, September 16–20, 2019, Revised Selected Papers*, vol. 13206, 128–147. Series Title: Lecture Notes in Computer Science. Cham: Springer.

Westera, Matthijs. 2022. Attentional Pragmatics: a pragmatic approach to exhaustivity. en. *Semantics and Pragmatics* 15(10).

# Internal Reading and Reciprocity

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Sentences with "each other" in English have been treated as the canonical reciprocal expressions. However, apart from "each other", some other sentences also carry a reciprocal meaning. A typical example is the following sentence:

John, Peter and Mary read the same books. (1)

The phrase with "the same" above is ambiguous with two readings: the deictic reading and the internal reading, which as argued in [3], are different readings without one being a special case of the other. Under the deictic reading, "same" means "same as something mentioned in the previous discourse or salient in the context", whereas under the internal reading, the sentence above is equivalent to the following (as pointed out by [7]):

John, Peter and Mary read the same books as each other. (2)

meaning that any two of the three persons read the same books (here I assume the strongest reciprocal meaning as discussed in [5] by default). What I am interested is the internal reading because it is this reading that carries a reciprocal meaning.

In addition to "the same", some other lexical items, hereinafter called "reciprocal items" and including "different", "opposite", "similar", "related", "separate", "adjacent", "complementary", "connected", "disjoint", etc, behave similarly in that a sentence containing one of these items has an internal reading carrying a reciprocal meaning. This is best illustrated by the following example which sounds weird:

*Particles 1, 2 and 3 have different charges. (internal reading) (3)

Under the intended (namely internal) reading, the sentence above means that the charges of the three particles are different from each other, i.e. particles 1 and 2 have different charges, particles 2 and 3 have different charges, and particles 3 and 1 have different charges. But this is impossible given that there are only two possible charges (positive vs negative).

Another evidence for the reciprocal meaning of these items is that many of them can be rendered in Chinese as words containing the morpheme "xiang" or "hu" meaning "mutual", e.g. "same" as "xiangtong", "different" as "xiangyi", "opposite" as "xiangfan", "similar" as "xiangsi", "related" as "xiangguan", "separate" as "xiangge", "adjacent" as "xianglin", "complementary" as "hubu", "connected" as "hutong", "disjoint" as "huchi", etc.

While the internal reading of "the same" has been studied by [3], [4], [7], [10], [13], etc from different perspectives using different theoretical frameworks, none of these studies based the semantics of "the same" on reciprocity. Neither did these studies consider other reciprocal items (except "different"). In this paper, I will provide a uniform formal treatment for the internal reading of the reciprocal items that reflects the reciprocal meaning.

For the formal framework of this paper, I will adopt the notation in [9], which uses small cap font and boldface font for the denotations of logical and non-logical terms, respectively. If $f$ is a characteristic function, then $f^*$ is the set of entities that $f$ characterizes. Moreover, I will also borrow ideas from the Generalized Quantifier Theory (GQT) enriched by the notion of generalized noun phrases (GNPs) developed by [11], [12], [14], etc.

Under the classical GQT, a generalized quantifier (GQ) is a function with a number of predicates as arguments and a truth value as output. The arities of the arguments are used to name the type of a GQ. For example, a determiner, such as "every", is treated as a type $\langle 1, 1\rangle$ GQ because it requires a nominal unary predicate and a verbal unary predicate as its arguments.

The notion of GNP is a generalization of GQ. Instead of outputting truth values, a GNP outputs a set (or characteristic function) of ordered $n$-tuples of individuals (represented by ": $n$") or a set (or characteristic function) of type $\langle 1\rangle$ GQs (represented by ": $\langle 1\rangle$"). For example, according to [12], "each other" should be treated as a GNP with a binary predicate as input and a set of type $\langle 1\rangle$ GQs as output, and its type is denoted $\langle 2 : \langle 1\rangle\rangle$.

Following [12], I will treat "each other" as a type $\langle 2 : \langle 1\rangle\rangle$ GNP. As for the truth condition of this GNP, I will adopt a modified version of the truth condition of the FUL quantifier studied in [6] which is given as follows:

$$\textsc{each other} = \lambda R \lambda Q[\exists X \in \mathrm{Wit}(Q)[|X| \geq 2 \wedge X^2 - Id^2_X \subseteq R^*]] \tag{4}$$

In the above, $R$ and $Q$ are variables of binary predicates and upward monotonic type $\langle 1\rangle$ GQs, respectively. $\mathrm{Wit}(Q)$ represents the set of witness sets of $Q$, whose definition can be found in [8]. $Id^2_X$ is the set $\{(x, x) : x \in X\}$ and so the statement $X^2 - Id^2_X \subseteq R^*$ means that every member $x$ of $X$ stands in the relation $R$ with every other member of $X$ except perhaps $x$ itself. For instance, the following sentence

John, Peter and Mary hit each other. (5)

will be denoted by

$$\textsc{each other}(\mathbf{hit})(\textsc{and}(I_{\mathbf{j}}, I_{\mathbf{p}}, I_{\mathbf{m}})) \tag{6}$$

where $I_{\mathbf{j}}$, $I_{\mathbf{p}}$ and $I_{\mathbf{m}}$ are the type $\langle 1\rangle$ quantifiers (also called "Montagovian individuals" in the GQT literature) corresponding to the individual terms $\mathbf{j}$ (short for "John"), $\mathbf{p}$ (short for "Peter") and $\mathbf{m}$ (short for "Mary"), respectively. For simplicity, here I use a polymorphic boolean operator AND which takes any number of type $\langle 1\rangle$ quantifiers as input and output the intersection of them. According to (4), the expression above is true if and only if there exists a plural witness set of $\textsc{and}(I_{\mathbf{j}}, I_{\mathbf{p}}, I_{\mathbf{m}})$ (which, according to the definition of witness sets, consists of the three individuals John, Peter and Mary) such that every member of that witness set hits every other member of that set, which is exactly what (5) means.

I propose that the internal reading of sentences containing the reciprocal items should also be treated using (4). For example, in order to use (4) to denote (1), we have to determine its argument $R$, which should be a binary predicate denoting "read the same books as". First, we determine the denotation of "the same ... as". According to [1], the structure "the same ... as" in the sentence "The same boys sang as danced" can be seen as a type $\langle 1, 1^2 \rangle$ GQ with the following truth condition:

$$\textsc{the same as} = \lambda A \lambda (B, C)[\textsc{the same}(A^* \cap B^*, A^* \cap C^*)] \tag{7}$$

where THE SAME is a logical term with the following denotation:

$$\textsc{the same} = \lambda (A, B)[A = B] \tag{8}$$

While the structure "the same ... as" in the phrase "read the same books as" cannot be seen as a GQ, it was analyzed as a "generalized comparative determiners" (a subtype of GNPs) in [11]. Modifying the notion of generalized comparative determiners a bit in this paper, I provide the denotation of "the same ... as" in "read the same books as" as follows:

$$(\textsc{the same as})_2 = \lambda X \lambda R \lambda (u, v)[\textsc{the same}(X^* \cap \{w : R(u, w) = 1\}, X^* \cap \{w : R(v, w) = 1\})] \tag{9}$$

where the subscript "2" means that "the same ... as" appears in the 2nd argument position (i.e. object) of the binary predicate $R$. Note that the variable $w$ representing the noun modified by "the same" does appear in the 2nd argument position of $R$ in the formula above. $(\textsc{the same as})_2$ as defined above is a type $\langle 1, 2 : 2 \rangle$ GNP, with a unary predicate and a binary predicate as inputs and a set of ordered pairs of individuals as output. Having defined the GNP above, we then apply it to the unary predicate **book** and the binary predicate **read** to obtain the denotation of "read the same books as" as follows:

$$(\textsc{the same as})_2(\mathbf{book})(\mathbf{read}) \tag{10}$$

Finally, we can determine the denotation of (1) as follows:

$$\textsc{each other}((\textsc{the same as})_2(\mathbf{book})(\mathbf{read}))(\textsc{and}(I_{\mathbf{j}}, I_{\mathbf{p}}, I_{\mathbf{m}})) \tag{11}$$

By using (4), (9) and (8), one can show that the expression above is true if and only if the following is true:

$$\begin{aligned} &\{(\mathbf{j}, \mathbf{p}), (\mathbf{j}, \mathbf{m}), (\mathbf{p}, \mathbf{j}), (\mathbf{p}, \mathbf{m}), (\mathbf{m}, \mathbf{j}), (\mathbf{m}, \mathbf{p})\} \\ \subseteq\ &\{(u, v) : \mathbf{book}^* \cap \{w : \mathbf{read}(u, w) = 1\} = \mathbf{book}^* \cap \{w : \mathbf{read}(v, w) = 1\}\} \end{aligned} \tag{12}$$

The expression above means that any two (different) individuals among John, Peter and Mary are such that the books that one read are the same as the books that the other read, which is exactly what (1) means.

The internal reading of sentences containing the other reciprocal items can also be treated analogously. More specifically, I propose that all these items (each with a suitable preposition) should be treated as generalized comparative determiners of type $\langle 1, 2 : 2\rangle$. For example, "separate ... from" is denoted by the following generalized comparative determiner:

$$(\textsc{separate from})_2 = \lambda X \lambda R \lambda(u, v)[\textbf{separate}(X^* \cap \{w : R(u, w) = 1\}, X^* \cap \{w : R(v, w) = 1\})] \tag{13}$$

A justification for the treatment above is that (13) satisfies a modified version of the property called "argument invariance for unary determiners" (D1AI) studied in [11], which can be seen as a defining property of such kind of GNPs. The modified definition of D1AI is given as follows: a type $\langle 1, 2 : 2\rangle$ GNP $F$ satisfies D1AI iff for any unary predicate $X$, binary predicate $R$ and individuals $a$, $b$, $c$, $d$, if $X^* \cap \{w : R(a, w) = 1\} = X^* \cap \{w : R(b, w) = 1\}$ and $X^* \cap \{w : R(c, w) = 1\} = X^* \cap \{w : R(d, w) = 1\}$, then $F(X)(R)(a, c) = F(X)(R)(b, d)$.

The only difference between (9) and (13) is that while THE SAME is a logical term with a denotation independent of models like (8), **separate** is a non-logical term whose denotation is dependent on models, i.e. $\textbf{separate}(A, B) = 1$ in a particular model if and only if $A^*$ and $B^*$ are singletons and the unique members in these two singletons are separate entities in that model. Note that "separate ... from" is structurally similar to "older ... than", which was discussed and considered as a generalized comparative determiner in [11].

Based on the above, the denotation of the following sentence

$$\text{John, Peter and Mary live on separate floors.} \tag{14}$$

can be determined as follows:

$$\textsc{each other}((\textsc{separate from})_2(\textbf{floor})(\textbf{live on}))(\textsc{and}(I_{\mathbf{j}}, I_{\mathbf{p}}, I_{\mathbf{m}})) \tag{15}$$

Apart from $\textsc{and}(I_{\mathbf{j}}, I_{\mathbf{p}}, I_{\mathbf{m}})$, other upward monotonic type $\langle 1\rangle$ GQs can also be used as the $Q$ argument of (4). For example, by replacing $\textsc{and}(I_{\mathbf{j}}, I_{\mathbf{p}}, I_{\mathbf{m}})$ with $\textsc{at least } 3(\textbf{person})$ in (11), we obtain the denotation of the internal reading of the sentence "At least three persons read the same books".

For downward monotonic or non-monotonic type $\langle 1\rangle$ GQs, the truth condition given in (4) is not adequate. To obtain the appropriate truth conditions in such cases, I propose to borrow ideas from [2] and modify (4) as follows:

$$\begin{aligned}\textsc{each other} = \lambda R \lambda Q\ \ &[(\exists X \in \mathrm{Wit}(Q)[|X| \geq 2 \wedge X^2 - Id_X^2 \subseteq R^*] \vee \mathrm{Top}(Q) \cap S = \emptyset) \\ &\wedge Q(S) = 1]\end{aligned} \tag{16}$$

where Top($Q$) represents the topic set of $Q$, whose definition can be found in [8], and $S$ is the following set denoting "individuals that enter into a mutual R relation":

$$S = \{x : \exists X[x \in X \wedge |X| \geq 2 \wedge X^2 - Id_X^2 \subseteq R^*]\} \tag{17}$$

In (16), the disjunct Top$(Q) \cap S$ is to handle sentences like "Nobody hit each other" whose denotation does not require a witness set, whereas the conjunct $Q(S) = 1$ corresponds to the "counting operator" discussed in [2] and is used to handle sentences with downward monotonic or non-monotonic type $\langle 1 \rangle$ GQs. It can be shown that when $Q$ is upward monotonic, then (16) reduces to (4) and so (4) is just a special case of (16).

We can now determine the denotation of reciprocal sentences with downward monotonic or non-monotonic type $\langle 1 \rangle$ GQs. For example, by replacing AND$(I_{\mathbf{j}}, I_{\mathbf{p}}, I_{\mathbf{m}})$ with EXACTLY 3(**person**) in (11) (and using (16) as the truth condition of EACH OTHER), we obtain the denotation of the internal reading of the sentence "Exactly three persons read the same books".

In this paper, I will also discuss how to modify the aforesaid framework to cover several types of sentences that are different in one way or another from the ones discussed above. The first type of sentences are those with a weaker reciprocal meaning such as "John, Peter and Mary live in adjacent buildings". Instead of using the truth condition given in (4) which is too strong for this sentence (because three buildings cannot be adjacent to each other in the sense given in (4) unless they are arranged in a circle), I propose to change the inequality $X^2 - Id_X^2 \subseteq R^*$ in (4) to $X^2 - Id_X^2 \subseteq (R^+)^*$ where $R^+$ represents the transitive closure of $R$, i.e. the smallest transitive relation containing $R$.

The second type of sentences are those in which the reciprocal items appear in a syntactic position other than object such as "The same waiter served John, Peter and Mary" in which "the same" appears in the 1st argument position (i.e. subject) of the verb "served". To determine the denotation of this sentence, I propose to change $R(u, w)$ and $R(v, w)$ in (9) to $R(w, u)$ and $R(w, v)$, respectively, so that the variable $w$ representing the noun modified by "the same" now appears in the 1st argument position of $R$. The modified GNP will now be denoted (THE SAME AS)$_1$.

The third type of sentences are those with more than one reciprocal items such as "John, Peter and Mary read the same books and different magazines". To determine the denotation of this sentence, I propose that we first write out the denotation of "read the same books as and read different magazines than" (with two occurrences of "read") by using AND. By using $\lambda$-abstraction to abstract out "read" to obtain a binary predicate and then applying this predicate back to **read**, we then obtain the denotation of "read the same books as and different magazines than" (with one occurrence of "read"). The remaining steps of determining the denotation of the aforesaid sentence is as usual.

## References


1. Beghelli, F.: Structured quantifiers. In Kanazawa, M. Piñón, C. (Eds.): Dynamics, Polarity and Quantification. CSLI Publications, Stanford, 119-143 (1994)
2. Ben-Avi, G., Winter, Y.: Monotonicity and collective quantification. Journal of Logic, Language and Information 12, 127–151 (2003)
3. Barker, C.: Parasitic scope. Linguistics and Philosophy 30(4), 407-444 (2007)
4. Carlson, G.: *Same* and *different*: some consequences for syntax and semantics. Linguistics and Philosophy 10:4, 531-565 (1987)
5. Dalrymple, M., Kanazawa, M., Kim, Y., Mchomno, S., Peters, S.: Reciprocal expressions and the concept of reciprocity. Linguistics and Philosophy 21, 159-210 (1998)
6. Peters, S., Westerståhl, D.: Quantifiers in Language and Logic. Clarendon Press, Oxford (2006)
7. Solomon, M.: The compositional semantics of *same*, manuscript (2012)
8. Szabolcsi, A.: Quantification. Cambridge University Press, Cambridge (2010)
9. Winter, Y.: Elements of Formal Semantics: An Introduction to the Mathematical Theory of Meaning in Natural Language. Edinburgh University Press, Edinburgh (2016)
10. Zuber, R.: Generalised quantifiers and the semantics of *the same*. In Proceedings of SALT 21, 515-531 (2011)
11. Zuber, R.: Some generalised comparative determiners. In Pogodalla, S., Prost, J.-P. (Eds.): LACL 2011, LNAI 6736, 267–281 (2011)
12. Zuber, R.: Reciprocals as higher order functions. In Proceedings of the Ninth International Workshop of Logic and Engineering of Natural Language Semantics 9, 118-129 (2012)
13. Zuber, R.: Set partitions and the meaning of *the same*. Journal of Logic, Language and Information 26, 1–20 (2017)
14. Zuber, R.: On generalized noun phrases. Formal Grammar, LNCS 10686, Springer, 142-156 (2018)

# TOPOLOGY AND JUSTIFIED TRUE BELIEF: A BASELESS, EVIDENCE-FREE (AND POINTLESS) APPROACH

KOHEI KISHIDA

## 1. Introduction

Topological spaces provide semantics for modal logic S4. Recently, the epistemic reading of S4 has attracted topological semantics, on the basis of the idea that the generating of a topology from a "base" can be interpreted as the justifying of knowledge with evidence. This is called the evidence-based approach. This approach stems at least from two schools: One is evidence logic [2, 3] on the basis of neighborhood semantics for modal logic, which led to the topological development comprehensively presented in Baltag et al. [1]. Another is the use of topology in formal learning theory, made to express verifiability, falsifiability, and other properties of propositions [4]; a modal-logical rendering of this topological semantics was given in Kishida [5]. In both schools, a topology is generated from a base that expresses a set of evidence or observable propositions.

This paper proposes an alternative approach that may be called evidence-free, in the sense that a topology or knowledge is generated from something other than a base or evidence. We also use the algebraic, "pointless" formalism of topology, so as to more perspicuously present the structural essence of the correspondence between semantics and logic. After reviewing the evidence-based approach in Section 2, we propose an alternative approach in Section 3. We briefly review an application of our new formalism to the notion of common knowledge in Section 4 before concluding the paper.

## 2. The Evidence-Based Approach: A Review

2.1. **From a base to an interior operator.** In this subsection we introduce notation concerning topology by reviewing well-known facts—albeit in the pointless form—that play crucial roles in the evidence-based approach to topological semantics of epistemic logic.

**Definition 1.** Let $L$ be a complete lattice and $B$ be any subset of $L$. Then, by the *interior operator on $L$ with base $B$* we mean a map

$$\mathbf{int}_B : L \to L :: x \mapsto \bigvee_{u \in B, u \leqslant x} u.$$

Note that the definition of $\mathbf{int}_B\, x$ as a join characterizes it as follows: it is the unique element of $L$ such that, for any $y \in L$,

(1) $$\mathbf{int}_B\, x \leqslant y \iff u \leqslant y \text{ for all } u \in B \text{ such that } u \leqslant x.$$

**Fact 2.** Let $\mathbf{int}_B : L \to L$ be any interior operator with base $B$. Then

(i) $\mathbf{int}_B$ is monotone, meaning that $x \leqslant y$ implies $\mathbf{int}_B\, x \leqslant \mathbf{int}_B\, y$.
(ii) $\mathbf{int}_B \leqslant 1_L$, i.e., $\mathbf{int}_B\, x \leqslant x$ for every $x \in L$.
(iii) $\mathbf{int}_B$ is idempotent, i.e. $\mathbf{int}_B \circ \mathbf{int}_B = \mathbf{int}_B$.
(iv) For each $x \in L$, we have $x \leqslant \mathbf{int}_B\, x$ (in addition to (ii) $\mathbf{int}_B\, x \leqslant x$) iff $x$ is a join of elements of $B$.

Joins of elements of $B$ are called *opens for* $\mathbf{int}_B$. Let us write $\mathcal{O}_{\mathbf{int}_B}$ for the family of opens for $\mathbf{int}_B$; then $\mathcal{O}_{\mathbf{int}_B} = \{ u \in L \mid u \leqslant \mathbf{int}_B\, u \}$ by (iv). A family of joins, $\mathcal{O}_{\mathbf{int}_B}$ is closed under arbitrary joins, so we may call it the *topology for* $\mathbf{int}_B$: in this paper, by a topology let us mean any family of elements that is closed under arbitrary joins, while we say that a topology is *proper* if it is also closed under finite meets. $\mathcal{O}_{\mathbf{int}_B}$ is a proper topology if $B$ is closed under finite meets—in which case $\mathbf{int}_B \top$ satisfies

$$\top \leqslant \mathbf{int}_B \top, \tag{2}$$

$$\mathbf{int}_B\, x \wedge \mathbf{int}_B\, y \leqslant \mathbf{int}_B(x \wedge y). \tag{3}$$

(i)–(iii) of Fact 2 mean that a modal operator $\square$ interpreted by $\mathbf{int}_B$ satisfies the corresponding rule and axioms. If moreover $B$ is closed under finite meets and $\mathcal{O}_{\mathbf{int}_B}$ is therefore a proper topology, then $\square$ satisfies the axioms corresponding to (2)–(3) and therefore satisfies the modal logic S4.

2.2. **Evidence-based topological semantics.** The evidence-based approach generates an interior operator $\mathbf{int}_B$ from a base $B$, so that $\mathbf{int}_B$ interprets a sort of knowledge modality and $B$ a set of pieces of evidence. This interpretation relies on

**Fact 3.** Given any interior operator $\mathbf{int}_B : L \to L$, for every $w, x \in L$ we have

$$w \leqslant \mathbf{int}_B\, x \iff w \leqslant u \leqslant x \text{ for some } u \in \mathcal{O}_{\mathbf{int}_B}.$$

This fact has a special case, in the form of Corollary 5 below, that connects our point-free formulation to the point-set, possible-world semantics by using the following notion of *tiny* elements as worlds:

**Definition 4.** We say that an element $w$ of a complete lattice $L$ is tiny to mean that, if $w \leqslant \bigvee_{x \in I} x$ for $I \neq \varnothing$, then $w \leqslant y$ for some $y \in I$.

When $L$ is a powerset in particular, $w \in L$ is tiny iff it is either empty or a singleton—so that the condition that $w \leqslant y$ for nonempty $w$, i.e. that the element of the singleton $w$ lies in the set $y$, can be read as if the proposition $y$ being true at the possible world $w$.

**Corollary 5.** Given any $\mathbf{int}_B : L \to L$ and $w, x \in L$, when $w$ is tiny we have

$$w \leqslant \mathbf{int}_B\, x \iff w \leqslant u \leqslant x \text{ for some } u \in B. \tag{4}$$

Baltag et al. [1], for instance, read (4) as the following truth condition: the proposition "the agent has factive evidence that $x$" is true at the world $w$ iff there is some piece of evidence corresponding to a proposition that is true at $w$ and entails $x$. In a slightly different reading, Kishida [5] reads the same as follows: $x$ is verifiably true at $w$ iff there is some observable proposition that is true at $w$ and entails $x$.

Let us take an example scenario from [5], in which the agent makes an infinite series of coin tosses. The series is represented by taking the Cantor space $2^{\mathbb{N}}$ as the set of worlds: for the world $w : \mathbb{N} \to 2$, $w(n) = 1$ means that the $(n+1)$st toss comes up heads in $w$. In the scenario, what we can directly observe is the outcome of each toss and finite combinations thereof—which is to set $u \in B$ iff $u$ is a finite intersection of $\{ w \in 2^{\mathbb{N}} \mid w(n) = i \}$ for $n \in \mathbb{N}$ and $i \in 2$. By contrast, when we write $x$ for the proposition that some toss comes up heads, we have $x \notin B$ since $x$ is an existential proposition and not directly observable. Nonetheless, $\mathbf{int}_B$—which is exactly the interior operator of the Cantor space—has $\mathbf{int}_B\, x = x$, so that $x$ is verifiably true if true at all: if $x$ is true in $w$, there is some toss, say the $(n+1)$st, that comes up heads in $w$, so you can verify $x$ by directly observing that outcome.

## 3. Our Evidence-Free Approach: A Proposal

3.1. **From a monotone map to a topology.** The novelty of our evidence-free approach to topological semantics is, formally speaking, the use of a monotone map $\vartriangle : L \to L$ rather than a subset $B \subseteq L$ as a primitive component of the semantics. This setup relies on the observation that the notion of opens makes sense not only for interior operators but for monotone maps in general.

**Definition 6.** Let $L$ be a complete lattice and $\vartriangle : L \to L$ be any monotone map on $L$. We say $x \in L$ is *open for* $\vartriangle$ if $x \leqslant \vartriangle x$. By the *topology for* $\vartriangle$ we mean the family

$$\mathcal{O}_{\vartriangle} = \{\, u \in L \mid u \leqslant \vartriangle u \,\}. \tag{5}$$

This terminology, extending the concept of opens from those for interior operators $\mathbf{int}_B$ to those for monotone maps $\vartriangle$, is justified by several facts, and most notably the following, which implies that $\mathcal{O}_{\vartriangle} = \mathcal{O}_{\mathbf{int}_{\mathcal{O}_{\vartriangle}}}$.

**Fact 7.** Given any complete lattice $L$, the following diagram commutes, where $\mathrm{Sub}_{\mathbf{Sets}}(L)$ is the family of all subsets of $L$; $\mathrm{Sub}_{\mathbf{CSLat}_\vee}(L)$ is the family of topologies (in the non-strict sense) on $L$, i.e., subsets of $L$ that are closed under arbitrary joins; $\mathbf{Pos}(L, L)$ is the family of all monotone maps on $L$; and $\mathbf{Int}(L)$ is the family of interior operators on $L$, i.e., idempotent monotone maps $\square$ s.th. $\square \leqslant 1_L$.

$$\begin{tikzcd}
\mathrm{Sub}_{\mathbf{CSLat}_\vee}(L) \arrow[r, shift right, "\mathbf{int}_-"'] & \mathbf{Int}(L) \arrow[l, shift right, "\mathcal{O}_-"'] \\
\mathrm{Sub}_{\mathbf{Sets}}(L) \arrow[ur, "\mathbf{int}_-"] & \mathbf{Pos}(L, L) \arrow[ul, "\mathcal{O}_-"']
\end{tikzcd}$$

The top row of the commutative diagram above means that interior operators and topologies are in one-to-one correspondence and carry the same information. On the other hand, subsets $B$ and monotone maps $\vartriangle$ carry more information: once we generate interior operators or topologies from them, this information is lost. Indeed, the information carried by $B$ and that by $\vartriangle$ are generally not comparable: we cannot extract the information carried by a subset (or, respectively, a monotone map) to the format of a monotone map (or a subset) without generating an interior operator (or a topology) and thereby losing some information.

We may add that $\mathcal{O}_{\vartriangle}$ is a proper topology if $\vartriangle$ satisfies the axioms (2)–(3) (in place of $\mathbf{int}_B$).

3.2. **Evidence-free topological semantics.** The evidence-based approach to topological semantics provides conceptually cogent readings for an interior operator $\mathbf{int}_B$ generated from a base $B \subseteq L$. Our aim in this subsection is to demonstrate that an equally cogent reading is available to an interior operator $\mathbf{int}_{\mathcal{O}_{\vartriangle}}$ generated from a monotone $\vartriangle : L \to L$.

By the definition of $\mathcal{O}_{\vartriangle}$, Fact 3 entails

**Corollary 8.** Given any monotone map $\vartriangle : L \to L$ and the interior operator $\mathbf{int}_{\mathcal{O}_{\vartriangle}} : L \to L$ it generates, for every $w, x \in L$ we have

$$w \leqslant \mathbf{int}_{\mathcal{O}_{\vartriangle}}\, x \iff w \leqslant u \leqslant x \text{ for some } u \text{ such that } u \leqslant \vartriangle u. \tag{6}$$

Read epistemically, (6), like (4), stipulates that "the agent knows that $x$" (in whatever suitable sense of "know" that we need to figure out) is true at the world $w$ iff there is some proposition $u$ that is true at $w$ and entails both $x$ and $\vartriangle u$. Here the significance of the condition that $w \leqslant u \leqslant x$ (i.e. $u$ is true at $w$ and entails $x$) can be the same as in the evidence-based approach. Therefore the crucial step in finding a suitable reading of (6) is to provide the other condition on the right-hand side, that $u \leqslant \triangle u$ (i.e. $u$ entails $\triangle u$) or that $u$ is an open for $\triangle$, with a suitable significance.

Here is a proposal: let us read $\triangle$ as "the agent believes that", and read the condition $u \leqslant \triangle u$ as stating that the proposition or fact that $u$, if true, induces the agent's belief that $u$. For instance, go back to the example of infinite coin tosses, and let $u$ be "the second toss comes up heads", so that $\triangle u$ is "the agent believes that the second toss comes up heads". Certainly, the condition $u \leqslant \triangle u$, as opposed to $u = \triangle u$, leaves possible the case in which $\triangle u$ is true while $u$ is not—so that the agent may believe that the second toss comes up heads when it actually does not. The assumption that $u \leqslant \triangle u$, however, is supposed to mean that the event of the second toss actually coming up heads induces the agent to believe that it comes up heads.

Given this interpretation of the condition $u \leqslant \triangle u$ as $u$ being belief-inducing, we can now read (6) epistemically as follows, taking advantage of a conception of knowledge as justified true belief:

- "the agent has *induced true belief* that $x$" is true at the world $w$ iff there is a belief-inducing proposition $u$ that is true at $w$ and entails $x$.

3.3. **Logic of belief and induced true belief.** One advantage of our evidence-free approach over the evidence-based one is that a monotone map $\triangle : L \to L$ from which we generate an interior operator $\mathbf{int}_{O_\triangle}$ can be taken as a modal operator itself. The logic with two modal operators, $\mathbf{int}_{O_\triangle}$ and $\triangle$, can then describe the primitive component of the semantics, i.e. $\triangle$, whereas from the logic of the evidence-based approach one cannot uniquely recover the primitive component of the semantics, i.e. the base—unless one adds more vocabulary to the logic such as the global necessity operator.

Combining (1) and (5) gives the following characterization of $\mathbf{int}_{O_\triangle}$: given any $x \in L$, $\mathbf{int}_{O_\triangle} x$ is the unique element such that, for any $y \in L$,

$$\mathbf{int}_{O_\triangle} x \leqslant y \iff u \leqslant y \text{ for all } u \in L \text{ such that } u \leqslant \triangle u \text{ and } u \leqslant x. \tag{7}$$

Then here is the principal theorem of this paper:

**Theorem 9.** *Let $\triangle : L \to L$ be any monotone map on $L$. Then a function $\Box : L \to L$ satisfies* (7) *in place of* $\mathbf{int}_{O_\triangle}$*—i.e. equals* $\mathbf{int}_{O_\triangle}$*—iff it satisfies the axioms*

$$\Box x \leqslant x, \tag{8}$$

$$\Box x \leqslant \triangle \Box x, \tag{9}$$

*and the rule*

$$\frac{u \leqslant \triangle u \qquad u \leqslant x}{u \leqslant \Box x}. \tag{10}$$

In other words, given a belief operator $\triangle$ that satisfies the rule corresponding to monotonicity, the axioms and rule corresponding to (8)–(10) axiomatize the induced true belief $\Box$. The principles corresponding to the monotonicity and idempotence of $\Box$ are derivable in this logic. So is

$$\Box x \leqslant \triangle x. \tag{11}$$

(10), (8), and (11) respectively state that $\Box$ means induced, true, and belief.

In addition, if $\triangle$ satisfies the axioms (2)–(3) (in place of $\mathbf{int}_B$) then $O_\triangle$ is a proper topology and hence $\Box = \mathbf{int}\, O_\triangle$ satisfies the same axioms and therefore the modal logic S4.

Finally, we have

**Theorem 10.** *For this logic of belief and induced true belief, we have soundness and completeness, both with respect to complete lattices equipped with a monotone map and with respect to powersets equipped with a monotone map.*

## 4. Common Knowledge

The formalism introduced in this paper is applicable to axiomatization and semantics of common knowledge. Axiomatically speaking, when we read $\triangle$ as distributed knowledge—assumed to satisfy $\triangle \leqslant 1_L$—of all agents, (8)–(9) and (11) along with the monotonicity of $\triangle$ mean that $\Box$ satisfies $\Box x = \triangle(\Box x \wedge x)$, the fixed-point characterization of common knowledge. A similar point is made semantically by

**Fact 11.** Let $\triangle$ be the necessity operator of a binary relation $R$. Then $\Box$ satisfying (8)–(10) is the necessity operator of the reflexive and transitive closure of $R$.

It is beneficial to compare this application with a similar work by Lismont and Mongin [6]. Lismont and Mongin use the condition $u \leqslant \triangle u$—which they call "belief-closure" whereas we call it belief-inducing—to generate common belief from distributed belief, albeit in the point-set rather than point-free setting. The core difference between the work of Lismont and Mongin and ours is that the former generates common *belief* $\Box$ from distributed belief $\triangle$, while our primary goal is to generate, even from belief $\triangle$, knowledge or justified *true* belief $\Box$. (Or, put more formally, topological *interior* operators are the target of our work but not Lismont and Mongin's.) Instead of (6), Lismont and Mongin have

$$w \leqslant \Box x \iff w \leqslant \triangle u \text{ and } u \leqslant x \text{ for some } u \text{ such that } u \leqslant \triangle u.$$

This results in a logic that is the same as ours except that (8) is missing, and, instead of Fact 11, the fact that $\Box$ is the necessity operator of the transitive (as opposed to reflexive and transitive) closure of $R$.

## 5. Conclusion

This paper has introduced a new approach to topological semantics of epistemic logic, viz., the evidence-free approach to justified true belief as an alternative to the evidence-based approach. The core idea is to take advantage of the belief-inducing property of a proposition $u$—i.e. that $u$ entails an agent's belief that $u$—by interpreting it as providing a criterion of $u$ being justified. This idea has given rise to a new logic of belief and justified true belief.

As an example of future work in this new approach, one may investigate what additional restrictions on the semantics would make $\Box$ behave more suitably as justified true belief. For instance, one may argue that it is reasonable to assume an agent's belief to satisfy the axioms (2)–(3) so that the logic of justified true belief is (at least) the modal logic S4. One may look for more axioms and rules that an agent's belief should satisfy in a similar fashion. Or one may look for reasonable conditions or assumptions that make it more plausible to interpret $u \leqslant \triangle u$ as belief induction.

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## References


[1] A. Baltag, N. Bezhanishvili, A. Özgün, and S. Smets, "Justified Belief, Knowledge, and the Topology of Evidence", *Synthese* 200:512 (2022).

[2] J. van Benthem and E. Pacuit, "Dynamic Logics of Evidence-Based Beliefs", *Studia Logica*, 99:1 (2011), 61–92.

[3] J. van Benthem, D. Fernández-Duque, D., and E. Pacuit, "Evidence Logic: A New Look at Neighborhood Structures", in Thomas Bolander, Torben Braüner, Silvio Ghilardi, and Larry Moss, eds., *Advances in Modal Logic Volume 9*, London: College Publications, 2012, pp. 97–118.

[4] K. Kelly, *The Logic of Reliable Inquiry*, Oxford: Oxford University Press, 1996.

[5] K. Kishida, *Generalized Topological Semantics of First-Order Modal Logic*, Ph.D. dissertation, University of Pittsburgh, 2010.

[6] L. Lismont and P. Mongin, "Belief Closure: A Semantics of Common Knowledge for Modal Propositional Logic", *Mathematical Social Sciences* 30:2 (1995), 127–153.

# Distributional, yes—but *semantics*? Comparing distributional representations, semantics and syntax

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## 1 Motivations

Vector-based word representations are probably one of the most noteworthy outcomes of the field of Natural Language Processing (NLP): The introduction of static neural embeddings such as the word2vec model of Mikolov et al. (2013) was in many respect paradigm-shifting and ushered a change of tooling from statistical to neural-based models. This change was soon to be followed by the adoption of contextualized embeddings (e.g., Peters et al., 2018). Both static and contextual embeddings have been argued to fall under the field of distributional semantics (DS, Lenci et al., 2022; Apidianaki, 2022), although what we construe of the distributional approach has noticeably strayed from its original definition (Brunila and LaViolette, 2022) and not all properties of contextual embeddings align well with what one expects of other DS representations (Mickus et al., 2020). This very name of distributional semantics is however begging a question: What evidence do we have that embeddings are indeed meaning representations? In fact, Harris (1954) was careful to present distributional structure as correlated with, but distinct from meaning structure. Moreover the historical review of Sahlgren (2008) also underscores how DS is rooted in the structuralist concepts of syntagmatic and paradigmatic axes—which can be construed as constraints of grammaticality, and thereby falling under the umbrella of syntax.

## 2 First experiment: Structural similarity

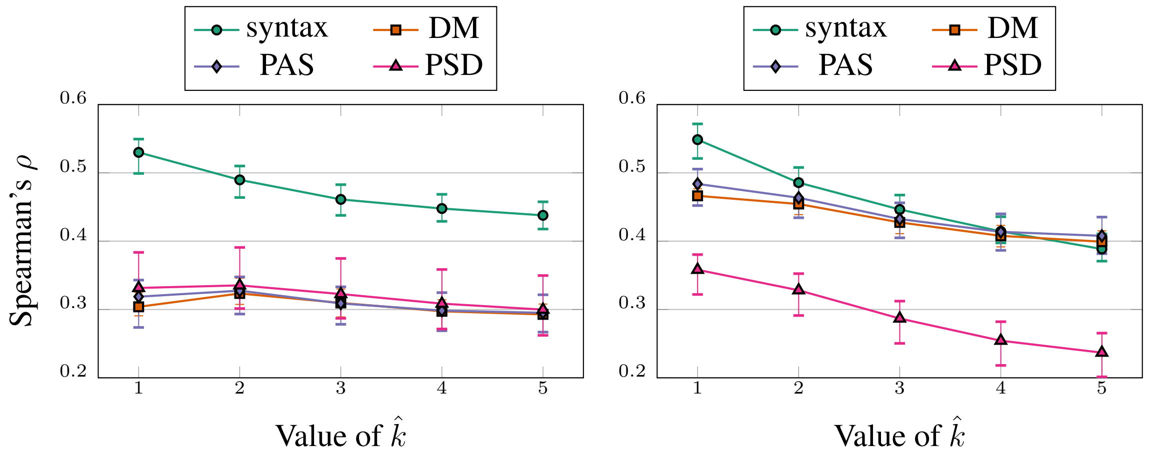
This background motivates the present study, in which we investigate whether distributional representations are more in line with semantic or syntactic structures. The approach we elicit borrows from topographical similarity (Brighton and Kirby, 2006): We derive correlation scores from measurements, on pairs of sentences, of how similar they are in terms of linguistic structure (either syntactic or semantic), and of how similar they are in distributional terms.

**Methodology.** We measure distributional similarity in two ways: (i) with BERTScore (Zhang et al., 2020), a method for measuring how similar two texts are based on the BERT embeddings of their tokens; and (ii) using the negative word mover's distance (Kusner et al., 2015, WMD) between word2vec vectors trained on English Wikipedia.[1] We measure structural similarity scores based on either syntactic dependency trees or one of three kinds of semantic dependency graphs, and rely on a variation of a Jaccard index (Jaccard, 1912) tailored to factor in structural information. Formally, given a labeled directed graph $G$ and noting an edge from node $n_{\text{in}}$ to node $n_{\text{out}}$ with label $\ell$ as $\langle n_{\text{in}}, n_{\text{out}}, \ell\rangle$, we define the *structural view of depth* $k \in \mathbb{N}$ of $G$ as the following multiset of sequences of labels:

$$\mathrm{v}_k(G) = \left\{ (\ell_1, \ldots, \ell_k) \mid \exists n_1, \ldots, n_{k+1}, \langle n_1, n_2, \ell_1\rangle, \ldots, \langle n_k, n_{k+1}, \ell_k\rangle \in G \right\} \quad (1)$$

The parameter $k$ allows us to control whether we focus on shallow or deep structural relations. Then, given some $\hat{k} \in \mathbb{N}$, we consider $\mathrm{v}_{\leq\hat{k}}(G) = \bigcup_{k=1}^{\hat{k}} \mathrm{v}_k(G)$, the union of all structural views of

[1] http://vectors.nlpl.eu/repository/, model 6.




(a) Using BertScore as distributional similarity

(b) Using negative WMD between word2vec vectors as distributional similarity

Figure 1: Spearman correlation between distributional similarity and structural depth similarity, as a function of the maximum structural depth $\hat{k}$. Observations aggregated over 5 runs; error bars indicate extrema.

depth $1 \leq k \leq \hat{k}$ to compute a similarity score for two graphs $G_a, G_b$:

$$\text{similarity}(G_a, G_b) = \frac{\left|\mathrm{v}_{\leq \hat{k}}(G_a) \cap \mathrm{v}_{\leq \hat{k}}(G_b)\right|}{\left|\mathrm{v}_{\leq \hat{k}}(G_a) \cup \mathrm{v}_{\leq \hat{k}}(G_b)\right|} \tag{2}$$

with $|S|$ the cardinal number of multiset $S$. Eq. (2) exhibits a number of interesting properties. First, it is equally applicable to syntactic trees and semantic DAGs and can be computed with a relatively low time complexity of $O(N\hat{k})$, where $N$ is the number of nodes in $G_a$ and $G_b$. In addition, eq. (2) assigns greater importance to longer matching sequences of labels, in the sense that any matching sequence of labels of length $k$ comes with two matching subsequences of length $k-1$, three of length $k-2$, etc.

For each sentence, we use the Stanford Basic dependencies trees derived from the PTB and the three semantic graphs (DM, PAS, PSD) provided by the SemEval 2015 shared-task 18 (Oepen et al., 2015). We (i) randomly select 1000 sentences from the dataset, (ii) compute all distinct pairwise distributional similarity scores (i.e., BERTScores or WMD), (iii) compute all distinct pairwise structural similarity scores (i.e., applying eq. (2) using one of the four kinds of structure), and finally (iv) compute a Spearman correlation between the two collections of scores.

**Results.** Quantitative results for this first experiment aggregated over 5 runs are shown in Figure 1. A number of interesting remarks emerge from these computations. Firstly, we observe that syntactic information systematically yields higher correlations than semantic information. This is especially prevalent in Figure 1a. In other words, distributional similarity, as captured here, is more in line with purely syntactic information than semantic one. Yet, WMD-based distributional similarity scores in Figure 1b suggest that, for values of $\hat{k} > 3$, DM and PAS semantic dependencies can yield correlations as high as syntactic dependencies—i.e., they are in this case an equally good fit for explaining what is captured by WMD distributional similarity assessments. Note however that maximal correlation scores are always obtained with syntax.

Secondly, we observe a general downward trend: In BERTScore-based measurements, while syntactic dependency graphs yield a correlation of $\rho = 0.531$ with a maximum structural depth of $\hat{k} = 1$, this correlation score falls to $\rho = 0.438$ when considering $\hat{k} = 5$. Under WMD assessments, the contrast is even starker, falling from $\rho = 0.549$ at $\hat{k} = 1$ to $\rho = 0.388$ at $\hat{k} = 5$. This suggests that distributional similarity is more in line with shallow syntactic information, rather than deep dependency paths. Interestingly, for BERTScore, the maximum with semantic dependency graphs is almost always obtained at $\hat{k} = 2$, suggesting that a minimal amount of depth can alleviate the discrepancy between semantic and distributional similarity measurements when using contextualized embeddings.

Thirdly, we find a very different behavior when looking at BERT-based distributional similarity assessments in Figure 1a and at word2vec-based WMD assessments in Figure 1b: In the former case, syntax is very distinct from all semantic annotations, whereas in the latter case, we find that PSD is a comparatively poorer fit than other annotation schemes. This can tentatively be explained by characteristics of the various annotation schemes: DM and PAS are known to be structurally closer to each other than to PSD, and PSD use a finer-grained inventory of dependency labels; in addition, PSD graphs are harder to predict (Oepen et al., 2015).

## 3 Second experiment: Binarization

We have discussed above how semantic structural information is less appropriate than syntactic information to describe what distributional representations encode. Equally important is a question of *format*: Can dense embedding vectors be converted into high-dimensional Boolean and, hopefully, interpretable vectors? Similar attempts have been made in previous works (e.g., Kruszewski et al., 2015; Arora et al., 2018), although for different motivations.

**Methodology.** We use autoencoders, where both encoder and decoder are MLPs, and the encoder ends with a sigmoid activation. Given an embedding $\mathbf{e} \in \mathbb{R}^d$, we define the networks as:

$$\begin{aligned} \mathbf{z} &= \mathrm{Enc}(\mathbf{e}) \in [0,1]^{d'} \\ \hat{\mathbf{e}} &= \mathrm{Dec}(\mathbf{z}) \in \mathbb{R}^d \end{aligned} \tag{3}$$

Models are trained to minimize the mean squared error (MSE) between input embeddings $\mathbf{e}$ and output reconstructed embeddings $\hat{\mathbf{e}}$. We further encourage these networks to produce binary latent representations by means of an auxiliary loss:

$$\mathcal{L}_{\text{bin}} = -\sum_{\mathbf{e} \in E} \mathrm{MSE}\left(\mathbf{z}, \begin{bmatrix} 0.5 \\ \vdots \\ 0.5 \end{bmatrix}\right) \tag{4}$$

In addition, to teach the system to treat the encoding $\mathbf{z}$ as Boolean vectors, we also introduce a schedule that progressively pushes the model towards stricter training conditions. Assuming that we are at the $i^{\text{th}}$ of a total of $N$ training steps, each coefficient of $\mathbf{z}$ is rounded (to 0 or 1) with probability $(\frac{i}{N})^\alpha$ where $\alpha > 0$ is a hyperparameter. We train autoencoders to reconstruct the set of word2vec embeddings of dimension $d = 300$ used in the previous experiment, with two hidden layers of dimension 300 in the encoder and decoder MLPs and a GELU activation.

**Hyperparameter exploration results.** Before trying to interpret the resulting binary features, our first aim is to establish whether such a binarization process can be learned efficiently, and we therefore strive to explore the hyperparameter space efficiently. We consider two latent representation dimensions $d' \in \{5\,000, 10\,000\}$, and rely on Bayesian optimization (Snoek et al., 2012) to search for optimal values of learning rate, weight decay, dropout, weight associated to $\mathcal{L}_{\text{bin}}$, and $\alpha$, with a budget of 100 models and a prior constructed by 10 random initial samples.

MSE scores achieved by the models tested during the two Bayesian optimization processes are shown in Figure 2; hues correspond to values of $d'$. Two useful baselines to keep in mind when

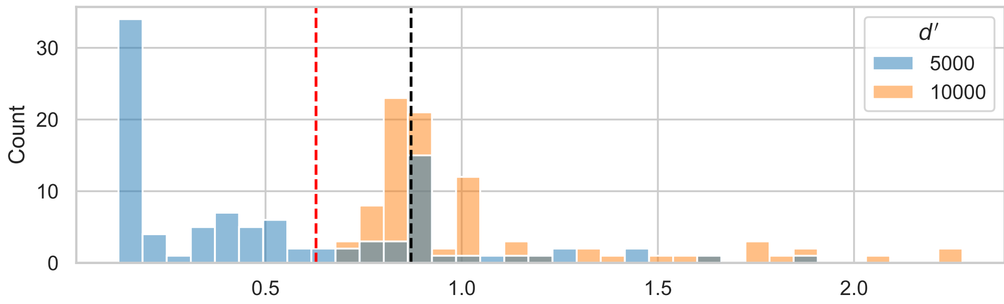



Figure 2: Embedding reconstruction MSE across all configurations explored, except outliers (MSE > 10). Black line: MSE obtained by comparing each embedding to the barycenter; red line: MSE obtained by comparing each embedding to its nearest neighbor.

considering the accuracy are (i) the MSE that one would obtain by comparing any embedding to the barycenter of the entire embedding set ($\approx 0.871$ in our case), and (ii) the MSE that one would obtain by comparing any neighbor to its closest neighbor ($\approx 0.629$). The former of these baseline is shown as the black dashed line in Figure 2, and the latter as the red dashed line.

Considering $d' = 10\ 000$, we can immediately notice that, while a number of hyperparameter configurations in fact manage to surpass the barycenter baseline, none outperform the closest-neighbor baselines. In simpler terms, this means that this setup fails to produce high-dimensional Boolean vector maps descriptive enough to distinguish a word from its nearest neighbor. Turning to $d' = 5\ 000$, we however find a successful optimization process: many of the models tested significantly outperform both baselines. This exemplifies the difficulties inherent to converting dense vectors into Boolean vectors: Large enough values of $d'$ are required to ensure that the Boolean vectors capture all the information present in the original dense embeddings, but this can significantly complicate training these models. In what follows, we focus on the most successful model with $d' = 5\ 000$, which achieves a MSE of $\approx 0.125$.

**Relating Booleans to linguistic information.** One aspect we have thus far left aside is what information these Booleans encode: It is equally possible that they encode pure spatial information owed to the random initialization of the embedding space, linguistic information accrued to solve the training objective (be it semantic or syntactic), or a combination of both. *A minima*, we are interested in establishing that some of these Booleans do convey linguistic information. We therefore consider learning decision trees to perform tagging: either tagging the Boolean vector representations of words according to their WordNet super-senses (Fellbaum, 1998; using the dataset of Tikhonov et al., 2023) or their WordNet POS tags. The former can be seen as testing the presence of semantic information, and the latter syntactic information.

For ease of interpretation, we use binary classification decision trees. To train these decision trees, we use data that are randomly downsampled to guarantee a balanced proportion of positive and negative examples; we report the accuracy on held-out test sets, aggregated over five trials (corresponding to different random downsamples). Decision trees are implemented in `scikit-learn` (Pedregosa et al., 2011) using the Gini criterion. We set maximum number of features, minimum weight fraction of leaves, minimum number of samples in leaves and minimum samples in split hyperparameters for the decision tree algorithm using Bayesian Optimization, all other hyperparameters (maximum depth and minimum impurity decrease) are left as default. For comparison, we also include similar results using the original dense embeddings.

The results are listed in Table 1. We can make three broad remarks. First, decision trees attain

| tag | Boolean vectors | | | original dense embeddings | | |
|---|---|---|---|---|---|---|
| | acc (%) | n. leaves | depth | acc (%) | n. leaves | depth |
| **act** | 68.8 ± 1.2 | 6.2 ± 4.0 | 3.2 ±1.3 | 63.8 ± 2.4 | 205.8 ±225.0 | 15.6 ±12.3 |
| **artifact** | 76.6 ± 2.3 | 90.8 ±174.1 | 8.8 ±7.0 | 71.1 ± 1.3 | 151.8 ±194.4 | 13.8 ±11.3 |
| **attribute** | 72.7 ± 1.5 | 7.8 ± 1.9 | 4.2 ±0.4 | 68.7 ± 2.8 | 58.8 ±107.5 | 9.6 ± 8.2 |
| **cognition** | 72.6 ± 2.5 | 12.6 ± 6.2 | 6.2 ±1.3 | 68.2 ± 1.6 | 98.8 ±128.0 | 11.4 ±11.6 |
| **communication** | 72.2 ± 2.4 | 77.0 ±142.8 | 9.8 ±7.1 | 65.9 ± 1.1 | 139.2 ±155.6 | 11.6 ± 5.8 |
| **person** | 81.4 ± 1.9 | 73.2 ±140.2 | 10.6 ±5.9 | 72.8 ± 1.2 | 375.4 ± 17.3 | 24.0 ± 5.2 |
| **state** | 73.6 ± 1.4 | 6.8 ± 6.3 | 3.8 ±2.4 | 68.5 ± 2.1 | 51.0 ± 79.9 | 7.6 ± 4.3 |
| **a** | 79.7 ± 6.4 | 5.4 ± 4.3 | 4.2 ±4.1 | 74.1 ± 8.4 | 5.6 ± 5.4 | 2.8 ± 2.5 |
| **n** | 89.1 ± 2.6 | 8.4 ± 6.6 | 7.4 ±6.6 | 69.7 ± 2.6 | 4.6 ± 2.7 | 2.6 ± 1.5 |
| **r** | 90.0 ±14.9 | 2.6 ± 1.1 | 1.6 ±1.1 | 91.4 ± 7.8 | 4.4 ± 3.3 | 2.2 ± 1.6 |
| **v** | 68.7 ± 2.3 | 68.6 ±128.5 | 9.4 ±7.1 | 63.5 ± 0.9 | 206.2 ±266.1 | 14.2 ±14.0 |

Table 1: Accuracy, number of leaves and depth of decision trees (± standard deviation).

higher than-chance accuracy scores in all scenarios we consider, which establishes that (some) combinations of components in both the Boolean and the dense vectors that we study correspond to linguistically meaningful information.

Second, Boolean vectors perform better than original dense representations, suggesting that this binarization procedure is at least helpful for disentangling spatial and linguistic information. This point is made stronger by the analysis of the shape of the decision trees. A shallow, narrow tree with few branches would indicate that a linguistic feature is easy to grasp and relies on few Boolean features. As we can see, dense embeddings often yield trees that are much more complex than what we observe for Boolean vectors, as well as higher variances. Likewise, semantic super-sense tagging often seems to require more leaves than syntactic POS tagging.

Third, we observe generally higher accuracy scores with POS tags as well as higher variance across trials for POS tags, rather than super-sense tags (although this does not hold for verbs). This higher average suggests that distributional representations tend to align more with syntactic information than semantic information (in line with conclusions from our first experiment). The surprisingly high variance we observe can tentatively be explained by positing that syntactic information tends to be encoded in an irregular fashion, and that as such different random samples lead to widely different behaviors, depending on what was selected.[2]

## 4 Conclusions

We have outlined two experiments attempting to test whether distributional representations ought to be construed as capturing semantic information. In the first, we have tested whether distributional similarity was more in line with semantic or syntactic structures, and found (i) that distributional similarity correlated more with syntax than semantics and (ii) that it correlated more with shallower structural information (be it syntactic or semantic). In the second experiment, we have discussed whether it is empirically straightforward to convert dense representations into high-dimensional Boolean vectors, and stressed the difficulty of this endeavor. Nonetheless, Boolean components of successfully converted models appear to properly encode linguistic information. Furthermore, here as well we find more evidence suggesting that distributional representations align more closely with syntax than semantics.

[2] Another possible, though unverified explanation that we leave for future work is overfiting. If the decision trees overfit their training data, we can conjecture that this is due to a more redundant encoding of syntactic information in Boolean vectors: That decision trees pick up on patterns that do not generalize well more often suggest that such patterns are more abundant.

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## References

Marianna Apidianaki. 2022. From Word Types to Tokens and Back: A Survey of Approaches to Word Meaning Representation and Interpretation. *Computational Linguistics*, 49(2):465–523.

Sanjeev Arora, Yuanzhi Li, Yingyu Liang, Tengyu Ma, and Andrej Risteski. 2018. Linear algebraic structure of word senses, with applications to polysemy. *Transactions of the Association for Computational Linguistics*, 6:483–495.

Henry Brighton and Simon Kirby. 2006. Understanding linguistic evolution by visualizing the emergence of topographic mappings. *Artif. Life*, 12(2):229–242.

Mikael Brunila and Jack LaViolette. 2022. What company do words keep? revisiting the distributional semantics of J.R. Firth & Zellig Harris. In *Proceedings of the 2022 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies*, pages 4403–4417, Seattle, United States. Association for Computational Linguistics.

Christiane Fellbaum. 1998. *WordNet: An Electronic Lexical Database*. Bradford Books.

Zellig S. Harris. 1954. Distributional structure. *Word*, 10(2-3):146–162.

Paul Jaccard. 1912. The distribution of the flora in the Alpine zone. *New Phytologist*, 11(2):37–50.

German Kruszewski, Denis Paperno, and Marco Baroni. 2015. Deriving Boolean structures from distributional vectors. *Transactions of the Association for Computational Linguistics*, 3:375–388.

Matt Kusner, Yu Sun, Nicholas Kolkin, and Kilian Weinberger. 2015. From word embeddings to document distances. In *Proceedings of the 32nd International Conference on Machine Learning*, volume 37 of *Proceedings of Machine Learning Research*, pages 957–966, Lille, France. PMLR.

Alessandro Lenci, Magnus Sahlgren, Patrick Jeuniaux, Amaru Cuba Gyllensten, and Martina Miliani. 2022. A comparative evaluation and analysis of three generations of distributional semantic models. *Lang. Resour. Eval.*, 56(4):1269–1313.

Timothee Mickus, Denis Paperno, Mathieu Constant, and Kees van Deemter. 2020. What do you mean, BERT? In *Proceedings of the Society for Computation in Linguistics 2020*, pages 279–290, New York, New York. Association for Computational Linguistics.

Tomas Mikolov, Wen-tau Yih, and Geoffrey Zweig. 2013. Linguistic regularities in continuous space word representations. In *Proceedings of the 2013 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies*, pages 746–751, Atlanta, Georgia. Association for Computational Linguistics.

Stephan Oepen, Marco Kuhlmann, Yusuke Miyao, Daniel Zeman, Silvie Cinková, Dan Flickinger, Jan Hajič, and Zdeňka Urešová. 2015. SemEval 2015 task 18: Broad-coverage semantic dependency parsing. In *Proceedings of the 9th International Workshop on Semantic Evaluation (SemEval 2015)*, pages 915–926, Denver, Colorado. Association for Computational Linguistics.

F. Pedregosa, G. Varoquaux, A. Gramfort, V. Michel, B. Thirion, O. Grisel, M. Blondel, P. Prettenhofer, R. Weiss, V. Dubourg, J. Vanderplas, A. Passos, D. Cournapeau, M. Brucher, M. Perrot, and E. Duchesnay. 2011. Scikit-learn: Machine learning in Python. *Journal of Machine Learning Research*, 12:2825–2830.

Matthew E. Peters, Mark Neumann, Mohit Iyyer, Matt Gardner, Christopher Clark, Kenton Lee, and Luke Zettlemoyer. 2018. Deep contextualized word representations. In *Proceedings of the 2018 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long Papers)*, pages 2227–2237, New Orleans, Louisiana. Association for Computational Linguistics.

Magnus Sahlgren. 2008. The distributional hypothesis. *The Italian Journal of Linguistics*, 20:33–54.

Jasper Snoek, Hugo Larochelle, and Ryan P Adams. 2012. Practical bayesian optimization of machine learning algorithms. In *Advances in Neural Information Processing Systems*, volume 25. Curran Associates, Inc.

Alexey Tikhonov, Lisa Bylinina, and Denis Paperno. 2023. Leverage points in modality shifts: Comparing language-only and multimodal word representations. In *Proceedings of the 12th Joint Conference on Lexical and Computational Semantics (*SEM 2023)*, pages 11–17, Toronto, Canada. Association for Computational Linguistics.

Tianyi Zhang, Varsha Kishore, Felix Wu, Kilian Q. Weinberger, and Yoav Artzi. 2020. Bertscore: Evaluating text generation with BERT. In *International Conference on Learning Representations*.

# Towards a Theory of Anaphoric Binding in Event Semantics

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**Abstract.** Scope and (anaphoric) binding are tough problems for event semantics. Unlike the former, the latter has not even been attempted, it seems. The present paper makes an attempt and reports on the ongoing work, in the context of polynomial event semantics.
Polynomial event semantics is a variable-free dialect of Neo-Davidsonian event semantics originally developed as a new approach to (quantifier) scope. Extended to relative clauses, it had to face traces, which is a form of anaphora. The present paper extends the mechanism proposed for traces to (nominal) pronouns. The same mechanism happens to also apply to discourse referents. Anaphoric binding becomes oddly symmetric.

## 1 Introduction

Pronouns and in general anaphora is the elephant in the room of event semantics. From surveys such as [7] or comprehensive treatments [2], among others, one may get an impression that anaphora is subject *non grata*. At least [8] explicitly says that "pronouns are not our main focus here, so I will not pursue it further." A theory of meaning and entailment, however, sooner or later must confront pronouns – and, eventually, crossover, gaps, ellipsis, donkey anaphora, paycheck pronouns, etc.

In contrast, a closely related problem of scope and quantification is widely acknowledged in event semantics literature, as event quantification problem, and has received considerable attention: see see [2] for survey. Dealing with quantification (and negation) in a non-traditional, variable-free way was the motivation for the polynomial event semantics [3, 4, 6] – a theory of meaning and entailment in a neo-Davidsonian tradition. It was later extended to relative clauses, including clauses with quantification and negation [5]. Giving denotations to traces, and paraphrasing relative clauses as independent matrix clauses linked via 'pronouns' came close to the treatment of anaphora.

The present work elaborates that approach and applies to pronouns and discourse referents, including bound-variable anaphora. Commonly, anaphoric binding is seen as asymmetric – which is particularly noticeable in dynamic semantics, which talks about "pushing discourse referents" and that a pronoun "pulls the value out of the context" [1]. On our account, however, we see a surprisingly symmetric picture of referents and pronouns.

## 2 Polynomial Event Semantics: Brief Reminder

As a reminder of the polynomial event semantics, (1) shows the denotation of a simple sample sentence. The denotation is clearly built compositionally, matching the structure of the sentence:

(1) $[\![\text{John traveled to Paris.}]\!] = (\mathsf{subj}'/\,\mathsf{john}) \ \cap\ \mathsf{Travel}\ \cap\ (\mathsf{toloc}'/\,\mathsf{paris})$

Here $\mathsf{john}$ and $\mathsf{paris}$ are individuals (notated $i$) and $\mathsf{Travel}$ is a set of events (notated $e$), specifically, traveling events. Further, $\mathsf{subj}'$ is a relation between events and individuals, viz. 'agents'.[1] The *relational selection* (or, restriction) $\mathsf{subj}'/\ \mathsf{john}$ is then the set of events whose 'agent' is John. Likewise, $\mathsf{toloc}'/\ \mathsf{paris}$, to be abbreviated as $\mathsf{TP}$, is the set of events involving Paris as the destination. The meaning of the whole sentence is the intersection of the meaning of its constituents: viz., the set of traveling events whose subject is John and destination is Paris. The denotation of a sentence is hence a set of events that witness it – or the formula like (1) that represents it, which may be regarded as a query of the record of world events. The sentence is true in that world if the result of the query is non-empty.

Simple sets do not suffice, however, when it comes to (distributive) coordination such as:

(2) $[\![\text{Bill and John traveled to Paris.}]\!] = \mathsf{subj}'/\ (\mathsf{john} \otimes \mathsf{bill}) \ \sqcap\ \mathsf{Travel} \ \sqcap\ \mathsf{TP}$

(3) $= (\mathsf{subj}'/\ \mathsf{john} \ \cap\ \mathsf{Travel} \ \cap\ \mathsf{TP}) \otimes (\mathsf{subj}'/\ \mathsf{bill} \ \cap\ \mathsf{Travel} \ \cap\ \mathsf{TP})$

We generalize individuals to poly-individuals, which beside individuals include groups built using $\otimes$, such as $\mathsf{john} \otimes \mathsf{bill}$, to be understood as both John and Bill have to be involved, but not necessarily together. Relational selection acts as homomorphism (or, 'commutes'):

$$\mathsf{subj}'/\ (\mathsf{john} \otimes \mathsf{bill}) = (\mathsf{subj}'/\ \mathsf{john}) \otimes (\mathsf{subj}'/\ \mathsf{bill})$$

The result is a group of event sets, called polyconcepts. Set intersection extended to polyconcepts is written as $\sqcap$. That is, if two polyconcepts $d_1$ and $d_2$ happen to be ordinary sets, then $d_1 \sqcap d_2 = d_1 \cap d_2$. The operation $\sqcap$ also applies to individuals and poly-individuals; in particular,

$$i_1 \sqcap i_2 = \begin{cases} i_1 & \text{if i1 = i2} \\ \perp & \text{otherwise} \end{cases}$$

where $\perp$ is the empty poly-individual/poly-concept.

The relational selection homomorphism and the distributive laws of [6] give (3). The sentence is hence justified by a pair of events, of John traveling to Paris, and of Bill.

For the choice "Either John or Bill" we introduce $\sqcup$ (when the choice is internal) or $\oplus$ (when external). Quantification is the generalization: "Everyone" is denoted by $\bigotimes_{i \in \mathsf{Person}} i$, to be abbreviated as $\mathcal{A}\ \mathsf{Person}$. A wide-scope existential and indefinite "a person" is $\bigoplus_{i \in \mathsf{Person}} i$ (abbreviated $\mathcal{I}\ \mathsf{Person}$) and the narrow-scope existential is $\bigsqcup_{i \in \mathsf{Person}} i$ (abbreviated $\mathcal{E}\ \mathsf{Person}$). Here $\mathsf{Person}$ is a set of individuals. For more detail (as well as negation, not used here), see [5, 6].

## 3 Polyconcepts in Context: Relative Denotations

The paper [5] applied the polynomial event semantics to relative clauses. For example, for the following noun-modification phrase we *derived* the intuitive denotation:

$$[\![\text{city John traveled to } \mathtt{T}]\!] = \mathsf{City} \cap \{i \mid [\![\text{John traveled to } i]\!] \neq \perp\}$$

[1] Since we take events in broad sense [7], including states, etc., 'agent' is to be understood as the event attribute roughly corresponding to the role played by the grammatical subject. Currently we take the events of, say, 'reading' and 'being read' as distinct, but relatable by semantic postulates.

where T is trace. The paper [5] derived the denotation in two ways, one of which is compositional – which means giving denotation to the trace T. We now elaborate this method and apply to pronouns and their referents.

To handle trace, [5] had to generalize denotations from poly-individuals (and poly-concepts) $d$ to relations between contexts and poly-individuals (resp. poly-concepts): in effect, set of pairs $\{(i, d) \mid i \in C\}$, for which we now adopt a more compact notation $d|i{:}C$. We call them relative denotations. The context $C$ at present is a set of individuals (although it may be any other set, or a tuple of sets). Any denotation $d$ can be converted – or embedded, relativized – to a relative denotation:

$$d \underset{\rho}{\overset{\iota}{\rightleftarrows}} d|i{:}C$$

where $\iota$ is inclusion (or, embedding) and $\rho$ is retract (or, projection):

$$\begin{aligned} &\iota_C\, d = d|i{:}C \\ &\rho\,(d|i{:}C) = d \qquad \text{provided } d \text{ is independent of } i \end{aligned}$$

An alternative way to define retract is to use the relational selection: after all, a relative denotation is a relation:

$$\rho_C\, r = d \qquad \text{where } r/C = \{d\}$$

Embeddings and retracts are the inverses of each other; however, an embedding is not surjective and a retract is not total, in general. An important particular case (which we come across later) is $C$ being a singleton. For the singleton context, the embedding is surjective and the projection is total: they form a bijection. In this case, the relative denotation is isomorphic to the non-relative one.

The relational selection $\mathsf{subj}'/\cdot$ is again homomorphism:

$$\mathsf{subj}'/\,(d|i{:}C) = (\mathsf{subj}'/\,d)|i{:}C$$

and hence commutes with $\iota$ and $\rho$. Polyconcept operations likewise commute:

$$(d_1|i{:}C) \sqcap (d_2|i{:}C) = (d_1 \sqcap d_2)|i{:}C \tag{4}$$

and similarly for $\otimes$, $\oplus$ and $\sqcup$. (4) does not apply to $(d_1|i_1{:}C_1) \sqcap (d_2|i_2{:}C_2)$ with $C_1 \neq C_2$, however. What we can do is to first embed the two polyconcepts into each other's context. Recall, embedding applies to any poly-individual or polyconcept, including a relative polyconcept.

$$\begin{aligned} &\iota_{C_2}(d_1|i_1{:}C_1) \;\sqcap\; \iota_{C_1}(d_2|i_2{:}C_2) = (d_1|i_1{:}C_1)|i_2{:}C_2 \;\sqcap\; (d_2|i_2{:}C_2)|i_1{:}C_1 \\ &\quad = (d_1|(i_1{:}C_1 \times i_2{:}C_2)) \sqcap (d_2|(i_1{:}C_1 \times i_2{:}C_2)) = (d_1 \sqcap d_2)|(i_1{:}C_1 \times i_2{:}C_2) \end{aligned} \tag{5}$$

## 4 Nominal Pronouns and Referents

As the first example of pronouns, consider "It is famous.". In [5], the trace was given the denotation $i|i{:}\mathcal{I}$ where $\mathcal{I}$ is the set of all individuals. Since trace is anaphoric, it is tempting to likewise make $[\![\text{it}]\!] = i|i\colon \mathsf{Thing}$, relativized to the set of things (non-human individuals). Let's give in to the temptation. The whole sentence then receives the denotation:

$$(6) \qquad [\![\text{It is famous.}]\!] = (\mathsf{subj}'/\ i \ \cap \ \mathsf{Famous})|i\colon \mathsf{Thing}$$

(We have applied embeddings as necessary; which we shall do hereafter without further mentioning).

The sentence is grammatical and meaningful, even by itself: a listener is free to imagine a suitable referent for "it", not constrained by any prior discourse (which does not exist here). The denotation is inherently relative ($\rho$ does not apply), which indicates it contains an unresolved anaphoric reference.

Next consider "John traveled to Paris$^{\triangleright}$." where Paris$^{\triangleright}$ is an NP creating a referent. We take its denotation to be the relativized $\mathsf{paris}$:

$$(7) \qquad [\![\text{Paris}^{\triangleright}]\!] = \iota_{\{\mathsf{paris}\}} \ \mathsf{paris} = \mathsf{paris}\ |i\colon \{\mathsf{paris}\} = i|i\colon \{\mathsf{paris}\}$$

Oddly, $[\![\text{Paris}^{\triangleright}]\!]$ turns out almost the same as $[\![\text{it}]\!]$; only the former is relativized to the singleton $\{\mathsf{paris}\}$ and the latter to the set of all things. Therefore, the former can be retracted to the non-relative denotation, but the latter cannot. For the whole sentence we obtain $[\![\text{John traveled to } i]\!]|i\colon \{\mathsf{paris}\}$.

If we combine the two sentences: "John traveled to Paris. It is famous.", we obtain, using (5) extended to the grouping

$$(8) \qquad ([\![\text{John traveled to } i_1]\!] \otimes [\![i_2 \text{ is famous}]\!])|(i_1\colon \{\mathsf{paris}\} \times i_2\colon \mathsf{Thing})$$

After all, "it" does not have to refer to Paris. We may, however, impose this reference, by applying the equality constraint to the context and effectively collapsing it:

$$(9) \qquad \Downarrow(d|(i_1{:}C_1 \times i_2{:}C_2)) = d[i_2{:=}i_1]|i_1{:}(C_1 \cap C_2)$$

obtaining

$$([\![\text{John traveled to } i]\!] \otimes [\![i \text{ is famous}]\!])|i : \{\mathsf{paris}\}$$

The context becomes the singleton set. Remember, a polyconcept relative to a singleton context is isomorphic to the non-relative polyconcept. Therefore, the above denotation is equivalent to the pair $[\![\text{John traveled to Paris}]\!]$ and $[\![\text{Paris is famous}]\!]$. It is now "context-free": with no longer any unresolved dependencies, no appeal to listener's imagination.

The context in (8) is an *ordered* pair. For instance, "John travel to it. Paris is famous." has the similar denotation with the similar pair context, but in a different order. It is this order that determines if anaphoric reference is possible. We refer to the full paper for details.

The key idea hence is that discourse is a constraint on listeners' imagination. The more narrow is the context, the tighter is the constraint. In the limit, a proper noun is the anaphoric reference in the singleton context, which constrains it unambiguously. The close similarity of $[\![\text{Paris}^{\triangleright}]\!]$ and $[\![\text{it}]\!]$ should not be so surprising.

We must stress that the question of deciding which pronoun refers to which referent is in domain of pragmatics and outside the scope of our theory. What we propose is a semantic framework, in which to carry out analyses and obtain denotations $\mathsf{without}$ having committed to a particular referent resolution. Once we obtain denotations, we can can see the derived context, the equality constraints that may be imposed, and then decide which to impose.

Indefinites may also bind pronouns: "John traveled to $\mathrm{a}^{\triangleright}_{W}$ city. It is famous.", where $\mathrm{a}^{\triangleright}_{W}$ is a referent-creating (wide-scope) indefinite (and therefore, it uses $\oplus$):

$$[\![\mathrm{a}^{\triangleright}_{W} \text{ city}]\!] = \bigoplus\nolimits_{j\in\mathsf{City}} \iota_{\{\mathsf{j}\}} j = \bigoplus\nolimits_{j\in\mathsf{City}} i|i\colon \{\mathsf{j}\} \tag{10}$$

The external choice $\oplus$ (of the city, in our case) distributes completely, giving

$$\bigoplus\nolimits_{j\in\mathsf{City}} [\![\text{John traveled to } i_1.\ i_2 \text{ is famous.}]\!] | i_1\colon \{\mathsf{j}\} \times i_2\colon \mathsf{Thing}$$

which can then be collapsed. The result is shown in [5] to be related to the denotation of the sentence with the relative clause: "A city John traveled to is famous.". The similar derivation does not work for "John traveled to every city. It is famous." because $\otimes$ does not distribute. (We can apply (5), but then the context is the product of singletons: usable for 'them', but not for 'it'.)

The full paper also analyses more interesting cases of bound variable anaphora: "Every boy loves his father" and "A referee rejected every paper she reviewed." (the latter is [1, (113)]).

## 5 Related Work

Anaphora in general, and its particular approach: dynamic semantics, is an active area with enormous literature (not as far as event semantics, however). The similarity between traces and pronouns has been noted and well investigated long time ago. For example, Dekker's PLA introduces two sort of contexts: usual and long-distance. Pronouns retrieve from the former and traces from the latter. Modeling such contexts in polynomial event semantics is an interesting research direction.

Although [1] pursues a rather different from us approach – dynamic semantics for anaphora and continuation semantics for the theory of scope – it is surprisingly related. It also represents the context as a (nested) tuple. The paper [1] is quite more precise and rigorous in its treatment of context, which we aspire to.

## 6 Conclusions and Future Work

We have thus seen that anaphoric dependencies can, after all, be expressed in a variable-free event semantics, and in a surprisingly symmetric way. Both the referent and the reference have the meaning of a polyconcept relative to a context.

The development of the theory of anaphoric binding in event semantics has just began. Dynamic semantics literature (including [1]) has the wealth of interesting examples of anaphora to investigate, from crossover to donkey anaphora to gaping and ellipsis – and also anaphoric references to times, worlds, degrees, events. The eventual goal is to apply our analyses to entailments.

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[1] Dylan Bumford and Simon Charlow. Dynamic semantics with static types. lingbuzz/006884, 5 October 2022.

[2] Lucas Champollion. The interaction of compositional semantics and event semantics. *Linguistics and Philosophy*, 38(1):31–66, 2015.

[3] Oleg Kiselyov. Polynomial event semantics - Non-Montagovian proper treatment of quantifiers. In *JSAI-isAI Workshops*, volume 11717 of *Lecture Notes in Computer Science*, pages 313–324. Springer, 2019.

[4] Oleg Kiselyov. Polynomial event semantics: Negation. In *JSAI-isAI Workshops: New Frontiers in Artificial Intelligence*, volume 12758 of *Lecture Notes in Computer Science*, pages 82–95. Springer, 2021.

[5] Oleg Kiselyov and Haruki Watanabe. Events and relative clauses. In *Logic and Engineering of Natural Language Semantics*, volume 14213 of *Lecture Notes in Computer Science*, pages 18–30, Cham, 2023. Springer Nature Switzerland. lingbuzz/007541.

[6] Oleg Kiselyov and Haruki Watanabe. QNP textual entailment with polynomial event semantics. In Katsutoshi Yada, Yasufumi Takama, Koji Mineshima, and Ken Satoh, editors, *New Frontiers in Artificial Intelligence: JSAI-isAI 2021*, volume 13856 of *Lecture Notes in Computer Science*, pages 198–211, Cham, 2023. Springer Nature Switzerland. lingbuzz/007213.

[7] Claudia Maienborn. *Event semantics*, chapter 8, pages 232–266. Semantics - Theories. De Gruyter Mouton, 2019.

[8] Roger Schwarzschild. Pure event semantics. lingbuzz/006888, 11 November 2022.

Appositive Projection as Implicit Context Extension in Dependent Type Semantics

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# 1 Introduction

The content of an appositive relative clause (ARC) is a type of *conventional implicature* (CI), that is, secondary or supplementary (*not-at-issue*) information of an utterance [9], and it interacts with at-issue content in various interesting ways. Focusing on the projection behavior and the interaction with quantifiers, we present an analysis of ARCs based on *Dependent Type Semantics* (DTS) [4]. Our central idea is that appositive content implicitly extends the typing context during the process of type checking.

# 2 Data

**2.1. Projection** The content of an ARC projects out of entailment-canceling environments such as negation (1a) and conditional antecedent (1b).

(1) a. It is not the case that Ann, who danced, met John. $\Rightarrow$ Ann danced.
b. If Ann, who danced, met John, Mary was happy. $\Rightarrow$ Ann danced.

Although it might thus seem that an ARC is semantically independent of its matrix clause, it has been suggested (e.g., [1]) that the two clauses should not be kept apart at the level of meaning representation because anaphoric dependencies can be established between them, as in (2):

(2) a. ARC $\rightarrow$ at-issue: John, who met a girl$_1$, smiled. She$_1$ danced.
b. At-issue $\rightarrow$ ARC: A girl$_1$ danced. John, who met her$_1$, smiled.

**2.2. Interaction with Quantifiers** An ARC cannot modify a quantified NP unless the quantifier has the referential reading (see, e.g., [5]).

(3) {#Every/#No/A} girl, who met John, danced.

In parallel, pronouns inside ARCs cannot be bound by non-referential quantified NPs.

(4) {#Every/#No/A} girl$_1$ met John, who praised her$_1$.

We remark that *a girl* in the previous two examples is interpreted as a so-called *specific indefinite*, which basically has only the widest-scope reading. For instance, *a professor* in (5) takes wider scope than the conditional [8, 10].

(5) If a professor, who is famous, publishes a book, he will make a lot of money.

# 3 Framework

**3.1. Overview** DTS is a semantic framework based on dependent type theory, where a type represents the meaning of a sentence [4]. It accounts for anaphora and presupposition by reducing the felicity of a sentence to the well-formedness of its semantic representation (SR). The version of DTS that we use here [2] introduces an *underspecified type* (or an *@-type*) to represent anaphoric meaning in a compositional way.[1] The type is characterized by the following inference rule:

$$(@)\ \frac{\Gamma \vdash A : \mathsf{type} \quad \Gamma \vdash M : A \quad \Gamma \vdash B[x := M] : \mathsf{type}}{\Gamma \vdash (x \mathbin{@} A) \times B : \mathsf{type}} \quad \left( \xrightarrow{\text{@-elimination}} \Gamma \vdash B[x := M] : \mathsf{type} \right)$$

Intuitively, $x$ is a placeholder for a concrete term $M$ of type $A$. The term is searched for when we type check the @-type, after which we replace $x$ with $M$ and obtain an @-free type $B[x := M]$.

[1]Due to space limitations, we omit the process of semantic composition throughout this abstract.

For illustration, consider how the pronoun *she* is resolved in (6a). (6b) shows the *felicity condition* (FC) of the second sentence.[2] Note that the SR for the first sentence is in the typing context, meaning it has already entered the common ground.

(6) a. A girl came. She danced.

b. $s : \begin{bmatrix} u : \mathtt{girl}^* \\ \mathtt{come}(\pi_1 u) \end{bmatrix} \vdash \begin{bmatrix} v \,@\, \mathtt{female}^* \\ \mathtt{dance}(\pi_1 v) \end{bmatrix} : \mathsf{type}$

To derive (6b), we need to find a term of $\mathtt{female}^*$, which is required by the second premise of the rule (@). By introducing the world knowledge that every girl is female and accordingly assuming a constant $\mathtt{g\text{-}to\text{-}f} : (u : \mathtt{girl}^*) \to \mathtt{female}(\pi_1 u)$, we can construct the term $\langle \pi_1\pi_1 s, \mathtt{g\text{-}to\text{-}f}(\pi_1 s)\rangle$ of type $\mathtt{female}^*$. Substituting this term for $v$, we obtain $\mathtt{dance}(\pi_1\pi_1 s)$. This result correctly predicts that *she* can be bound by *a girl*, because $\pi_1\pi_1 s$ refers to the entity introduced by the first sentence.

**3.2. @-elimination** What is yet to be specified is how we can replace the variable of a @-type in tandem with the process of type checking. In a recent version of DTS [2], the type checking function $[\![-]\!]$ returns a set of derivation trees for a typing judgment, the clause for the @-type being as follows (see [2] for the clauses for other type constructors)[3]. Note that the value of $[\![-]\!]$ is not a single derivation because there can be multiple ways to construct a term of type $A$.

$$[\![\Gamma \vdash (x \,@\, A) \times B : \mathsf{type}]\!] = \left\{ \mathcal{D}_3 \;\middle|\; \begin{array}{l} \mathcal{D}_1 \in [\![\Gamma \vdash A : \mathsf{type}]\!] \text{ (Let } \mathcal{D}_1\text{'s root be } \Gamma \vdash A' : \mathsf{type}) \\ \mathcal{D}_2 \in [\![\Gamma \vdash M : A']\!] \text{ for some term } M. \\ \mathcal{D}_3 \in [\![\Gamma \vdash \mathsf{nf}(B[x := M]) : \mathsf{type}]\!] \text{ (Let } \mathcal{D}_2\text{'s root be } \Gamma \vdash B' : \mathsf{type}) \end{array} \right\}$$

The derivations of the three premises of the rule (@) are internally constructed, but $\mathcal{D}_1$ and $\mathcal{D}_2$ are discarded; only $\mathcal{D}_3$ is returned. That is, what we obtain as a result of type checking $(x \,@\, A) \times B$ is an @-free type $B'$, as if it were the type we wanted to check from the beginning. We can thus simultaneously perform type checking and eliminate @-types.

**3.3. Two-stage Validation** Before presenting our proposal, we must clarify how discourses are processed in DTS, which is crucial in distinguishing between at-issue and not-at-issue content. Importantly, type checking confirms only the FC of a sentence; it does not consider whether it is accepted by the addressee. In other words, whether the SR is added to the typing context is determined after it is type checked, based on some pragmatic factors.[4] In this paper, we assume two validation stages before an SR $A$ is added to the context $\Gamma$.

(i) By calculating $[\![\Gamma \vdash A : \mathsf{type}]\!]$, we check the well-formedness of $A$ under $\Gamma$ and eliminate the @-types in $A$ (suppose we obtain $\Gamma \vdash A' : \mathsf{type}$ as a result).

(ii) We check whether $A'$ is acceptable under $\Gamma$. If it is true, we extend $\Gamma$ with $x : A'$ ($x \notin \mathrm{FV}(\Gamma)$).

# 4 Proposal

**4.1. CI Type** We propose extending DTS with a new type $(x \lhd A) \times B$ (a *CI type*), characterized by the following inference rule:

$$(\lhd)\ \frac{\Gamma \vdash A : \mathsf{type} \qquad \Gamma, x : A \vdash B : \mathsf{type}}{\Gamma \vdash (x \lhd A) \times B : \mathsf{type}} \quad \left( \xrightarrow{\lhd\text{-elimination}} \Gamma, x : A \vdash B : \mathsf{type} \right)$$

As well as the @-type, elimination of the $\lhd$-type is defined in a clause for $[\![-]\!]$.

$$[\![\Gamma \vdash (x \lhd A) \times B : \mathsf{type}]\!] = \left\{ \mathcal{D}_2 \;\middle|\; \begin{array}{l} \mathcal{D}_1 \in [\![\Gamma \vdash A : \mathsf{type}]\!] \text{ (Let } \mathcal{D}_1\text{'s root be } \Gamma, \Delta \vdash A' : \mathsf{type}) \\ \mathcal{D}_2 \in [\![\Gamma, \Delta, x : A' \vdash B : \mathsf{type}]\!] \end{array} \right\}$$

[2]We interchangeably use two notations for $\Sigma$-like operators such as $(x : A) \times B$ and $\begin{bmatrix} x : A \\ B \end{bmatrix}$. We also abbreviate $(x : \mathsf{e}) \times Px$ as $P^*$, where $\mathsf{e}$ is the type of entities and $P$ is of type $\mathsf{e} \to \mathsf{type}$.

[3]$\mathsf{nf}(M)$ is the normal form of $M$ (if any).

[4]Although it is beyond the scope of the present paper to characterize such factors, we at least require that the acceptance of the assertion should not contradict the preceding discourse (i.e., $\Gamma, x : A \nvdash \bot$).

Unlike the @-type, this type does not require a term of $A$ for its well-formedness. Instead, it extends the context $\Gamma$ with $x : A$ when it is eliminated after the two premises are derived. In other words, well-formedness of the $\lhd$-type requires the context to behave as if $x : A$ had already been introduced before $B$'s well-formedness is checked.

Conceptually, the context extension launched by $(x \lhd A) \times B$ is *implicit* in that it leaves no room for the addressee to choose whether to accept or reject $A$. In fact, $x : A$ is added to the context while the felicity of the whole SR is being checked; $A$ is not subject to the second validation stage. This behavior reflects the idea by [1] that appositive content is an *imposition* on the common ground, which is normally hard to respond to or negotiate on.

**4.2. Permutation** With the $\lhd$-type, computing $[\![\Gamma \vdash A : \mathsf{type}]\!]$ may change the original context ($\Gamma$) as well as the type ($A$). Hence, the above-mentioned two-stage validation needs to be revised as indicated by underlines below. Note that $\Delta$ is empty if $A$ contains no $\lhd$-types.

(i) By calculating $[\![\Gamma \vdash A : \mathsf{type}]\!]$, we check the well-formedness of $A$ under $\Gamma$ and eliminate the @-types <u>and $\lhd$-types</u> in $A$ (suppose we obtain $\Gamma\underline{, \Delta} \vdash A' : \mathsf{type}$ as a result).
(ii) We check whether $A'$ is acceptable under $\Gamma\underline{, \Delta}$. If it is true, we extend $\Gamma\underline{, \Delta}$ with $x : A'$ ($x \notin \mathrm{FV}(\Gamma\underline{, \Delta})$).

However, this revision clashes with other parts of the theory. Suppose that while type checking $(x : A) \to B$, we verified $\Gamma, x : A \vdash B : \mathsf{type}$, resulting in an extended context $\Gamma, x : A, y : C$ due to a $\lhd$-type inside $B$. We cannot apply the rule $(\Pi F)$ in such cases because $x : A$ is not on the right end of the context. With this motivation, we introduce the following structural rule (*permutation*), which is admissible in the dependent type theory on which DTS is based.

$$(\mathrm{perm})\ \frac{\Gamma, x : A, y : B, \Delta \vdash M : C}{\Gamma, y : B, x : A, \Delta \vdash M : C}\ (x \notin \mathrm{FV}(B))$$

The side condition $x \notin \mathrm{FV}(B)$ is required by the property of dependent type theory that a type can depend on terms: if $x : A$ occurs free in $B$, exchanging the two premises would result in an ill-formed context. We will see that this (independently motivated) restriction is important in explaining the interaction between an ARC and a quantified NP.

Using permutation, we can formally define the type checking algorithm for the $\Pi$-type as follows (the same applies to the $\Sigma$-type). Here, $\mathsf{Arrange}$ is a partial function that applies the rule (perm) to $\mathcal{D}$ and returns the derivation (if any) such that its root has the variable $x$ at the right end of the context. If there is no such derivation, type checking fails because the result of $[\![-]\!]$ is empty.

$$[\![\Gamma \vdash (x : A) \to B : \mathsf{type}]\!] = \left\{ \begin{array}{c|l} \dfrac{\dfrac{\dfrac{\mathcal{D}_1}{\Gamma, \Delta \vdash A' : \mathsf{type}}\,(\mathrm{wk})}{\vdots}\,(\mathrm{wk}) \quad \mathcal{D}_3}{\dfrac{\Gamma, \Delta, \Theta \vdash A' : \mathsf{type} \quad \Gamma, \Delta, \Theta, x : A' \vdash B' : \mathsf{type}}{\Gamma, \Delta, \Theta \vdash (x : A') \to B' : \mathsf{type}}\,(\Pi F)} & \begin{array}{l} \mathcal{D}_1 \in [\![\Gamma \vdash A : \mathsf{type}]\!] \\ \text{(Let } \mathcal{D}_1\text{'s root be } \Gamma, \Delta \vdash A' : \mathsf{type}) \\ \mathcal{D}_2 \in [\![\Gamma, \Delta, x : A' \vdash B : \mathsf{type}]\!] \\ \text{(Let } \mathcal{D}_2\text{'s root be } \Gamma, \Delta, x : A', \Theta \vdash B' : \mathsf{type}) \\ \mathcal{D}_3 = \mathsf{Arrange}(\mathcal{D}_2, x) \end{array} \end{array} \right\}$$

# 5 Verification

**5.1. Projection** We demonstrate that the $\lhd$-type correctly predicts the behavior of ARCs. First, we verify their projectivity. (7) shows the FC of (1a).[5]

(7) $\vdash \left( v : \begin{bmatrix} u \lhd \mathtt{dance}(\mathtt{a}) \\ \mathtt{meet}(\mathtt{a}, \mathtt{j}) \end{bmatrix} \right) \to \bot : \mathsf{type}$

Figure 1 shows the process by which the FC is validated. Deriving the sub-goal (g1) results in an extended context $u : \mathtt{dance}(\mathtt{a})$, and this change is propagated to the other sub-goal (g2). After (g2) is derived, we apply the rule $(\Pi F)$ and obtain $u : \mathtt{dance}(\mathtt{a}) \vdash (v : \mathtt{meet}(\mathtt{a}, \mathtt{j})) \to \bot : \mathsf{type}$. The appositive content $\mathtt{dance}(\mathtt{a})$ has thus successfully projected out of the negation.[6]

[5]In DTS, negation $\neg A$ is defined as $(x : A) \to \bot$, where $\bot$ is the empty type [4].

[6]This claim is justified by the fact that $\mathtt{dance}(\mathtt{a})$ is inhabited under the updated context $u : \mathtt{dance}(\mathtt{a}), s : (v : \mathtt{meet}(\mathtt{a}, \mathtt{j})) \to \bot$. To be precise, we need a revised definition of an inference, which we will describe in the full paper.

The sub-goals to derive (7)

$$\boxed{\begin{array}{l}(\text{g1})\ \vdash \begin{bmatrix}u \lhd \mathtt{d(a)}\\ \mathtt{m(a,j)}\end{bmatrix} : \mathsf{type}\\ (\text{g2})\ v : \begin{bmatrix}u \lhd \mathtt{d(a)}\\ \mathtt{m(a,j)}\end{bmatrix} \vdash \bot : \mathsf{type}\end{array}} \xRightarrow[\mathcal{D}_1[\underline{u : \mathtt{d(a)}} \vdash \boxed{\mathtt{m(a,j)}} : \mathsf{type}]]{\text{Derive (g1)}} \boxed{(\text{g2})\ \underline{u : \mathtt{d(a)}}, v : \boxed{\mathtt{m(a,j)}} \vdash \bot : \mathsf{type}}$$

$$\xRightarrow[\mathcal{D}_2[\cdots \vdash \bot : \mathsf{type}]]{\text{Derive (g2)}} \boxed{(\text{done})} \left(\text{return} \quad (\Pi F)\ \dfrac{\overset{\mathcal{D}_1}{u : \mathtt{d(a)} \vdash \mathtt{m(a,j)} : \mathsf{type}} \qquad \overset{\mathcal{D}_2}{u : \mathtt{d(a)}, v : \mathtt{m(a,j)} \vdash \bot : \mathsf{type}}}{u : \mathtt{d(a)} \vdash (v : \mathtt{m(a,j)}) \to \bot : \mathsf{type}}\right)$$

The sub-goals to derive (g1)

$$\boxed{\begin{array}{l}(\text{g3})\ \vdash \mathtt{d(a)} : \mathsf{type}\\ (\text{g4})\ u : \mathtt{d(a)} \vdash \mathtt{m(a,j)} : \mathsf{type}\end{array}} \xRightarrow[\mathcal{D}_3[\ \vdash \mathtt{d(a)} : \mathsf{type}]]{\text{Derive (g3)}} \boxed{(\text{g4})\ u : \mathtt{d(a)} \vdash \mathtt{m(a,j)} : \mathsf{type}} \xRightarrow[\mathcal{D}_4[u : \mathtt{d(a)} \vdash \mathtt{m(a,j)} : \mathsf{type}]]{\text{Derive (g4)}} \boxed{(\text{done})}\ (\text{return } \mathcal{D}_4)$$

Figure 1: The process of validating the FC of (1a). We abbreviate the names of the predicates (e.g., $\mathtt{dance} \mapsto \mathtt{d}$). We also write $\mathcal{D}[J]$ for a derivation $\mathcal{D}$ with root $J$. The underlined parts indicate the context extension, and the gray boxes show the types transformed during type checking.

**5.2. Anaphoric Dependencies** Next, we check how anaphora crossing the boundary between at-issue and ARC content can be resolved. (8a) is the FC of the first sentence of (2a), whose validation extends the context with $v : [\cdots]$. Assuming the at-issue content $\mathtt{smile(j)}$ is accepted, the FC of the second sentence is (8b).[7] The @-type can be resolved with $v$ in a way similar to (6b).

(8) a. $\vdash \begin{bmatrix} v \lhd \begin{bmatrix} u : \mathtt{girl}^* \\ \mathtt{meet}(\mathtt{j}, \pi_1 u) \end{bmatrix} \\ \mathtt{smile(j)} \end{bmatrix} : \mathsf{type} \xrightarrow{\text{type checking}} v : \begin{bmatrix} u : \mathtt{girl}^* \\ \mathtt{meet}(\mathtt{j}, \pi_1 u) \end{bmatrix} \vdash \mathtt{smile(j)} : \mathsf{type}$

b. $v : [\cdots], s : \mathtt{smile(j)} \vdash \begin{bmatrix} w \mathbin{@} \mathtt{female}^* \\ \mathtt{dance}(\pi_1 u) \end{bmatrix} : \mathsf{type} \xrightarrow{\text{type checking}} v : [\cdots], s : \cdots \vdash \mathtt{dance}(\pi_1 \pi_1 v) : \mathsf{type}$

The other direction, shown in (2b), is more complicated. Provided that the first sentence is successfully type checked and accepted, the FC of the second sentence is as follows.

(9) $v : \begin{bmatrix} u : \mathtt{girl}^* \\ \mathtt{dance}(\pi_1 u) \end{bmatrix} \vdash \begin{bmatrix} z \lhd \begin{bmatrix} w \mathbin{@} \mathtt{female}^* \\ \mathtt{meet}(\mathtt{j}, \pi_1 w) \end{bmatrix} \\ \mathtt{smile(j)} \end{bmatrix} : \mathsf{type}$

Figure 2 shows the derivation process. In deriving the first sub-goal, we can resolve the @-type as in (8b),[8] and the result is reflected in the other sub-goal. Finally, we obtain a context extended with $z : \mathtt{meet}(\mathtt{j}, \pi_1 \pi_1 v)$ (*John met her*), as expected.

The sub-goals to derive (9)

$$\boxed{\begin{array}{l}(\text{g1})\ v : [\cdots] \vdash \begin{bmatrix} w \mathbin{@} \mathtt{f}^* \\ \mathtt{m}(\mathtt{j}, \pi_1 w) \end{bmatrix} : \mathsf{type}\\ (\text{g2})\ v : [\cdots], z : \begin{bmatrix} w \mathbin{@} \mathtt{f}^* \\ \mathtt{m}(\mathtt{j}, \pi_1 w) \end{bmatrix} \vdash \mathtt{s(j)} : \mathsf{type}\end{array}} \xRightarrow[\mathcal{D}_1[v : [\cdots] \vdash \boxed{\mathtt{m}(\mathtt{j}, \pi_1 \pi_1 v)} : \mathsf{type}]]{\text{Derive (g1)}} \boxed{(\text{g2})\ v : [\cdots], z : \boxed{\mathtt{m}(\mathtt{j}, \pi_1 \pi_1 v)} \vdash \mathtt{s(j)} : \mathsf{type}}$$

$$\xRightarrow[\mathcal{D}_2[v : [\cdots], z : \mathtt{m}(\mathtt{j}, \pi_1 \pi_1 v) \vdash \mathtt{s(j)} : \mathsf{type}]]{\text{Derive (g2)}} \boxed{(\text{done})}\ (\text{return } \mathcal{D}_2)$$

Figure 2: The process of validating the FC of (2b).

**5.3. ARC + Non-referential Quantifier** Let us turn to the interaction with quantifiers. Taking *every* as an example,[9] we show the FC of (3) in (10).

(10) $\vdash (u : \mathtt{girl}^*) \to \begin{bmatrix} v \lhd \mathtt{meet}(\pi_1 u, \mathtt{j}) \\ \mathtt{dance}(\pi_1 u) \end{bmatrix} : \mathsf{type}$

[7]Note that the context in (8b) is the same as when the first sentence is replaced with "John met a girl. He smiled." The difference lies in how $v : [\cdots]$ (*John met a girl*) is added to the context.

[8]If we could not resolve the @-type here, the whole SR would not be well-typed. Hence, our theory predicts that the infelicity of the appositive content leads to the infelicity of the whole sentence.

[9]The prediction is the same for "No girl ...," which is translated using a Π-type ($(u : \mathtt{girl}^*) \to \neg(\cdots)$).

The sub-goals to derive (10)

$$\boxed{\begin{array}{l}\text{(g1)}\ \vdash \mathtt{g}^* : \mathsf{type} \\ \text{(g2)}\ u : \mathtt{g}^* \vdash \begin{bmatrix} v \lhd \mathtt{m}(\pi_1 u, \mathtt{j}) \\ \mathtt{d}(\pi_1 u) \end{bmatrix} : \mathsf{type}\end{array}} \ (\cdots) \ \xRightarrow{\text{Derive (g2)}} \ \mathcal{D}_2[u : \mathtt{g}^*, \underline{v : \mathtt{m}(\pi_1 u, \mathtt{j})} \vdash \boxed{\mathtt{d}(\pi_1 u)} : \mathsf{type}] \quad \text{(perm)}\ \dfrac{\overset{\mathcal{D}_2}{u : \mathtt{g}^*, v : \mathtt{m}(\pi_1 u, \mathtt{j}) \vdash \mathtt{d}(\pi_1 u) : \mathsf{type}}}{\times}$$

Figure 3: The process showing the infelicity of (3). The step for (g1) is omitted for brevity.

Figure 3 describes how its infelicity is predicted. When the sub-goal (g2) is derived, the context is extended with $v : \mathtt{meet}(\pi_1 u, \mathtt{j})$, in which $u$ occurs free. This prevents the application of the rule (perm), so $u : \mathtt{girl}^*$ cannot be moved to the right end of the context, causing type checking to fail.

We can handle the case of binding in a similar way. Again using *every girl* as our example, we describe the FC of (4) in (11). We first need to resolve the @-type corresponding to *her* under the context $u : \mathtt{girl}^*$. We can replace $w$ using $u$ and obtain $(w \lhd \mathtt{praise}(\mathtt{j}, \pi_1 u)) \times \cdots$. Since $u$ occurs free in the appositive content $\mathtt{praise}(\mathtt{j}, \pi_1 u)$, type checking fails as in (10).

(11) $\vdash (u : \mathtt{girl}^*) \to \begin{bmatrix} v \,@\, \mathtt{female}^* \\ \begin{bmatrix} w \lhd \mathtt{praise}(\mathtt{j}, \pi_1 v) \\ \mathtt{meet}(\pi_1 v, \mathtt{j}) \end{bmatrix} \end{bmatrix} : \mathsf{type}$

In summary, the appositive content $x \lhd A$ cannot project out if it depends on a variable introduced by $\Pi$ or $\Sigma$. Importantly, this restriction derives from the side condition of the permutation rule, which is inherent in dependent type theory.

**5.4. ARC + Specific Indefinite** Finally, we check the case of specific indefinites. We assume that the determiner *a* with the specific reading is translated with a $\lhd$-type.[10] Then, the type checking of the SR for "A girl, who met John, danced" proceeds as described in (12). Since $u : \mathtt{girl}^*$, on which the appositive content $\mathtt{meet}(\pi_1 u, \mathtt{j})$ depends, is also implicitly added to the context, we need not apply (perm) and thus we can complete type checking.

(12) $\vdash \begin{bmatrix} u \lhd \mathtt{girl}^* \\ \begin{bmatrix} v \lhd \mathtt{meet}(\pi_1 u, \mathtt{j}) \\ \mathtt{dance}(\pi_1 u) \end{bmatrix} \end{bmatrix} : \mathsf{type} \xrightarrow{\text{type checking}} u : \mathtt{girl}^*, v : \mathtt{meet}(\pi_1 u, \mathtt{j}) \vdash \mathtt{dance}(\pi_1 u) : \mathsf{type}$

The same line of reasoning shows that a specific indefinite with an ARC projects out of a conditional antecedent, which accounts for the wide-scope reading of (5).

# 6 Discussion and Conclusion

We proposed an extension of DTS with a new type that implicitly extends the context during type checking. This mechanism not only predicts the projection behavior of ARCs but also captures their interaction with quantifiers, based on the restriction on the permutation rule.

Closely related to this work is [3], which also analyzed CIs with DTS. Informally, the proposal treated a CI as a presupposition that is obligatorily accommodated and does not contribute to the at-issue content. We can point out that the system does not straightforwardly account for the infelicity of an ARC under the scope of non-referential quantifiers, because in such cases it would accommodate the appositive content (as a presupposition) and incorrectly predict that the sentence is felicitous. However, since that study used a different version of DTS, we need an in-depth comparison, which we leave for future work.

We also have not discussed cases where appositives do not project. For instance, appositive content inside an attitude operator is sometimes attributed to the attitude holder rather than the speaker [6], and nominal appositives can take narrow scope with respect to intensional operators [10]. We need to further consider the treatment of extended contexts to account for such challenging phenomena.

[10] Viewing the specificity of an indefinite as a conventional implicature is uncommon but not unnatural because it projects out of entailment-canceling environments (not at-issue) and is generally new to the addressee (not presuppositional). [7] presented a similar argument, analyzing a Persian specificity marker with the system proposed by [9] (note that in his analysis, the CI content is the uniqueness of the nominal to be modified).

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## References


[1] S. AnderBois, A. Brasoveanu, and R. Henderson. At-issue proposals and appositive impositions in discourse. *Journal of Semantics*, 32(1):93–138, 2015.

[2] D. Bekki. A proof-theoretic analysis of weak crossover. In K. Yada, Y. Takama, K. Mineshima, and K. Satoh, editors, *New Frontiers in Artificial Intelligence*, pages 228–241, Cham. Springer Nature Switzerland, 2023.

[3] D. Bekki and E. McCready. *Ci via dts*. In *New Frontiers in Artificial Intelligence: JSAI-isAI 2014 Workshops, LENLS, JURISIN, and GABA, Kanagawa, Japan, October 27–28, 2014, Revised Selected Papers*. 2015, pages 23–36.

[4] D. Bekki and K. Mineshima. *Context-Passing and Underspecification in Dependent Type Semantics*. In *Modern Perspectives in Type-Theoretical Semantics*. S. Chatzikyriakidis and Z. Luo, editors. Springer, 2017, pages 11–41.

[5] F. del Gobbo. *Appositives at the interface*. PhD thesis, University of California, 2003.

[6] J. A. Harris and C. Potts. Perspective-shifting with appositives and expressives. *Linguistics and Philosophy*, 32:523–552, 2009.

[7] M. Jasbi. The suffix that makes persian nouns unique. In *Advances in Iranian linguistics*, pages 107–118. John Benjamins, 2020.

[8] R. Nouwen. A note on the projection of appositives. *Formal approaches to semantics and pragmatics: Japanese and beyond*:205–222, 2014.

[9] C. Potts. *The Logic of Conventional Implicatures*. Oxford University Press, 2005.

[10] L. Wang, B. Reese, and E. McCready. The projection problem of nominal appositives. *Snippets*, 10(1):13–14, 2005.

**Focus Representation and Backward Underspecification in Dependent Type Semantics**

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## 1 Introduction

Dependent type semantics (DTS; [1, 2]) is a framework for type-theoretic natural language semantics, based on Martin-Löf's dependent type theory [6]. The key element in DTS is *underspecified terms*. Intuitively, underspecified terms serve as symbols in semantic representations that indicate where completion by context is required. Using underspecified terms, various phenomena such as E-type anaphora [1], factive presuppositions [9] can be accounted for. Although analyses of questions within DTS exist [10, 4], focus, which is closely related to question-answer congruence, is not covered. In this study, I extend DTS to handle focus without sacrificing the existing explanatory power. The emphasis is placed on how to formalize elements with focus features and derive predictions within the DTS framework. Therefore, I do *not* delve into how focus features are assigned, leaving issues such as intonation structure outside the scope.

**Central issue** In traditional model-theoretic semantics, the standard approach for representing focus is based on an idea originating from Rooth [7], which uses a set of propositions called focus alternatives. On the other hand, how to represent focus in DTS is not straightforward. This is because, unlike model-theoretic semantics, which represents propositions as sets of possible worlds, type-theoretic semantics represents propositions as *types*. Furthermore, because DTS explains semantic phenomena through formal inference, it is not trivial how to account for focus-related phenomena in this framework. The subjects of investigation here can be summarized as follows.

- How can focus be represented in DTS?
- How can focus-sensitive phenomena be accounted for in DTS?

**Motivation** In this study, I target on question-answer congruence, a standard benchmark in focus theory, and introduce *focus contexts* for representing focus and *backward underspecified terms* for representing the meaning of questions. While the analysis of questions in DTS has been conducted in [10, 4], these analyses represent the meaning of *wh*-questions using weak/strong Σ-types.

(1) Who likes Mary?

a. $(x : \mathbf{e}) \oplus \mathbf{like}(x, m)$ (by [10])

b. $(x : \mathbf{e}) \times \mathbf{like}(x, m)$ (by [4])

These representations have no constraint on focus patterns of answers to the question. To achieve more accurate semantics for question-answer pairs, I propose a focus-sensitive analysis for questions and answers.

## 2 Proposals: focus contexts and backward underspecified terms

In this section, focus contexts and backward underspecified terms are introduced, and I explain how the proposed analysis accounts for the following cases: single/multiple *wh*-questions, phrasal focus, and answers with anaphoric expressions.

$$\dfrac{\dfrac{}{\text{[John]}_{\mathrm{F}} \atop NP;\ j;\ j : \mathbf{e}} \qquad \dfrac{\text{likes} \atop (S\backslash NP)/NP;\ \lambda xy.\mathbf{like}(y,x);\ () \qquad \text{Mary} \atop NP;\ m;\ ()}{S\backslash NP;\ \lambda y.\mathbf{like}(y,m);\ ()}{>}}{S;\ \mathbf{like}(j,m);\ j : \mathbf{e}}{<}$$

Figure 1: The CCG derivation of "[John]$_{\mathrm{F}}$ likes Mary". The focus context $j : \mathbf{e}$ is obtained in parallel with the derivation.

### 2.1 Focus contexts

A focus context is a sequence of judgments, which is derived from a sentence. Intuitively, the focus context derived from a sentence $S$ serves to indicate what is highlighted by $S$. For example, the focus contexts derived from (2-a) and (3-a) are (2-b) and (3-b), respectively.

(2) a. [John]$_{\mathrm{F}}$ likes Mary.
  b. $j : \mathbf{e}$

(3) a. John [likes]$_{\mathrm{F}}$ Mary.
  b. $\mathbf{like} : \mathbf{e} \to \mathbf{e} \to \mathtt{type}$

Focus contexts are assumed to be constructed at the stage of semantic composition. To achieve this, new elements are added to the lexical entries and the syntactic rules (I adopt Combinatory Categorial Grammar ([8], CCG) as the syntactic component here). Traditional lexical entries in CCG are represented as a triplet of phonological form, syntactic category, and semantic representation. In addition to these, I propose that focus contexts are also defined within lexical entries. Each lexicon is assigned different focus contexts depending on whether it appears in a focused constituent or not. An example is shown in (4). Note that the empty sequence of judgements is denoted as ().

(4) Examples of focus-context-augmented lexical entries
  a. John; $NP$; $j$; $j : \mathbf{e}$ (for *John* in a F-marked phrase)
  b. John; $NP$; $j$; () (for *John* not in a F-marked phrase)

For each combination rule, an operation to concatenate the two focus contexts of the inputs is added, in addition to the handling of syntactic categories and semantic representations. Under the above assumptions, the CCG derivation of (2-a) is shown in Figure 1. As illustrated in the derivation, a sequence of type judgments related to focused expressions (that is, the focus context) is obtained in parallel with semantic composition. To achieve this purpose, the rules of CCG will follow the schema below. Let $C_1$, $C_2$, and $C_3$ be metavariables for categories, $S_1$, $S_2$, and $S_3$ for semantic representations, and $F_1$ and $F_2$ for focus contexts.

$$\frac{C_1 : S_1 : F_1 \qquad C_2 : S_2 : F_2}{C_3 : S_3 : F_1, F_2}$$

By this schema, the focus context for complex expressions can also be obtained compositionally. As will be discussed later, focus contexts serve as a context to resolve backward underspecified terms.

### 2.2 Backward underspecified term

A backward underspecified term is a symbol that indicates a gap in the semantic representation, similar to an ordinary underspecified term. In contrast to ordinary underspecified terms, backward underspecified terms trigger the proof search from the focus context constituted by a *subsequent* discourse, and is replaced by a found proof term. While ordinary underspecified terms are represented by @, backward underspecified terms are represented by $@^B$. A semantic representation containing ordinary/backward underspecified terms is not well-formed in itself; it becomes well-formed only after @-elimination/$@^B$-elimination is performed with an appropriate proof term.

Therefore, the discourse update mechanism of DTS, where every semantic representation is required to be well-typed as they are uttered and conjoined in the order they are uttered, needs to be revised. This is because, within the proposed framework, a semantic representation containing a backward underspecified term is not necessarily well-typed at the point it is uttered. In this study, the specific definition of the discourse mechanism is left as a future task, and it is assumed that the semantic representation of a question is stored in some form separate from the common ground.

In the following, I will describe the behavior of backward underspecified terms along with specific examples. As a simple example, consider (5) and (6).

(5) Who likes Mary?

(6) a. $[\text{John}]_{\text{F}}$ likes Mary. (a congruent answer)
b. John likes $[\text{Mary}]_{\text{F}}$. (an incongruent answer)
c. John $[\text{likes}]_{\text{F}}$ Mary. (an incongruent answer)

Each sentence is represented as follows.

(7) $S;\ \mathbf{like}(@^B_1, m);\ @^B_1 : \mathbf{e}$ (for (5))

(8) a. $S;\ \mathbf{like}(j, m);\ j : \mathbf{e}$ (for (6-a))
b. $S;\ \mathbf{like}(j, m);\ m : \mathbf{e}$ (for (6-b))
c. $S;\ \mathbf{like}(j, m);\ \mathbf{like} : \mathbf{e} \to \mathbf{e} \to \mathtt{type}$ (for (6-c))

A term $@^B_1$ is a backward underspecified term, and it indicates the unresolved part. The subscripted number is used to distinguish it from other backward underspecified terms. As shown in (8), each sentence in (6) has the same semantic representation, while having different focus contexts. In the following, the semantic representation of a sentence $S$ is denoted as $\text{SR}(S)$, and the focus context of $S$ is denoted as $\text{Foc}(S)$.

As a preparation for defining Question-answer congruence in DTS, I define $@^B$-elimination as follows.

**Definition 2.1** ($@^B$-elimination)**.** Let $\text{SR}(S)$ be the semantic representation of a sentence $S$, and let $\Gamma$ be a sequence of type judgments. If $\text{SR}(S)$ contains a backward underspecified term $@^B_i$ of type $A$, the following proof search is triggered.

$$\Gamma \vdash ? : A$$

If a $\tau$ satisfying $\tau : A$ is found, replace the occurrences of $@^B_i$ in $\text{SR}(S)$ with $\tau$. The semantic representation obtained is denoted as $\text{SR}(S)^{[\tau/@^B_i]}_{\Gamma}$.[1] □

The result of $@^B$-elimination on the multiple backward underspecified terms $@^B_1, \dots, @^B_n$ that appear in a semantic representation $\text{SR}(S)$, using the proof terms $\tau_1, \dots, \tau_n$ which are derived from a context $\Gamma$, is denoted as $\text{SR}(S)^{[\tau_1/@^B_1][\tau_2/@^B_2]\cdots[\tau_n/@^B_n]}_{\Gamma}$.

Then, I define the question-answer congruence in DTS as follows. Note that knowledge is denoted as $\mathcal{K}$ in the following. $\mathcal{K}$ is a sequence of judgments which encode knowledge about constants (e.g. $j : \mathbf{e}, \mathbf{student} : \mathbf{e} \to \mathtt{type}$) and world knowledge (e.g. $f : \mathbf{student}(j)$, $g : (x : \mathbf{e}) \to \mathbf{thing}(x) \to \neg\mathbf{human}(x)$).

**Definition 2.2** (Question-answer congruence in DTS)**.** A sentence $A$ is a congruent answer to a sentence $Q$ if there exist $\tau_i$'s that satisfy the following:

**Entailment** Let $@^B_1, \dots, @^B_n$ are the backward underspecified terms that appear in $\text{SR}(Q)$, the following holds:

$$\mathcal{K}, a : \text{SR}(A) \vdash \text{SR}(Q)^{[\tau_1/@^B_1]\cdots[\tau_n/@^B_n]}_{\text{Foc}(A)}\ \mathit{true}$$

[1] We would like to thank an anonymous reviewer for pointing out an error in the Definition 2.1 in the initial abstract.

**Equilibrium** No judgment in Foc($A$) is unnecessary for the proof search of $@^B_1, \ldots, @^B_n$.

$\square$

**Single *wh*-questions** Under these definitions, (6-a) is predicted to be a congruent answer to (5) because the following holds.

$$\mathcal{K}, a : \mathrm{SR}([\mathrm{John}]_\mathrm{F} \text{ likes Mary}) \vdash \mathrm{SR}(\text{Who likes Mary})^{[j/@^B]}_{\mathrm{Foc}([\mathrm{John}]_\mathrm{F} \text{ likes Mary})}\ true$$

On the other hand, (6-b) is ruled out, because the only $@^B$-eliminable term under Foc(6-b) is $m$, and therefore the following holds. Note that $\mathrm{SR}(\text{Who likes Mary})^{[m/@^B]}_{\mathrm{Foc}(\text{John likes }[\mathrm{Mary}]_\mathrm{F})} \equiv \mathbf{like}(m, m)$.

$$\mathcal{K}, a : \mathrm{SR}(\text{John likes } [\mathrm{Mary}]_\mathrm{F}) \nvdash \mathrm{SR}(\text{Who likes Mary})^{[m/@^B]}_{\mathrm{Foc}(\text{John likes }[\mathrm{Mary}]_\mathrm{F})}\ true$$

Also, (6-c) is ruled out, since no term of type $\mathbf{e}$ can be constructed from the focus context of (6-c). The latter part of the Definition 2.2 serves to exclude cases that are overly focused, as the following example.

(9) $[\mathrm{John}]_\mathrm{F}$ likes $[\mathrm{Mary}]_\mathrm{F}$. (an incongruent answer)

As pointed out by Krifka [5], this example cannot be excluded in early Alternative Semantics [7]. Büring [3] provides a revised definition of question-answer congruence as a solution to this problem. Büring's definition includes a direct reference to the natural language expression in order to exclude overfocusing. On the other hand, according to the Definition 2.2, it is possible to formally determine whether overfocusing is occurring.

**Multiple *wh*-questions** For multiple *wh*-questions, the proposed framework can capture focus patterns as in (10)-(11).

(10) Who likes whom? $\mapsto S;\ \mathbf{like}(@^B_1, @^B_2);\ @^B_1 : \mathbf{e}, @^B_2 : \mathbf{e}$

(11) a. $[\mathrm{John}]_\mathrm{F}$ likes $[\mathrm{Mary}]_\mathrm{F}$. $\mapsto S;\ \mathbf{like}(j, m);\ j : \mathbf{e}, m : \mathbf{e}$ (a congruent single-pair answer)
b. $[\mathrm{John}]_\mathrm{F}$ likes $[\mathrm{Mary}]_\mathrm{F}$, and $[\mathrm{Mary}]_\mathrm{F}$ likes $[\mathrm{John}]_\mathrm{F}$.
$\mapsto S;\ \mathbf{like}(j, m) \times \mathbf{like}(m, j);\ j : \mathbf{e}, m : \mathbf{e}$ (a congruent pair-list answer)
c. $[\mathrm{John}]_\mathrm{F}$ likes Mary. $\mapsto S;\ \mathbf{like}(j, m);\ j : \mathbf{e}$ (an incongruent answer)
d. John likes $[\mathrm{Mary}]_\mathrm{F}$. $\mapsto S;\ \mathbf{like}(j, m);\ j : \mathbf{e}$ (an incongruent answer)

Regarding (11-c) and (11-d), the only possible $@^B$-eliminated representation for the question is $\mathbf{like}(j, j)$. Since $\mathbf{like}(j, m)$ does not entail $\mathbf{like}(j, j)$, these answers are ruled out.

**Phrasal focus** The proposed analysis can handle phrasal focus as in (12)-(13). A derivation of the representations for (13-a) is shown in Figure 2.

(12) What did John do? $\mapsto S;\ @^B(j);\ @^B : \mathbf{e} \to \mathtt{type}$

(13) a. John $[\text{met Mary}]_\mathrm{F}$.
$\mapsto S;\ \mathbf{meet}(j, m);\ \mathbf{meet} : \mathbf{e} \to \mathbf{e} \to \mathtt{type}, m : \mathbf{e}$ (a congruent answer)
b. John $[\mathrm{met}]_\mathrm{F}$ Mary.
$\mapsto S;\ \mathbf{meet}(j, m);\ \mathbf{meet} : \mathbf{e} \to \mathbf{e} \to \mathtt{type}$ (an incongruent answer)
c. $[\text{John met Mary}]_\mathrm{F}$.
$\mapsto S;\ \mathbf{meet}(j, m);\ j : \mathbf{e}, \mathbf{meet} : \mathbf{e} \to \mathbf{e} \to \mathtt{type}, m : \mathbf{e}$ (an incongruent answer)

**Answers with anaphoric expressions** Question-answer pairs with anaphoric expressions such as (14) motivates lexical entries such as (15) and a slight modification of @-elimination.

(14) a. Who does Mary like?

$$
\dfrac{\dfrac{\text{John}}{NP;\ j;\ ()} \quad \dfrac{\dfrac{[\text{met}}{(S\backslash NP)/NP;\ \lambda xy.\mathbf{meet}(y,x);\ \mathbf{meet}:\mathbf{e}\to\mathbf{e}\to\mathtt{type}} \quad \dfrac{\text{Mary}]_{\text{F}}}{NP;\ m;\ m:\mathbf{e}}}{S\backslash NP;\ \lambda y.\mathbf{meet}(y,m);\ \mathbf{meet}:\mathbf{e}\to\mathbf{e}\to\mathtt{type}, m:\mathbf{e}}>}{S;\ \mathbf{meet}(j,m);\ \mathbf{meet}:\mathbf{e}\to\mathbf{e}\to\mathtt{type}, m:\mathbf{e}}<
$$

Figure 2: The CCG derivation of "John [met Mary]$_{\text{F}}$"

b. Mary likes [him]$_{\text{F}}$.

(15) him; $S\backslash(S/NP)$; $\lambda p.p(@_i)$; $@_i : \mathbf{e}$

By (15), the following representation is assigned to (14-b).

(16) Mary likes [him]$_{\text{F}}$. $\mapsto S$; $\mathbf{like}(m, @_1)$; $@_1 : \mathbf{e}$

Since $\mathbf{like}(m, @_1)$ contains an ordinary underspecified term of type $\mathbf{e}$, the following proof search is triggered during the type-checking to determine whether $\mathbf{like}(m, @_1)$ is of type $\mathtt{type}$.

$$\mathcal{K} \vdash ? : \mathbf{e}$$

If a term $a$ satisfying the above is found, replace $@_1$ in the type-checking derivation with $a$. In response to the introduction of focus context, I configure it to similarly substitute $@_1$ that appears in the focus context. Under this assumption, the $@^B$-eliminated representation for the answer is obtained as follows.

(17) Mary likes [him]$_{\text{F}}$. $\mapsto S$; $\mathbf{like}(m, a)$; $a : \mathbf{e}$

The $@^B$-elimination and the judgement of congruence are performed subsequently. The possible $@^B$-eliminated SR for the question is as follows:

(18) $\text{SR(Who does Mary like)}^{[a/@_1^B]}_{\text{Foc(Mary likes [him]}_{\text{F}})} \equiv \mathbf{like}(m, a)$

Since (17) and (18) satisfy the Definition 2.2, the answer is predicted to be congruent.

**Open issues** I have analyzed the focus information for proper nouns and common nouns. However, it's not clear how to represent the meaning of focused quantificational expressions. Further research is also needed to explore the applicability of the proposed method to other focus-related phenomena in various domains.

## References


[**1**] D. Bekki. "Representing anaphora with dependent types". In: *International conference on logical aspects of computational linguistics*. Springer. 2014. [**2**] D. Bekki and K. Mineshima. "Context-passing and underspecification in dependent type semantics". In: *Modern perspectives in type-theoretical semantics*. Springer, 2017. [**3**] D. Büring. "Question-Answer congruence-unstructured comments on Krifka (2001)". In: *Berlin: ZAS* (2002). [**4**] H. Funakura. "Answers, Exhaustivity, and Presupposition of wh-questions in Dependent Type Semantics". In: *Proceedings of the 19th International Workshop of Logic and Engineering of Natural Language Semantics 19 (LENLS19)*. The Association for Logic, Language and Information (FoLLI). 2022. [**5**] M. Krifka. "For a Structured Meaning Account of Questions and Answers". In: *Audiatur Vox Sapientia. A Festschrift for Arnim von Stechow* (2001). [**6**] P. Martin-Löf. *Intuitionistic type theory*. Vol. 17. Bibliopolis Naples, 1984. [**7**] M. Rooth. "A theory of focus interpretation". In: *Natural language semantics* 1.1 (1992). [**8**] M. Steedman. *The syntactic process*. MIT press, 2000. [**9**] R. Tanaka, K. Mineshima, and D. Bekki. "Factivity and presupposition in dependent type semantics". In: *Journal of Language Modelling* 5 (2017). [**10**] K. Watanabe, K. Mineshima, and D. Bekki. "Questions in Dependent Type Semantics". In: *Proceedings of the Sixth Workshop on Natural Language and Computer Science*. Gothenburg, Sweden: Association for Computational Linguistics, May 2019.

# Matrix and Relative Weak Crossover on the Level of the Individual: A Proposed Experimental Investigation

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## 1 Introduction

In this work, we present a design of an experiment for an empirical verification of a prediction of the theory of Dependent Type Semantics (DTS:Bekki (2014)) by the method of Language Faculty Science (LFS: Hoji (2015)).

DTS is a proof-theoretic framework of natural language semantics. One of the main features of DTS is the fully-compositional account of anaphora and presuppositions. Recently, Bekki (2021) proposed an update on the theory of DTS about the underspesification mechanism for anaphora in order to better capture subject-object asymmetry, in particular, to address the question how and why so-called "Weak Crossover (WCO: Wasow (1972)) effects" obtains.

Here, sentences (1a) and (1b) are examples of WCO effects in a matrix clause, or matrix WCO.

(1) a. Every boy praised his father.
    b. *His father praised every boy.

In general, sentence (1a) allows an interpretation in which each boy praised his *own* father, namely, $\text{boy}_1$ praised $\text{boy}_1$'s father, $\text{boy}_2$ praised $\text{boy}_2$'s father, and so on. This interpretation is called the Bound Variable Anaphora (BVA: Reinhart (1983b)) reading.

On the other hand, some hypotheses in generative syntax predict a BVA reading is impossible in sentence (1b), which were it possible, would mean that each boy was praised by his own father. Bekki (2021)'s account also predicts the contrast between acceptability of sentences (1a) and (1b).

Now, sentences (2a) and (2b) are examples of WCO effects in relative clauses, or relative WCO.

(2) a. I know every boy who loves his mother.
    b. *I know every boy who his mother loves.

Some hypotheses such as Higginbotham (1980) and Safir (2017) predict that the BVA reading is possible in the sentence (2a), which would mean that I know every boy loves his own mother, but they predict the BVA reading is impossible in the sentence (2b) which would mean that I know every boy is loved by his own mother. (see, e.g., Safir (2017)'s overview of this basic proposal)

However, Bekki (2021)'s DTS account predicts, unlike the case of matrix WCO, these sentences lack a contrast, and the sentence (2b) can mean that I know every boy is loved by his own mother.

One challenge to distinguishing these two hypotheses is that judgements as to the acceptability of BVA in such constructions are highly variable, with many speakers disagreeing about what is and is not acceptable. The same is in fact true of matrix WCO as well.

Despite this variation, the contrast of matrix WCO has been substantiated by the method of Language Faculty Science (LFS). The basic idea of the LFS method is that people's judgements can vary based on various factors such as situation, time or words in the sentence, but specific correlations between judgements are invariant. These correlations can be used to assess structural hypotheses, and this is assessed by having an individual judge multiple sentences with various interpretations so that the relevant correlations of judgements can be seen.

This method has yielded universally consistent results with regard to the unacceptability of WCO when non-structural interference on BVA interpretations is eliminated. Otherwise, so far, no one seems to have conducted an experiment with sufficiently clear results that would give us hope of reliably assessing the status of the different predictions about relative WCO, given the judgement variation issue.

Therefore, in this project, we check the predictions of DTS regarding BVA readings in matrix clauses and BVA readings in relative clauses by conducting an empirical investigation about relative WCO by the LFS method.

In particular, we make schemata to be judged with regards to the acceptability of certain meaning relations, especially BVA, and we ask informants (English native speakers) to judge them. Then, based on their judgements on diagnostic sentences, we focus on informants who judge sentences based purely on structural factors. Then, we check their judgements about potential relative WCO effects, which allows us to determine whether the sources of BVA reading in matrix clauses are the same as those in relative clauses or not.

If some individuals are clearly shown to be making judgements without the interference of non-structural "noise" accept the BVA reading on sentences like both (2a) and (2b), the result supports the DTS theory and shows relative WCO effects do not have the same status as their matrix counterparts. If all of them accept the BVA reading on sentences like (2a) and reject those like (2b), the result does not support the DTS theory and shows the sources of BVA reading on sentences in a relative clause are the same as those in a matrix clause.

## 2 Previous works

**Predictions about WCO** In generative syntactic literature, Reinhart (1983a) proposed that only when a quantifier c-commands the pronoun it is intended to bind is a BVA reading possible.

C-command is a syntactic relation. "X c-commands Y" means Y is a daughter of X's sister or, recursively, Y is the daughter of something else c-commanded by X.

According to Reinhart (1983a), in the sentence (1a), *every boy* c-commands *his father*, so a BVA reading is possible. In contrast, in the sentence (1b), *every boy* does not c-command *his father*, so a BVA reading is impossible. In sentence (2a), *every boy* and *who* bind *his mother*, and in the relative clause, they move to head position and c-command *his mother*; in contrast, in sentence (2b), *every boy* and *who* also bind *his mother*, but in the relative clause, they move to object position and do not c-command *his mother*.

Using the DTS framework, Bekki (2021) proposes underspecified types, which make the subject-object asymmetry matter in anaphora resolution. In particular, pronouns are resolved at the syntactic position they occur, not in the argument position of predicates. Therefore, though traditional DTS predicts BVA reading about both sentence (1a) and (1b) is possible (as DRT and other dynamic semantics do), Bekki (2021)'s DTS correctly predicts the contrast between sentences (1a) and (1b) .

On the other hand, Bekki (2021)' s DTS predicts that BVA readings on both sentences (2a) and (2b) are possible, yielding the propositions (3a) and (3b).

(3) a. $(r : \begin{bmatrix} x : e \\ \begin{bmatrix} w : boy(x) \\ love(x, \pi_1 motherOf(x, w))) \end{bmatrix} \end{bmatrix}) \to know(I, \pi_1 r)$

b. $(r : \begin{bmatrix} x : e \\ \begin{bmatrix} w : boy(x) \\ love(\pi_1 motherOf(x, w), x)) \end{bmatrix} \end{bmatrix}) \to know(I, \pi_1 r)$

**LFS method** Hoji (2022) discusses matrix WCO in Japanese and shows that native speakers for whom independent tests diagnose no interference of "noise" consistently reject BVA interpretations regarding the binder X and the bindee Y in sentences where X does not c-command Y. Secondly, Plesniak (2023) succeeds in reproducing results of Hoji (2022) about English matrix WCO.

In these two previous studies, the experiments performed are divided so that there are sub-experiments and a main experiment, with sub-experiments checking things like informant attentiveness and comprehension, and the main experiment performing the diagnosis-and-test procedure discussed in the introduction.

In the main experiment, these works utilize three meaning relations, Bound Variable Anaphora (BVA), Coreference (Coref), and Distributive Reading (DR) (which are used to assess the potential presence of interfering non-structural noise on an individual's BVA judgements).

(4) DR ($S^{[+cc]}$, X, Y') : yes
$\wedge$ Coref ($S^{[+cc]}$, X', Y) : yes
$\wedge$ BVA ($S^{[+cc]}$, X, Y) : yes
$\wedge$ DR ($S^{[-cc]}$, X, Y') : no
$\wedge$ Coref ($S^{[-cc]}$, X', Y) : no
$\to$ BVA ($S^{[-cc]}$, X, Y) : no

Then, a correlation (4) is tested based on Hoji (2022), where [+cc] means X (or X') c-commands Y (or Y'), and [-cc] otherwise.

This follows from a number of factors, most crucially the potential sources of BVA, as argued for in works like Plesniak (2023), which gives the following list:

(5) Conditions for Sources of BVA(X, Y):

a. FR (Formal Relation in Hoji (2022b)): X must c-command Y.

b. ID (Indexical Dependency in Ueyama (1998)) : X must precede Y.

c. NFS1 (Non-Formal Source 1 in Hoji (2022b)): (among other things) X must be understood as the "sentence topic."

d. NFS2 (Non-Formal Source 2 in Hoji (2022b)): Y must be understood as "non-individual denoting."

In both Hoji and Plesniak's experiments, though many informants did accept WCO readings, all such informants were independently diagnosed via their DR and Coref judgements as utilizing non-FR sources. Those who were diagnosed as using only FR universally rejected WCO, even while still accepting BVA in other constructions such as reconstruction-based OSV.

## 3 Design of experiment

**Forms of sentences** In conditions for Sources of BVA (5), condition (5b) is met in both sentences (2a) and (2b), so we focus on condition (5a) about relative WCO effects. In order to check the judgements of informants who judge the sentences as (4) about relative WCO effects, the experimental design discussed below is intended to both replicate and expand the coverage of previous LFS-style experiments to the relative clause domain.

In this work, in a similar way to Plesniak (2023), we use various BVA, DR, Coref schemata, as given in Table1, and Table 2 shows c-command relation and precedence of X and Y in each type of form.

| Type | Form |
|---|---|
| SVO (ok (5a), ok(5b)) | X V [Y's N]. |
| WCO (* (5a), * (5b)) | [Y's N] V X. |
| PSB (* (5a), ok (5b)) | [X's N] V [Y's N]. |
| OSV (ok (5a), *(5b)) | [Y's N], X V. |
| SRC | X who V [Y's N] ... |
| ORC | X who [Y's N] V ... |

Table 1: Forms of schemata in the main experiment

| Type | X c-commands Y | X precedes Y |
|---|---|---|
| SVO | ok | ok |
| WCO | no | no |
| PSB | no | ok |
| OSV | ok | no |

Table 2: C-command relation and precedence in schemata in the main experiment

In Plesniak (2023), OSV type and WCO type are only used in order to check whether the judgments are based on c-command relation, but SVO, PSB (Precedence Spec-Binding), SRC (Subject Relative Clause) and ORC (Object Relative Clause) are used in this experiment. The type and the forms of schemata are all the same among BVA, DR, and Coref. This will prevent the informant's confusion because forms of schemata are not the same.

The reason for using PSB type is to check whether X preceding Y can lead to BVA, i.e., whether ID(X, Y) is possible for a given individual with a particular choice of X and Y; if it is, this is a potential confound, as we cannot be sure whether that individual's BVA judgements reflect purely structural relations or also precedence, which is relevant given that, in English relative clauses, the head noun, our X, always precedes the relative clause, which includes Y. SRC is a type of sentence like (2a) and ORC is that of a sentence like (2b) and we check the judgement on sentences like them.

Informants who we should focus on are those that are shown to judge the diagnotic sentences based on c-command relation, so they should accept SVO and OSV type sentences and reject PSB and WCO type sentences.

If they accept the BVA reading of at least some of both SRC type sentences and ORC type sentences, then the prediction of DTS is supported and the result of this experiment lends credence to Bekki (2021)'s hypotheses. On the other hand, if they accept the BVA reading of at least some SRC type sentences but do not accept the BVA reading of any ORC type schemata, some variants of the Safir 2017-style hypotheses are supported.

Any other result would suggest that either (a) a third theory, and not either of the two considered, is correct, or (b) there are additional factors that need to be controlled in order to obtain a clear result; regardless, a follow-up experiment would be in order.

**About X, Y, V, N** In addition, due to (5c) and (5d), what is used as X, Y, V and N in sentences affects judgements.

For example, regarding the binder, X, past experiments suggest many people can accept WCO type of BVA(every N, Y), but if we use "more than one N" in this work, it is rarer for people to accept it. In Plesniak (2022a), "John" as X for Coref schemata, but we decided to use "A N" or "The N".

Regarding the bindee, Y, according to Plesniak (2022a), informants are sometimes confused because of gender and stylistic issues surrounding "his", "her", and "their". Therefore, we decided to use "its" as Y for BVA or Coref schemata in this work. It is also better to use nouns as N about Y for BVA or DR type that each X cannot share as

N because it makes DR and BVA reading more clearly distinct from something like a "collective readings", so in this work, we decided to use "high-achieving student" as N about Y, "school in Japan" as N about X, because students cannot be in more than two schools at the same time. In addition, regarding verbs as V, it is better to use active verbs, so we decided to use "lied to" or "sued " as V.

Here, some parts of SVO type schemata are (6), (7) and (8).

(6) Coref (a school in Japan,its)
A school in Japan sued its high-achieving student.

(7) DR(more than one school in Japan, two high-achieving students)
More than one school in Japan sued two high-achieving students.

(8) BVA (more than one school in Japan, its)
More than one school in Japan sued its high-achieving student.

To summarize, we decided to use 1 X and 1 Y for BVA, 2 X for Coref, 2 Y for DR, and 2 V, so the number of schemata in the main experiment is 60. (excluding Hoji (2015) style sub-experiments to check informants' attentiveness and comprehension)

**The way to convey interpretations** In Plesniak (2023), as the way to ask informants judgements on the sentences, the interpretation such as BVA, DR, and Coref shows as paraphrase like (9).

(9) "His student spoke to every teacher."
  a. In this sentence, "his student" can refer to each teacher's own student.
  b. In this sentence, "his student" cannot refer to each teacher's own student.
  c. This is not a sentence of English.

If we use paraphrase, we should have a test which is called BVA Inst-Sub, to check whether informants understand the paraphrase such as "*each teacher's own student*" about (9). However, according to Plesniak (2022b), paraphrase is easy to misunderstand.

In order to get clearer results and make it easy for informants to understand the interpretation, we use figures like Figure 1 referring to Plesniak (2022a). Moreover, to prevent the figures from being too complex, because the number of words in SRC or ORC type sentences is much more than other type sentences, we decided to use some

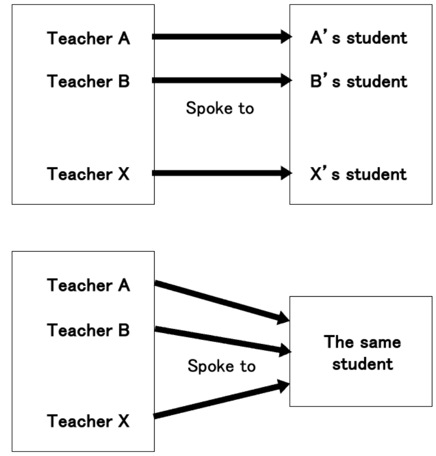


Figure 1: Figures of interpretations about (9)

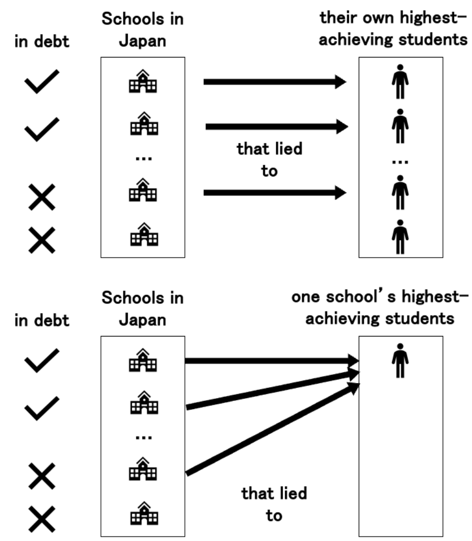


Figure 2: Figures of interpretations about (10)

pictures on the figures like Figure2 and 3. These are the figures for sentence (10) and (11).

(10) SRC type of BVA (more than one school in Japan, its)
More than one school in Japan who sued two high-achieving students is now in debt.

(11) ORC type of BVA (more than one school in Japan, its)
More than one school in Japan which its high-achieving student sued is now in debt.

These figures look similar, but in Figure3, "that were lied to by" is used as a representation of a verb in the relative clause as opposite to Figure2.

In this way, we also need to check whether informants understand the intended interpretations of the figures by

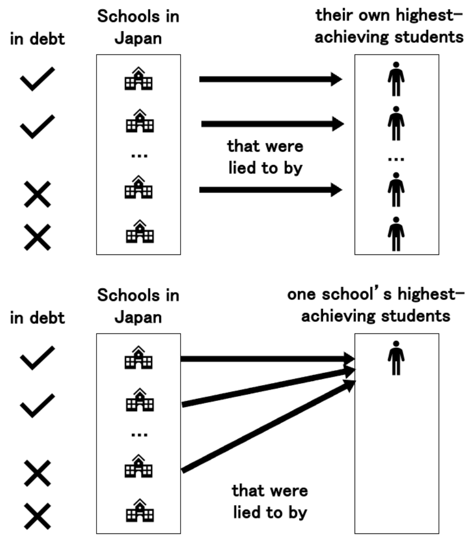


Figure 3: Figures of interpretations about (12)

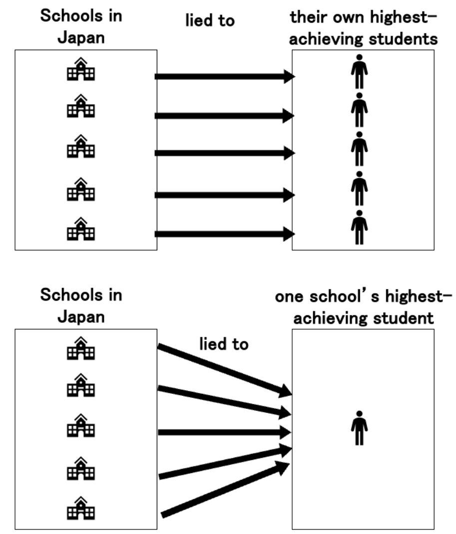


Figure 4: Figures of interpretations about (12) and (13)

sub-experiment which sentence like (12) or (13) and interpretations like Figure4, and explain to informants the intended interpretations through tutorial sections using sentences like (14) and interpretations like Figure5.

(12) BVA Inst-Sub
Every school in Japan lied to the same high-achieving student.

(13) BVA Lex Sub
Every school in Japan lied to the top school's high-achieving student.

(14) BVA Tutorial Sentences (English)
  a. Every city in Japan has its city office.
  b. Every city in Japan has that city office over there.
  c. Every city in Japan has its museum.

Plesniak (2022a) adopts a way to ask informants what interpretations are possible by showing possible interpretations and, allowing informants to select all choices of interpretation they judge to be possible, unlike in (9).

In this case, for (12), informants are expected to select both (b) in Figure4, and for (13), they are expected to select neither (a) nor (b) in Figure4, and for (14a), they are expected to select both (a) and (b) in Figure5, for (14b), they are expected to select only (b), and for (14c), they are expected to select neither (a) nor (b).

## 4 Conclusion

In this work, we present the design of the experiment to check the predictions of DTS regarding BVA availability in matrix clauses vs. in relative clauses by the LFS method.

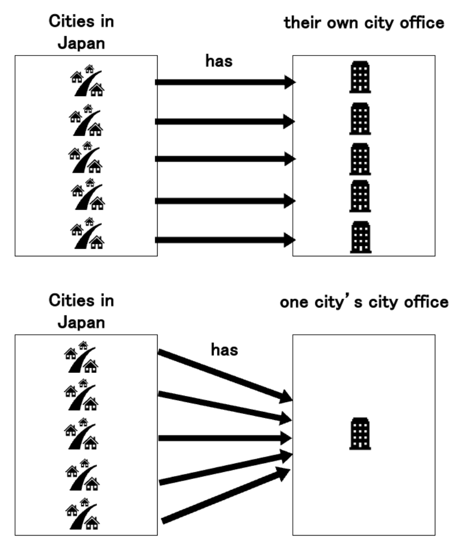


Figure 5: Tutorial interpretations about (14)

In particular, we addressed (i) the six types of sentences for three meaning relations, BVA, DR, and Coref are used in order to focus on informants who judge the sentences based on c-command relation, (ii) what is better to use as binder X, bindee Y, noun N, and verb V in the sentences, and (iii) the way to ask informants the judgement on the sentences.

The results of this experiment have significance for the theories about anaphora resolution, including DTS, allowing us to distinguish between different competing hypotheses.

## Acknowledgements

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## References

Daisuke Bekki. 2014. Representing anaphora with dependent types. In *N. Asher and S. V. Soloviev (eds.): Logical Aspects of Computational Linguistics (8th international conference, LACL2014, Toulouse, France, June 2014 Proceedings)*, Lecture Notes in Computer Science, vol 8535. Heidelberg, Springer.

Daisuke Bekki. 2021. A proof-theoretic analysis of weak crossover. In *Proceedings of LENLS18*, pages 75–88.

James Higginbotham. 1980. Pronouns and bound variables. *Linguistic Inquiry*, 11(4):679–708.

Hajime Hoji. 2015. *Language Faculty Science*. Cambridge University Press.

Hajime Hoji. 2022. Predicted correlations of judgments in japanese. In *The Theory and Practice of Language Faculty Science.* Berlin and Boston: De Gruyter Mouton.

Hajime Hoji. 2022b. Detection of c-command effects. in the theory and practice of language faculty science. In *The Theory and Practice of Language Faculty Science.* Berlin and Boston: De Gruyter Mouton.

Daniel Plesniak. 2022a. *Towards a correlational law of language: Three factors constraining judgement variation*. Ph.D. thesis, University of Southern California.

Daniel Plesniak. 2022b. Implementing experiments on the language faculty. In *The Theory and Practice of Language Faculty Science.* Berlin and Boston: De Gruyter Mouton.

Daniel Plesniak. 2023. Possibility-seeking experiments: Testing syntactic hypotheses on the level of the individual 1. In *Studies in Generative Grammar*.

Tanya Reinhart. 1983a. *Anaphora and semantic interpretation*. University of Chicago Press.

Tanya. Reinhart. 1983b. Coreference and bound anaphora: a restatement of the anaphora questions. *Linguistics and Philosophy*, 6:47–88.

Ken Safir. 2017. Weak crossover. In *the Wiley Blackwell Companion to Syntax,SECOND EDITION*. Wiley Blackwell.

Ayumi Ueyama. 1998. *Two Types of Dependency.* Ph.D. thesis, Los Angeles: University of Southern California.

Thomas Wasow. 1972. *Anaphoric relations in English*. Ph.D. thesis, Massachusetts Institute of Technology.

# Analyzing Japanese Cleft Construction in Combinatory Categorial Grammar[†]

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**Introduction** In the Japanese cleft construction, multiple noun phrases (NPs) can occupy the focus position even if they do not form a "constituent" in the mainstream generative grammar. However, a single NP with the nominative case marker *ga* cannot.[1] Kubota and Smith (2006, 2007) analyze the cleft construction with Combinatory Categorial Grammar (CCG, Steedman, 1996, 2000; Baldridge, 2002), but their analysis overgenerates a *ga*-marked NP in the focus position. Indeed, they recognized the obligatory omission of the nominative case marker in that position, and they assumed that some independently motivated principles should explain the distribution. However, it would be better if the distribution could be explained within the grammar formalism. This study aims to address this issue by partially incorporating the idea of *constructivist* analysis of argument structure from the mainstream generative grammar (Kratzer, 1996) into the CCG framework. Furthermore, I will show that this revision correctly predicts two syntactic phenomena where the *ga*-marked NP behaves differently from other case marked NPs.

**Background** The Japanese cleft construction has the general form *X no wa Y da*. In this structure, *X* is a topicalized sentence with a gap, while *Y* is a focus phrase that functions as its filler. (1-a) has a single NP *sono hon-o* 'that book-ACC' in the focus position, while (1-b) has multiple NPs *Mary-ni sono hon-o* 'Mary-DAT that book-ACC'.

(1) a. Ken-ga Mary-ni watasi-ta no wa sono hon-o da.
Ken-NOM Mary-DAT give-PAST NMLZ TOP that book-ACC COP
'It was that book that Ken gave to Mary.'

b. Ken-ga watasi-ta no wa Mary-ni sono hon-o da.
Ken-NOM give-PAST NMLZ TOP Mary-DAT that book-ACC COP
'It was that book to Mary that Ken gave.'

Kubota and Smith (2006, 2007) proposed a CCG-based analysis of the Japanese cleft construction which can derive not only a single-focus cleft but also a multiple-foci cleft. As an example, the derivation of the single-focus cleft according to the analysis of Kubota and Smith (2006) is illustrated below:

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[1] In this paper, following Hiraiwa and Ishihara (2002), constructions with case marked NPs in the focus position are termed "cleft", while those without a case marked NP are termed "pseudo-cleft". My primary focus lies on the former. I follow Takano (2015) for the acceptability judgment of the cleft constructions used in this paper. As for the pseudo-cleft, if we interpret *no* as a pronoun, my proposed analysis can correctly derive it with slight adjustments to the category of the relativizer, as proposed in Bekki (2010, p.247)

(2)

$$\begin{array}{cccccc}
\text{Ken-ga} & \text{Mary-ni} & \text{watasi-ta} & \text{no wa} & \text{sono hon-o} & \text{da}\\
\hline
NP_{ga} & NP_{ni} & S[^{-N}_{-T}]\backslash NP_{ga}\backslash NP_{ni}\backslash NP_o & (S[^{+N}_{+T}]\backslash \$)\backslash(S[^{-N}_{-T}]\backslash \$) & NP_o & (S_{[-T]}\backslash X)\backslash(S_{[+T]}/X)\\
: k & : m & : \lambda x\lambda y\lambda z.gave'(z,y,x) & : \lambda f.f & : \iota x.book'(x) & : \lambda f.f
\end{array}$$

$$\frac{S[^{-N}_{-T}]\backslash NP_{ga}\backslash NP_{ni}\backslash NP_o : \lambda x\lambda y\lambda z.gave'(z,y,x)}{S[^{-N}_{-T}]\backslash NP_o\backslash NP_{ga}\backslash NP_{ni} : \lambda y\lambda z\lambda x.gave'(z,y,x)}\text{Perm}$$

$$\frac{NP_o : \iota x.book'(x)}{S_{[+T]}/(S_{[+T]}\backslash NP_o) : \lambda P.P(\iota x.book'(x))}{>}\mathbf{T}$$

$$\frac{NP_{ni} : m \quad S[^{-N}_{-T}]\backslash NP_o\backslash NP_{ga}\backslash NP_{ni} : \lambda y\lambda z\lambda x.gave'(z,y,x)}{S[^{-N}_{-T}]\backslash NP_o\backslash NP_{ga} : \lambda z\lambda x.gave'(z,m,x)}{<}$$

$$\frac{NP_{ga} : k \quad S[^{-N}_{-T}]\backslash NP_o\backslash NP_{ga} : \lambda z\lambda x.gave'(z,m,x)}{S[^{-N}_{-T}]\backslash NP_o : \lambda x.gave'(k,m,x)}{<}$$

$$\frac{S[^{-N}_{-T}]\backslash NP_o : \lambda x.gave'(k,m,x) \quad (S[^{+N}_{+T}]\backslash \$)\backslash(S[^{-N}_{-T}]\backslash \$) : \lambda f.f}{S[^{+N}_{+T}]\backslash NP_o : \lambda x.gave'(k,m,x)}{<}$$

$$\frac{S_{[+T]}/(S_{[+T]}\backslash NP_o) : \lambda P.P(\iota x.book'(x)) \quad (S_{[-T]}\backslash X)\backslash(S_{[+T]}/X) : \lambda f.f}{S_{[-T]}\backslash(S_{[+T]}\backslash NP_o) : \lambda P.P(\iota x.book'(x))}{<}$$

$$\frac{S[^{+N}_{+T}]\backslash NP_o : \lambda x.gave'(k,m,x) \quad S_{[-T]}\backslash(S_{[+T]}\backslash NP_o) : \lambda P.P(\iota x.book'(x))}{S_{[-T]} : gave'(k,m,\iota x.book'(x))}{<}$$

The features $\pm N$ and $\pm T$ indicate whether the category has been nominalized and whether the category has been topicalized, respectively. In addition to the standard Function Application ("$>$", "$<$"), Function Composition ("**B**"), and Type Raising ("**T**") used in the usual CCG framework, Kubota and Smith also employ a permutation rule ("Perm") as a combinatory rule to account for scrambling. The category of *no wa*, $(S[^{+N}_{+T}]\backslash\$)\backslash(S[^{-N}_{-T}]\backslash\$)$ topicalizes a sentence with a gap, and the category of *da*, $(S_{[-T]}\backslash X)\backslash(S_{[+T]}/X)$ associates the filler with the gap in the topicalized sentence.

However, in Kubota and Smith's analysis, they treat cases as being assigned within the lexicon. In other words, since the analysis distinguishes cases solely based on the feature-values of the *NP* category, it fails to capture the asymmetrical distribution of cases. As a result, the analysis incorrectly licenses ungrammatical sentences with a single *ga*-marked nominative NP in the focus position like (3).

(3) *Sono hon-o Mary-ni watasi-ta no wa Ken-**ga** da.
That book-ACC Mary-DAT give-PAST NMLZ TOP Ken-NOM COP
'It was Ken that gave that book to Mary.'

It is important to clarify that *ga*-marked NPs are not always excluded from the focus position. When the focus comprises multiple NPs, the inclusion of a *ga*-marked NP is acceptable as shown in (4). Particularly in (4-b), a *ga*-marked NP is placed immediately before the copula. Thus, it does not seem appropriate to attribute the ungrammaticality of the *ga*-marked NP in the focus position of the cleft construction to morpho-phonological constraints that ban the linear sequence of *ga da*, as argued in Takano (2015).

(4) a. Sono hon-o watasi-ta no wa Ken-**ga** Mary-ni da.
That book-ACC give-PAST NMLZ TOP Ken-NOM Mary-DAT COP
'It was Ken to Mary that gave that book.'

b. Sono hon-o watasi-ta no wa Mary-ni Ken-**ga** da.
That book-ACC give-PAST NMLZ TOP Mary-DAT Ken-NOM COP
'It was Ken to Mary that gave that book.'

In the following section, I propose an analysis that syntactically excludes *ga*-marked NPs from the focus position of the single-focus cleft.

**Proposal** To treat the *ga*-case distinctly from other cases, I incorporate an idea proposed within the mainstream generative grammar into CCG in line with Isono et al. (2023). I assume that *ga*-marked NPs occupy a *structurally distinct position* compared to other case marked NPs. Within the mainstream generative grammar, Kratzer (1996) strips the verb of its ability to take an external argument and introduces a phonologically null "Voice" head as in (5). The Voice head takes a verb phrase as its complement and introduces the external argument as its specifier. The argument structure is analyzed using the neo-Davidsonian semantics.

(5) [VoiceP $\lambda e.\mathit{feed}'(\iota x.\mathit{dog}'(x), e) \wedge \mathit{Agent}(j, e)$ [John $j$] [$\lambda x.\lambda e.\mathit{feed}'(\iota x.\mathit{dog}'(x), e) \wedge \mathit{Agent}(x, e)$(by Kratzer's Event Identification) [Voice $\lambda x.\lambda e.\mathit{Agent}(x, e)$] [VP $\lambda e.\mathit{feed}'(\iota x.\mathit{dog}'(x), e)$ [feed the dog]]]]

I adopt Kratzer's proposal of the Voice head to CCG as shown in (6). Regarding the semantics of the verb, I adopt the approach of Champollion (2015), ensuring that the verb binds the event variable.[2]

(6) a.

Ken: $NP_{nc} : k$ ga: $(S/(S\backslash NP_{ga}))\backslash NP_{nc} : \lambda x.\lambda Q.Q(x)$ Ø: $(S\backslash NP_{ga})/\hat{S} : \lambda R.\lambda x.R(\lambda e.\mathit{Agent}(x, e))$

$$\text{Ken ga} \xrightarrow{<} S/(S\backslash NP_{ga}) : \lambda Q.Q(k)$$

$$\xrightarrow{>\mathbf{B}} S/\hat{S} : \lambda P.(\lambda Q.Q(k)((\lambda R.\lambda x.R(\lambda e.\mathit{Agent}(x, e))(P)))) \xrightarrow{\beta} \lambda P.P(\lambda e.\mathit{Agent}(k, e))$$

b.

Ken-ga: $S/\hat{S} : \lambda P.P(\lambda e.\mathit{Agent}(k, e))$ Mary-ni: $NP_{ni} : m$ sono hon-o: $NP_o : \iota x.\mathit{book}'(x)$ watasi-ta: $(\hat{S}\backslash NP_{ni})\backslash NP_o : \lambda x.\lambda y.\lambda f.\lambda e.\mathit{gave}'(y, x, e) \wedge f(e)$

$$\xrightarrow{<} \hat{S}\backslash NP_{ni} : \lambda y.\lambda f.\lambda e.\mathit{gave}'(y, \iota x.\mathit{book}'(x), e) \wedge f(e)$$

$$\xrightarrow{<} \hat{S} : \lambda f.\lambda e.\mathit{gave}'(m, \iota x.\mathit{book}'(x), e) \wedge f(e)$$

$$\xrightarrow{>} S : \lambda e.\mathit{gave}'(m, \iota x.\mathit{book}'(x), e) \wedge \mathit{Agent}(k, e)$$

$NP_{nc}$ represents an NP without a case marker. $\hat{S}$ indicates the entire verb phrase without the external argument (i.e., VP in (5)). Ø functions similarly to Kratzer's Voice head. It becomes $S$ when it takes $\hat{S}$ on its right and $NP_{ga}$ on its left. The syntactic category of *ga*, $(S/(S\backslash NP_{ga}))\backslash NP_{nc}$, takes $NP_{nc}$ on its left, yielding $S/(S\backslash NP_{ga})$, which indicates that the *ga*-marked NP occupies a structurally higher position than other case marked NPs. Since the external argument is introduced by Ø, independent of the verb, the category of the verb *watasi-ta* is $(\hat{S}\backslash NP_{ni})\backslash NP_o$, which does not require the *ga*-marked NP.

The categories for *no wa* and *da* can now be revised using the $\hat{S}$ category as shown below:

(7) *no wa* $\vdash (\hat{S}[^{+N}_{+T}]\backslash\$)\backslash(\hat{S}[^{-N}_{-T}]\backslash\$)$
*da* $\vdash (\hat{S}_{[-T]}\backslash X)\backslash(\hat{S}_{[+T]}|X)$[3]

The revised CCG analysis can correctly derive both the single-focus cleft (8) and the multiple-foci cleft with the *ga*-marked NP (9).

[2]I am grateful to an anonymous reviewer for pointing out that the event variable bounded at sentence level is problematic for some compositional semantics and this can be solved by the idea of Champollion (2015).

[3]Another difference from the category assumed by Kubota and Smith is the direction of the slash. The vertical slash "|" signifies that either "/" or "\" can be used, and I replaced "/" in the category of *da* with this vertical slash.

(8) Ken-ga, Mary-ni watasi-ta, no wa, sono hon-o, da

$$
\begin{array}{ccccc}
\text{Ken-ga} & \text{Mary-ni watasi-ta} & \text{no wa} & \text{sono hon-o} & \text{da} \\
\hline
S/\hat{S} & \hat{S}\backslash NP_o & (\hat{S}[^{+N}_{+T}]\backslash\$)\backslash & NP_o & (\hat{S}_{[-T]}\backslash X)\backslash \\
: \lambda P.P(\lambda e.Agent(k,e)) & : \lambda x.\lambda f.\lambda e.gave'(m,x,e) \wedge f(e) & (\hat{S}[^{-N}_{-T}]\backslash\$) : \lambda f.f & : \iota x.book'(x) & (\hat{S}_{[+T]}|X) : \lambda f.f
\end{array}
$$

$$
\frac{\text{Mary-ni watasi-ta} \quad \text{no wa}}{\hat{S}[^{+N}_{+T}]\backslash NP_o : \lambda x.\lambda P.\lambda e.gave'(m,x,e) \wedge P(e)}<
$$

$$
\frac{NP_o : \iota x.book'(x)}{\hat{S}_{[+T]}/(\hat{S}_{[+T]}\backslash NP_o) : \lambda P.P(\iota x.book'(x))}>\mathbf{T}
$$

$$
\frac{\hat{S}_{[+T]}/(\hat{S}_{[+T]}\backslash NP_o) \quad \text{da}}{\hat{S}_{[-T]}\backslash(\hat{S}_{[+T]}\backslash NP_o) : \lambda P.P(\iota x.book'(x))}<
$$

$$
\frac{\hat{S}[^{+N}_{+T}]\backslash NP_o \quad \hat{S}_{[-T]}\backslash(\hat{S}_{[+T]}\backslash NP_o)}{\hat{S}_{[-T]} : \lambda P.\lambda e.gave'(m,\iota x.book'(x),e) \wedge P(e)}<
$$

$$
\frac{S/\hat{S} \quad \hat{S}_{[-T]}}{S : \lambda e.gave'(m,\iota x.book'(x),e) \wedge Agent(k,e)}>
$$

(9) Mary-ni watasita, no wa, Ken-ga, sono hon-o, da

$$
\begin{array}{ccccc}
\text{Mary-ni watasita} & \text{no wa} & \text{Ken-ga} & \text{sono hon-o} & \text{da} \\
\hline
\hat{S}\backslash NP_o & (\hat{S}[^{+N}_{+T}]\backslash\$)\backslash(\hat{S}[^{-N}_{-T}]\backslash\$) & S/\hat{S} & \hat{S}_{[-T]}/(\hat{S}_{[-T]}\backslash NP_o) & (\hat{S}_{[-T]}\backslash X)\backslash(\hat{S}_{[+T]}|X)
\end{array}
$$

$$
\frac{\hat{S}\backslash NP_o \quad (\hat{S}[^{+N}_{+T}]\backslash\$)\backslash(\hat{S}[^{-N}_{-T}]\backslash\$)}{\hat{S}[^{+N}_{+T}]\backslash NP_o}< \qquad
\frac{S/\hat{S} \quad \hat{S}_{[-T]}/(\hat{S}_{[-T]}\backslash NP_o)}{S/(\hat{S}_{[-T]}\backslash NP_o)}>\mathbf{B}
$$

$$
\frac{S/(\hat{S}_{[-T]}\backslash NP_o) \quad (\hat{S}_{[-T]}\backslash X)\backslash(\hat{S}_{[+T]}|X)}{S\backslash(\hat{S}_{[+T]}|NP_o)}>\mathbf{B}_\times
$$

$$
\frac{\hat{S}[^{+N}_{+T}]\backslash NP_o \quad S\backslash(\hat{S}_{[+T]}|NP_o)}{S}<
$$

Furthermore, as demonstrated in (10), the scrambling rule proposed by Bekki (2010) contributes to syntactically deriving the construction where scrambling occurs within the same clause.[4] On the other hand, as shown in (11), the revised analysis correctly fails to derive the cleft construction when only a single *ga*-marked NP is focused. This accurately captures the distribution of the *ga*-case in the Japanese cleft construction.

(10) Mary-ni watasita, no wa, sono hon-o, Ken-ga, da

$$
\begin{array}{ccccc}
\text{Mary-ni watasita} & \text{no wa} & \text{sono hon-o} & \text{Ken-ga} & \text{da} \\
\hline
\hat{S}\backslash NP_o & (\hat{S}[^{+N}_{+T}]\backslash\$)\backslash(\hat{S}[^{-N}_{-T}]\backslash\$) & NP_o & S/\hat{S} & (\hat{S}_{[-T]}\backslash X)\backslash(\hat{S}_{[+T]}|X)
\end{array}
$$

$$
\frac{\hat{S}\backslash NP_o \quad (\hat{S}[^{+N}_{+T}]\backslash\$)\backslash(\hat{S}[^{-N}_{-T}]\backslash\$)}{\hat{S}[^{+N}_{+T}]\backslash NP_o}<
$$

$$
\frac{NP_o}{\hat{S}_{[-T]}/(\hat{S}_{[-T]}\backslash NP_o)}>\mathbf{T} \qquad
\frac{\hat{S}_{[-T]}/(\hat{S}_{[-T]}\backslash NP_o)}{(S/(\hat{S}_{[-T]}\backslash NP_o))/(S/\hat{S}_{[-T]})}>\sigma
$$

$$
\frac{(S/(\hat{S}_{[-T]}\backslash NP_o))/(S/\hat{S}_{[-T]}) \quad S/\hat{S}}{S/(\hat{S}_{[-T]}\backslash NP_o)}>
$$

$$
\frac{S/(\hat{S}_{[-T]}\backslash NP_o) \quad (\hat{S}_{[-T]}\backslash X)\backslash(\hat{S}_{[+T]}|X)}{S\backslash(\hat{S}_{[+T]}|NP_o)}>\mathbf{B}_\times
$$

$$
\frac{\hat{S}[^{+N}_{+T}]\backslash NP_o \quad S\backslash(\hat{S}_{[+T]}|NP_o)}{S}<
$$

(11) Sono hon-o Mary-ni watasita, no wa, Ken-ga, da

$$
\begin{array}{cccc}
\text{Sono hon-o Mary-ni watasita} & \text{no wa} & \text{Ken-ga} & \text{da} \\
\hline
\hat{S} & (\hat{S}[^{+N}_{+T}]\backslash\$)\backslash(\hat{S}[^{-N}_{-T}]\backslash\$) & S/\hat{S} & (\hat{S}_{[-T]}\backslash X)\backslash(\hat{S}_{[+T]}|X)
\end{array}
$$

$$
\frac{\hat{S} \quad (\hat{S}[^{+N}_{+T}]\backslash\$)\backslash(\hat{S}[^{-N}_{-T}]\backslash\$)}{\hat{S}[^{+N}_{+T}]}< \qquad
\frac{S/\hat{S} \quad (\hat{S}_{[-T]}\backslash X)\backslash(\hat{S}_{[+T]}|X)}{\quad}*
$$

As the *ga*-marked NP is categorized as $S/\hat{S}$, it exhibits behavior distinct from NPs of other cases. $S/\hat{S}$ can take *da* on its right side when combined with other type-raised NPs (9–10). However, when standing alone, it cannot be combined with *da* as shown in (11).

**Extensions** I have proposed a revised CCG analysis in which the *ga*-marked NP occupies a structurally higher position than other case marked NPs, achieved by assigning the category $S/\hat{S}$ to the *ga*-marked NP. Furthermore, the revised analysis correctly predicts two other syntactic phenomena where the *ga*-marked NP behaves differently from other case marked NPs.

[4]Due to space constraints, I do not show in detail, but even if the scrambling occurs within a topicalized sentence like *Mary-ni Ken-ga watasi-ta no wa sono hon-o da*, it can be derived by using both Bekki's scrambling rule and a permutation rule.

First, the revised analysis predicts that the *ga*-marked NP cannot move across a clause boundary in *long-distance scrambling*. Long-distance scrambling is a construction in which an argument is scrambled out of a clause. On the assumption that Type Raising only applies to basic categories, the *ga*-marked NP cannot move out of a clause, while other case marked NPs can move out of their boundaries. Indeed, as shown in Saito (1985), the subject NPs are not subject to "long-distance scrambling" in Japanese, while other case marked NPs can be scrambled out.

Second, the revised analysis predicts that the *ga*-marked NP cannot be situated within a small clause. On the assumption that a small clause does not constitute an $S$ node, then the *ga*-marked NP, which forms an $S$ node in the revised analysis, cannot be placed within a small clause. This is also the case, as demonstrated by Takezawa (1987).

(12) John-wa [Mary-no yokogao-{*ga/o} totemo utukusiku] omot-ta.
John-TOP Mary-GEN profile-NOM-ACC very beautiful think-PAST
'John thought [Mary's profile (to be) very beautiful].' (from Takezawa (1987, p.153))

**Conclusion** In this paper, I have proposed a novel analysis of the distribution of the *ga*-marked NP in the Japanese cleft construction by integrating Kratzer's constructivist approach into CCG. As a result, I demonstrated that it is possible to account for the distribution of the *ga*-marked NP in the cleft construction within the grammar formalism. Furthermore, I showed that this analysis correctly predicts two other syntactic phenomena where only the *ga*-marked NP behaves differently from other case marked NPs. These results suggest, in line with Isono et al. (2023), that it is effective to incorporate the constructivist analysis, which has been developed within the mainstream generative grammar, into CCG.

**References** [1] Baldridge, Jason. 2002. Lexically specified derivational control in Combinatory Categorial Grammar. Doctoral Dissertation, University of Edinburgh. [2] Bekki, Daisuke. 2010. *Nihongo bunpoo no keisiki riron [Formal theory of Japanese grammar]*. Tokyo: Kurosio. [3] Champollion, Lucas. 2015. The interaction of compositional semantics and event semantics. *Linguistics and Philosophy* 38:31–66. [4] Hiraiwa, Ken, and Shinichiro Ishihara. 2002. Missing links: Cleft, sluicing, and "no da" construction in Japanese. *MIT Working Papers in Linguistics* 43:35–54. [5] Isono, Shinnosuke, Takuya Hasegawa, Kohei Kajikawa, Koichi Kono, Shiho Nakamura, and Yohei Oseki. 2023. Formalizing argument structures with Combinatory Categorial Grammar. In *Logic and Engineering of Natural Language Semantics*, ed. Daisuke Bekki, Koji Mineshima, and Eric McCready, 83–99. Cham: Springer Nature Switzerland. [6] Kratzer, Angelika. 1996. Severing the external argument from its verb. In *Phrase structure and the lexicon*, ed. Johan Rooryck and Laurie Zaring, 109–137. Dordrecht: Kluwer. [7] Kubota, Yusuke, and E Allyn Smith. 2006. Syntax and semantics of Japanese nonconstituent clefting in Combinatory Categorial Grammar. In *Proceedings of the Thrity-Sixth Annual Meeting of the North East Linguistic Society*, ed. C. Davis, A. R. Deal, and Y. Zabbal, 413–426. Amherst, MA: GLSA Publications. [8] Kubota, Yusuke, and E Allyn Smith. 2007. A Multi-Modal Combinatory Categorial Grammar analysis of Japanese nonconstituent clefting. In *Proceedings of the Twelfth ESSLLI Student Session*, ed. Ville Nurmi and Dmitry Sustretov, 161–172. [9] Saito, Mamoru. 1985. Some asymmetries in Japanese and their theoretical implications. Doctoral Dissertation, MIT. [10] Steedman, Mark. 1996. *Surface structure and interpretation*. MIT press. [11] Steedman, Mark. 2000. *The syntactic process*. MIT press. [12] Takano, Yuji. 2015. Surprising constituentas unlabeled syntactic objects. *Nanzan Linguistics* 10:55–73. [13] Takezawa, Koichi. 1987. A configurational approach to case-marking in Japanese. Doctoral Dissertation, University of Washington.

# On the semantics of dependencies: relative clauses and open clausal complements
— extended abstract —

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## 1 Introduction

Dependency grammars, which stem from a long linguistic tradition [12, 7], have seen a resurgence of interest in recent years, especially due to the Universal Dependency project [9]. Their principle is to make explicit the dependency relations existing between the words of a sentence, these relations being identified by the syntactic functions they represent.

Dependency parsing offers an interesting alternative to constituent parsing. In particular, parsing an agrammatical sentence does not result in a failure, but in a partial dependency structure that still contains some information. For this reason, dependency parsing is considered to be more robust than constituent parsing.

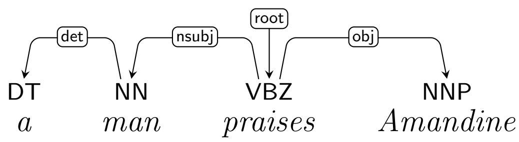
Formal compositional semantics, in the tradition of Montague [8], is based on a homomorphism between syntactic structure and semantic representation. As a result, it relies heavily on the notion of constituent, which does not appear explicitly in dependency structures. For this reason, providing a dependency grammar with a Montagovian semantic interpretation is not straightforward.

Nonetheless, in recent years, several ways of adapting Montague's semantics to the case of dependency grammars have been proposed in the literature. In a series of papers, Haug and his coauthors show how to assign a formal interpretation to a dependency structure using glue semantics [6, 3, 5, 4]. Other authors, including ourself, rely on a compositionality principle close to Montague's by exploiting a functional representation of dependency structures [10, 11, 2]. In this paper, we continue the latter line of thought. In particular, we aim to show that the basic principles that we have stated in [2] allow one to deal with more advanced syntactic phenomena. We consider two cases: the relative clauses (which depend on the acl:relcl relation) and the open clausal complements (which depend on the xcomp relation).

## 2 Relative clauses and wh-extraction

In this section, we propose a solution to the problem of the semantic treatment of wh-extraction. We deal with relative clauses as a paradigmatic example.

First, consider the following sentence together with its dependency tree:




Following the approach that we have advocated in [2], the above sentence may be assigned a meaning by interpreting the following term:

$$\mathsf{root}\ (\mathsf{nsubj}\ (\mathsf{obj}\ \text{PRAISES AMANDINE})\ (\mathsf{det}\ \text{MAN A}))$$

using the following semantics recipes:

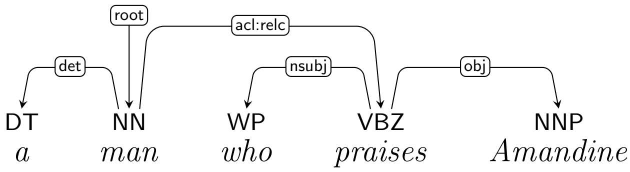
$$\begin{aligned}
\text{A} = \text{SOME} &= \lambda pq.\, \exists x.\, (p\, x) \wedge (q\, x) : \text{DET} \\
\text{MAN} &= \lambda da.\, d\, (a\, \mathbf{man}) : \text{NP} \\
\text{AMANDINE} &= \lambda dap.\, p\, \mathbf{a} : \text{NP} \\
\text{PRAISE} &= \lambda p.\, \exists e.\, (\mathbf{praise}\, e) \wedge (p\, e) : \text{VP}
\end{aligned}$$

$$\begin{aligned}
\mathsf{det} &= \lambda nd.\, \lambda ea.\, n\, d\, a : \text{NP} \to \text{DET} \to \text{NP} \\
\mathsf{nsubj} &= \lambda vn.\, \lambda p.\, n\, \text{SOME}\, (\lambda x.\, x)\, (\lambda x.\, v\, (\lambda e.\, (\mathbf{agent}\, e\, x) \wedge (p\, e))) : \text{VP} \to \text{NP} \to \text{VP} \\
\mathsf{obj} &= \lambda vn.\, \lambda p.\, n\, \text{SOME}\, (\lambda x.\, x)\, (\lambda x.\, v\, (\lambda e.\, (\mathbf{theme}\, e\, x) \wedge (p\, e))) : \text{VP} \to \text{NP} \to \text{VP} \\
\mathsf{root} &= \lambda v.\, v\, (\lambda e.\, \mathbf{true}) : \text{VP} \to \text{S}
\end{aligned}$$

where:

$$\begin{aligned}
\text{DET} &= (\mathbf{e} \to \mathbf{t}) \to (\mathbf{e} \to \mathbf{t}) \to \mathbf{t} \\
\text{NP} &= ((\mathbf{e} \to \mathbf{t}) \to (\mathbf{e} \to \mathbf{t}) \to \mathbf{t}) \to ((\mathbf{e} \to \mathbf{t}) \to \mathbf{e} \to \mathbf{t}) \to (\mathbf{e} \to \mathbf{t}) \to \mathbf{t} \\
\text{VP} &= (\mathbf{v} \to \mathbf{t}) \to \mathbf{t} \\
\text{S} &= \mathbf{t}
\end{aligned}$$

Now consider the following noun phrase, where the acl:relc relation indicates that a noun governs a verb that is the head of a relative clause:




A usual way to give a semantic account of wh-movement is by means of $\lambda$-abstraction and, possibly, combinators to simulate it. This is the approach we follow. Accordingly, we posit:

$$\textsc{wnp} = \mathbf{e} \to \textsc{np}$$
$$\textsc{wvp} = \mathbf{e} \to \textsc{vp}$$

This allows our semantic lexicon to be extended as follows:

$$\textsc{who} = \lambda xdap.\, p\, x : \textsc{wnp}$$
$$\mathsf{acl{:}relcl} = \lambda nvda.\, n\, d\, (\lambda p.\, a\, (\lambda x.\, (p\, x) \wedge (v\, x\, (\lambda e.\, \mathbf{true})))) : \textsc{np} \to \textsc{wvp} \to \textsc{np}$$

But then, the expression below gives rise to a type mismatch:

$$\mathsf{nsubj}\ \textsc{praises}\ \textsc{who}$$

Indeed, ($\mathsf{nsubj}$ $\textsc{praises}$) is of type $\textsc{np} \to \textsc{vp}$ while $\textsc{who}$ is of type $\textsc{wnp}$. One way out of this typing problem is to coerce the types of the dependency relations using combinators similar to the $\mathsf{B}$ and $\mathsf{C}$ combinators of combinatory logic [1]:

$$\mathsf{warg1} = \lambda rvnx.\, r\, (v\, x)\, n : (\textsc{vp} \to \textsc{np} \to \textsc{vp}) \to \textsc{wvp} \to \textsc{np} \to \textsc{wvp}$$
$$\mathsf{warg2} = \lambda rvnx.\, r\, v\, (n\, x) : (\textsc{vp} \to \textsc{np} \to \textsc{vp}) \to \textsc{vp} \to \textsc{wnp} \to \textsc{wvp}$$

Then, the semantic interpretation of the noun phrase, *a man who praises amandine*, may be computed by evaluating the following expression:

$$\mathsf{root}\ (\mathsf{det}\ (\mathsf{acl{:}relcl}\ \textsc{man}\ (\mathsf{warg2}\ \mathsf{nsubj}\ (\mathsf{obj}\ \textsc{praises}\ \textsc{Amandine})\ \textsc{who}))\ \textsc{a})$$

which reduces to the following formula:[1]

$$\lambda q.\, \exists x.\, (\mathbf{man}\, x) \wedge (\exists e.\, (\mathbf{praise}\, e) \wedge (\mathbf{theme}\, e\, \mathbf{a}) \wedge (\mathbf{agent}\, e\, x) \wedge \mathbf{true}) \wedge (q\, x)$$

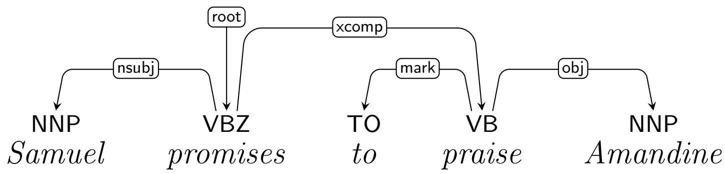
[1] When applied to a noun phrase, $\mathsf{root}$ is defined as $\mathsf{root} = \lambda n.\, n\, \textsc{some}\, (\lambda x.\, x)$.

The solution we have sketched is consistent with the approach that we have advocated in [2]. In particular, it satisfies our coherence principle. Indeed, all the following expressions provide the same semantic interpretation:

root (det (acl:relcl MAN (warg2 nsubj (obj PRAISES AMANDINE) WHO)) A)
root (det (acl:relcl MAN (warg1 obj (warg2 nsubj PRAISES WHO) AMANDINE)) A)
root (acl:relcl (det MAN A) (warg2 nsubj (obj PRAISES AMANDINE) WHO))
root (acl:relcl (det MAN A) (warg1 obj (warg2 nsubj PRAISES WHO) AMANDINE))

# 3 Control verbs and open clausal complements

Open clausal complements are clauses that are missing their own subject and that are typically governed by a control verb or a raising verb.[2] The dependency relation between a control verb and its open clausal complement is marked by the xcomp relation, like in the following example:




The puzzle here is that the nsubj dependency relation must provide a subject not only for *promises* but also for *praise*.

The solution we propose is based on a new interpretation of verb phrases that is obtained by type-raising the type of events not on $\mathbf{t}$ but on $\mathbf{e} \to \mathbf{t}$:

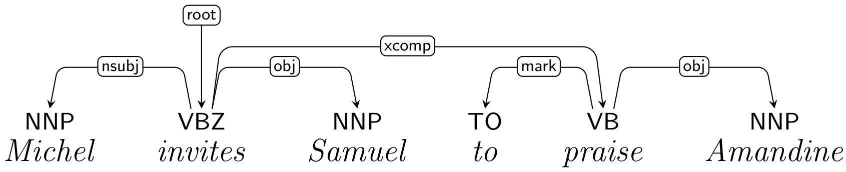
$$\textsc{vp} = (\mathbf{v} \to \mathbf{e} \to \mathbf{t}) \to \mathbf{e} \to \mathbf{t}$$

This idea, the details and rationale of which would be too long to develop in this extended abstract, leads to the following interpretation of xcomp together with a revisited interpretation of nsubj to be used for control verbs:

$$\mathsf{xcomp} = \lambda vcpx.\, v\,(\lambda ey.\,(\mathbf{topic}\, e\,(c\,(\lambda fz.\,\mathbf{agent}\, f\, z)\, y)) \wedge (p\, e\, y))\, x$$
$$\mathsf{nsubj} = \lambda vnpx.\, n\, \textsc{some}\,(\lambda x.\, x)\,(\lambda y.\, v\,(\lambda ez.\,(\mathbf{agent}\, e\, y) \wedge (p\, e\, y))\, y)$$

But this is not the end of the story, because it is not always the subject of the control verb that provides the open clausal complement with a semantic subject. It can also be the object, as the following sentence illustrates:

[2] An open clausal complement may also be the governee of an adjective.




It is even the case that a same control verb admits both constructions:

*Michel wants to praise Amandine*
*Michel wants Samuel to praise Amandine*

Our solution can account for these phenomena by relying on a kind of ad hoc polymorphism, which we discuss in the next section.

## 4 Ad hoc polymorphism and typing

The semantic developments we have outlined in the previous sections make it necessary to assign several different interpretations to the same dependency relation. For instance, we have given two interpretations to nsubj, and these two interpretations need to coexist. This need for some kind of polymorphism can be satisfied by refining the typing system used at the syntax-semantics interface level. In a full version of this paper, we will propose and discuss several ways of doing so, explaining how they corresponds to encoding notions of lexical semantics in the typing systems.

## 5 Conclusions

We have shown how dependency relations involving implicit semantic arguments can be treated along the lines we developed in [2]. We argue that this helps to demonstrate of the feasibility and adequacy of the formal theory of dependency semantics, whose basic principles we laid out in [2].

## References

1. H.B. Curry and R. Feys. *Combinatory Logic, Vol. I.* North-Holland, 1958.

2. Ph. de Groote. Deriving formal semantic representations from dependency structures. In D. Bekki, K. Mineshima, and E McCready, editors, *19th International Conference, LENLS19, Tokyo, Japan, November 19–21, 2022, Revised Selected Papers*, volume 14213 of *Lecture Notes in Computer Science*. Springer, 2023.
3. J. Y. Findlay and D. T. T. Haug. How useful are enhanced Universal Dependencies for semantic interpretation? In *Proceedings of the Sixth International Conference on Dependency Linguistics (Depling, SyntaxFest 2021)*, pages 22–34. Association for Computational Linguistics, 2021.
4. J. Y. Findlay, S. Salimifar, A. Yıldırım, and D. T. T. Haug. Rule-based semantic interpretation for Universal Dependencies. In *Proceedings of the Sixth Workshop on Universal Dependencies (UDW, GURT/SyntaxFest 2023)*, pages 47–57. Association for Computational Linguistics, 2023.
5. D. T. T. Haug and J. Y. Findlay. Formal semantics for dependency grammar. In *Proceedings of the Seventh International Conference on Dependency Linguistics (Depling, GURT/SyntaxFest 2023)*, pages 22–31. Association for Computational Linguistics, 2023.
6. D. T. T. Haug and M. Gotham. Glue semantics for universal dependencies. In *Proceedings of the LFG-conference*, pages 208–226. CSLI Publications, 2021.
7. Igor Mel'čuk. *Dependency Syntax: Theory and Practice*. State University of New York Press, 1988.
8. R. Montague. *Formal Philosophy: selected papers of Richard Montague, edited and with an introduction by Richmond Thomason*. Yale University Press, 1974.
9. J. Nivre, M.-C. de Marneffe, F. Ginter, Y. Goldberg, J. Hajič, C. D. Manning, R. McDonald, S. Petrov, S. Pyysalo, N. Silveira, R. Tsarfaty, and D. Zeman. Universal Dependencies v1: A multilingual treebank collection. In *Proceedings of the Tenth International Conference on Language Resources and Evaluation (LREC'16)*, pages 1659–1666, Portorož, Slovenia, May 2016. European Language Resources Association (ELRA).
10. S Reddy, O. Täckström, M. Collins, T. Kwiatkowski, D. Das, M. Steedman, and M. Lapata. Transforming dependency structures to logical forms for semantic parsing. *Transactions of the Association for Computational Linguistics*, 4:127–140, 2016.
11. S Reddy, O. Täckström, S. Petrov, M. Steedman, and M. Lapata. Universal semantic parsing. In *Proceedings of the 2017 Conference on Empirical Methods in Natural Language Processing*, pages 89–101. Association for Computational Linguistics, 2017.
12. L. Tesnière. *Eléments de syntaxe structurale*. Klincksieck, Paris, 1959.

# Dot-to-dot semantic representation

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**Abstract**

This paper introduces dot-to-dot semantic representation as an encoding for abstract dependency interpretations of natural language data. The format is illustrated with content created initially as syntactic tree annotations. This is transformed into construction information for Discourse Representation Structures. This gives a basis for resolving event and entity dependencies across discourse for transformation to Conjunctive Normal Forms with skolemisation from which governor to dependent relations arise for graph structures that are dot-to-dot semantic representations.

**Keywords:** semantic dependencies, discourse representation, event semantics, scope, skolemisation

## 1 Introduction

This paper introduces dot-to-dot semantic representation. The aim is to have a representation pitched at a level of abstraction that is informative about semantic argument dependencies and scope relations across discourse, only in a manner that still allows for recovery of the represented language data (sentence fragment, sentence, or discourse).

Following the SemR representation level of Meaning-text theory (Mel'čuk 1988) and Abstract Meaning Representation (AMR; Banarescu et al 2013), dot-to-dot semantic representations: are event semantic relation based, are easily read when visualised as graphs, and can be used for storing database knowledge, e.g., as Datalog facts.

Points of difference from SemR and AMR include: connections across discourse are captured, there is representation of scope and quantification restriction, there is a text-based encoding for comparisons on sorted line differences (e.g., for analysis/parser evaluation), and there is less abstraction in the sense that information is retained for the represented language data to be recoverable.

The paper is organised as follows. Section 2 offers background and illustrative examples. Section 3 describes steps for reaching analysis. Section 4 is a summary.

## 2 Background and examples

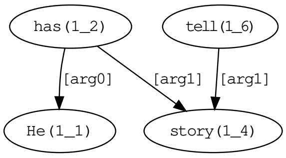
Suppose there are **discourse entities** as references to things talked about in discourse (individuals, events, attributes, etc.). Suppose language communication involves: (i) introducing discourse entities, and (ii) providing the means to integrate information about already introduced discourse entities. Part (ii) can include referring back to discourse entities after attention will have diverted to introducing and giving information about other newer discourse entities. Such a viewpoint underlies much natural language research in formal semantics, with, e.g., this discourse perspective articulated in Discourse Representation Theory (Kamp and Reyle 1993) and related theories of Dynamic Semantics (e.g., Dekker 2012 among many others).

We can think about both wider discourse and single sentences and even sentence fragments as being organised around discourse entities. We can picture information from discourse with a graph of connected nodes. Each node is a discourse entity. Connections leading to or from nodes gather the information content communicated by the analysed language data (sentence fragment, sentence, or discourse).

As an example, consider (1) with its dot-to-do semantic representation of (2).

(1) He has a story to tell.

(2)



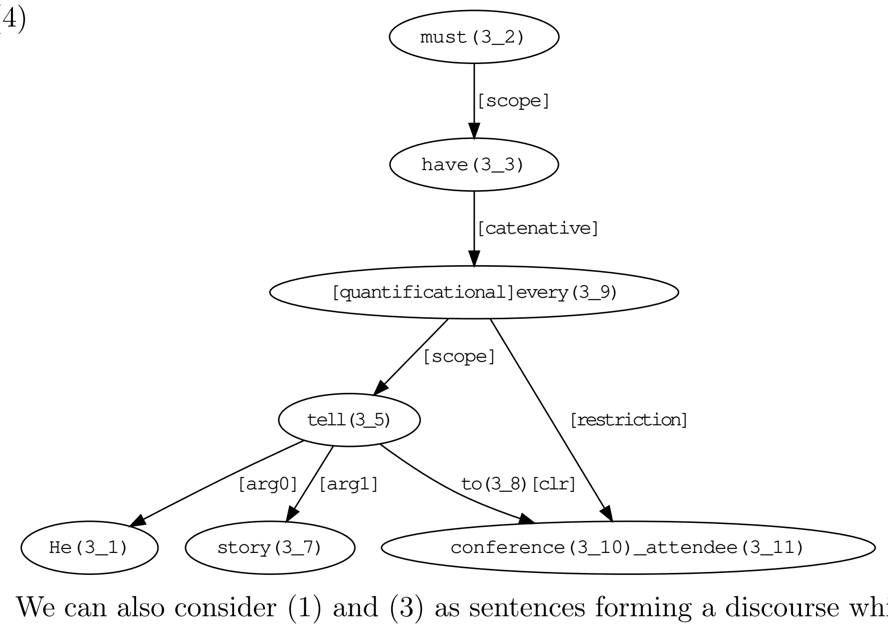

This connects four discourse entity nodes, each of which is referenced to an indexed word of the analysed data. Word indexing consists of two numbers separated by an underscore character. The first number references the sentence to which the word belongs, while the second number is the position of the word in its sentence.

One node of (2) comes from the pronoun subject, giving a discourse entity referencing word content *He(1_1)* as an unresolved pronoun. Another node comes from the main verb to give a discourse entity that is an event with word content *has(1_2)*. A connection labelled `[arg0]` links *has(1_2)* as a dependency governor to *He(1_1)* as its dependent. This captures the information that the *He(1_1)* individual is the 'have-er" of the *has(1_2)* event. In addition, a connection labelled `[arg1]` links *has(1_2)* to a discourse entity that is the *story(1_4)* individual. This captures the information that *story(1_4)* is what is had in the *has(1_2)* event. Finally, a connection labelled `[arg1]` links *story(1_4)* as a dependent of the *tell(1_6)* event to capture the information that *story(1_4)* is the told content of the *tell(1_6)* event (which has no referenced teller).

As a larger example, consider (3) and its dot-to-dot semantic representation of (4) which has seven connected nodes, including a scope taking *must(3_2)* and quantification with the quantifier *every(3_9)* having a restriction and scope.

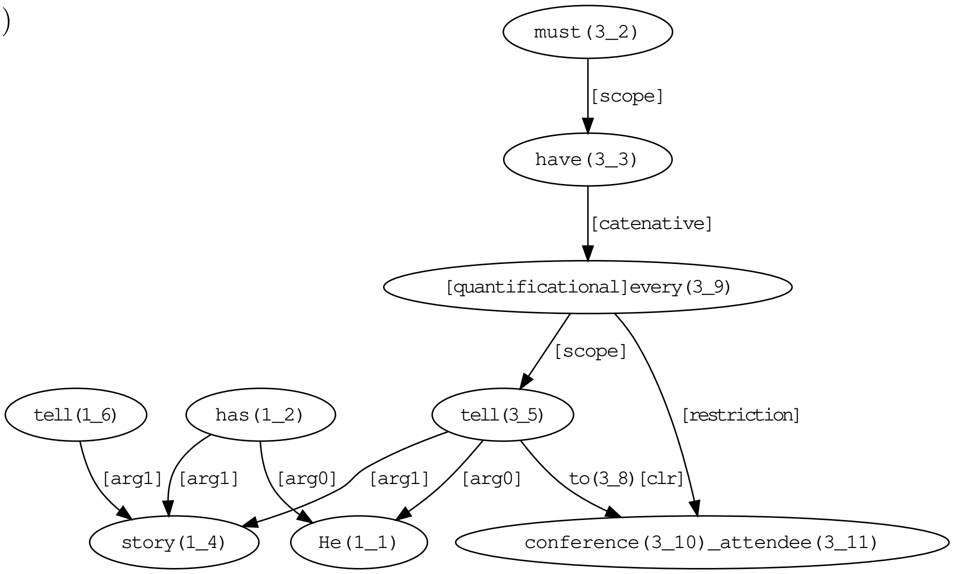
(3) He must have to tell the story to every conference attendee.

(4)




We can also consider (1) and (3) as sentences forming a discourse which is represented with the graph of (5).

(5)




The referenced nodes of (5) are the same sentence references as seen with the graphs of (2) and (4) except there is anaphoric resolution, with the *He(3_1)* and *story(3_7)* node connections for *tell(3_5)* in (4) replaced in (5) by connections to *He(1_1)* (itself still an unresolved pronoun) and *story(1_4)*.

## 3 Steps for deriving the analysis

This section briefly sketches how the dot-to-dot semantic representation of (5) is constructed. We start from syntactic tree annotations for the language data, as in (6).

(6)

```
/w_0001_0001/He/      (IP-MAT (NP-SBJ;{PERSON} (PRO w_0001_0001))
/w_0001_0002/has/             (HVP;~Tn w_0001_0002)
/w_0001_0003/a/               (NP-OB1;{STORY} (D w_0001_0003)
/w_0001_0004/story/                           (N w_0001_0004)
/w_0001_0005/to/                              (IP-INF-REL (TO w_0001_0005)
/w_0001_0006/tell/                                        (VB;~Tn w_0001_0006)
                                                          (NP-OB1 *T*)))
/w_0001_0007/./               (PUNC w_0001_0007))

/w_0003_0001/He/          (IP-MAT (NP-SBJ;{PERSON} (PRO w_0003_0001))
/w_0003_0002/must/                (MD w_0003_0002)
/w_0003_0003/have/                (HV;~cat_Vt w_0003_0003)
/w_0003_0004/to/                  (IP-INF-CAT (TO w_0003_0004)
/w_0003_0005/tell/                            (VB;~Tn.pr w_0003_0005)
/w_0003_0006/the/                             (NP-OB1;{STORY} (D w_0003_0006)
/w_0003_0007/story/                                           (N w_0003_0007))
/w_0003_0008/to/                              (PP-CLR (P-ROLE w_0003_0008)
/w_0003_0009/every/                                   (NP (Q w_0003_0009)
/w_0003_0010/conference/                                  (N w_0003_0010)
/w_0003_0011/attendee/                                    (N w_0003_0011))))
/w_0003_0012/./                   (PUNC w_0003_0012))
```

The annotation of (6) follows the Treebank Semantics Parsed Corpus guidelines (Butler 2022). This style of analysis has projections of word class (`PRO`=pronoun, `VB`=infinitive verb, etc.) from base word references, and then further projections of function marked phrase and clause structure (`IP-MAT`=matrix clause, `NP-SBJ`=subject noun phrase, etc.).

The annotation of (6) is automatically converted into the TPTP formula of (7) which is a Discourse Representation Structure over an event semantics based information encoding, with bound variables (`STATEX7`, `PERSONX6`, `STORYX8`, etc.) acting as discourse referents, but also constants (notably, `r_0001_0001__He` referencing the instance of unresolvable *He* in (1)).

(7)
```
fof(id__1_ex__3_ex,axiom,
    ? [STATEX7,PERSONX6,STORYX8,OPERATORX12,EVENTX13,QUANTX10,EVENTX11,EVENTX5,EVENTX4,ENTITYX9,STORYX1] :
      ( STATEX7 = QUANTX10
      & isA(QUANTX10,r_0003_0009__quantificational__every)
      & restriction(QUANTX10) = ENTITYX9
      & isA(ENTITYX9,r_0003_0010__conference_attendee)
      & scope(QUANTX10) = EVENTX11
      & isA(EVENTX11,r_0003_0005__tell)
      & arg0(EVENTX11) = PERSONX6
      & arg1(EVENTX11) = STORYX8
      & r_0003_0008__to_clr(EVENTX11) = ENTITYX9
      & isA(EVENTX4,r_0001_0006__tell)
      & arg1(EVENTX4) = STORYX1
      & isA(STORYX1,r_0001_0004__story)
      & PERSONX6 = r_0001_0001__He
      & STORYX8 = STORYX1
      & isA(EVENTX5,r_0001_0002__has)
      & arg0(EVENTX5) = r_0001_0001__He
      & arg1(EVENTX5) = STORYX1
      & isA(OPERATORX12,r_0003_0002__must)
      & scope(OPERATORX12) = EVENTX13
      & isA(EVENTX13,r_0003_0003__have)
      & catenative(EVENTX13) = STATEX7 ) ).
```

The formula (7) is converted by the FLOTTER utility (Nonnengart et al 1998) (which implements the Optimized Skolemization of Ohlback and Weidenbach (1995) and Strong Skolemization of Nonnengart 1996) into the Clause Normal Form (CNF) encoding of (8).

(8)
```
list_of_clauses(axioms, cnf).
  clause( ||  -> isA(skc4,r_0001_0002__has),1).
  clause( ||  -> isA(skc3,r_0001_0006__tell),2).
  clause( ||  -> isA(skc5,r_0003_0002__must),3).
  clause( ||  -> equal(arg0(skc4),r_0001_0001__He),4).
  clause( ||  -> isA(arg1(skc3),r_0001_0004__story),5).
  clause( ||  -> isA(scope(skc5),r_0003_0003__have),6).
  clause( ||  -> isA(catenative(scope(skc5)),r_0003_0009__quantificational__every),7).
  clause( ||  -> equal(arg1(skc3),arg1(skc4)),8).
  clause( ||  -> isA(restriction(catenative(scope(skc5))),r_0003_0010__conference_attendee),9).
  clause( ||  -> isA(scope(catenative(scope(skc5))),r_0003_0005__tell),10).
  clause( ||  -> equal(arg0(scope(catenative(scope(skc5)))),r_0001_0001__He),11).
  clause( ||  -> equal(arg1(scope(catenative(scope(skc5)))),arg1(skc3)),12).
  clause( ||  -> equal(r_0003_0008__to_clr(scope(catenative(scope(skc5)))),restriction(catenative(scope(skc5)))),13).
end_of_list.
```

The CNF (8) is revealing of the dependency structure of the discourse. Thus, unembedded items (typically verbs) are associated with skolem constants (clauses 1, 2 and 3) while arguments for verbs are connected with their skolem constants under function symbols that are semantic roles (`arg0`, `arg1`, etc.). Note how clause 10 of (8) has the verb *tell* embedded as a `scope(catenative(scope(skc5))` dependent for *must* of `skc5`. This verb in turn has its arguments linked with a further layer of function symbol embedding (as seen with `arg0(scope(catenative(scope(skc5))))` of clause 11, `arg1(scope(catenative(scope(skc5))))` of clause 12, and `r_0003_0008__to_clr(scope(catenative(scope(skc5))))` of clause 13).

Taking the content of (8) as a series of Prolog facts and assuming the `equal` relation is reflexive, symmetric and transitive, we can extract dependencies with the `find_arc` rules of (9), with `G` as a governor of dependent `X` under relation `R`.

(9)
```
find_arc(arc(G,X,R)) :-
  equal(S,X), atom(X), S =.. [R,E], isA(E,G), atom(G).
find_arc(arc(G,X,R)) :-
  isA(S1,X), atom(X), equal(S,S1), S =.. [R,E], isA(E,G), atom(G).
```

The first rule of (9) will find the dependencies of (10). These are dependencies that involve a governor (`G`) found as content for an `isA` relation related to a skolem term that is under a semantic role function symbol as the relation (`R`) and that is equal to a constant that is the dependent (`X`).

(10)
```
arc(r_0001_0002__has,r_0001_0001__He,arg0).
arc(r_0003_0005__tell,r_0001_0001__He,arg0).
```

The second rule of (9) will find the dependencies of (11). These are dependencies that involve a governor (`G`) found as content for an `isA` relation related to a skolem term that is under a semantic role function as the relation (`R`) and that is equal to a skolem term that is in an `isA` relation with content that is the dependent (`X`).

(11)
```
arc(r_0001_0002__has,r_0001_0004__story,arg1).
arc(r_0001_0006__tell,r_0001_0004__story,arg1).
arc(r_0003_0002__must,r_0003_0003__have,scope).
arc(r_0003_0003__have,r_0003_0009__quantificational__every,catenative).
arc(r_0003_0005__tell,r_0001_0004__story,arg1).
arc(r_0003_0005__tell,r_0003_0010__conference_attendee,r_0003_0008__to_clr).
arc(r_0003_0009__quantificational__every,r_0003_0005__tell,scope).
arc(r_0003_0009__quantificational__every,r_0003_0010__conference_attendee,restriction).
```

The information now gathered with (10) and (11) is the information for presenting the graph of (5).

## 4 Summary

Representations capturing word and sentence syntax based analysis can have clear links to language data that consist of nested groupings, as seen with the syntactic trees of (6) above. But semantic relations necessitate more detachment from language data, with connections that have no clear counterpart from the language data as they arise from the resolution of interpretive options (e.g., picking an antecedent for a pronoun or definite description). This paper has illustrated building a discourse representation that is sufficiently disconnected from language data to capture relationships across discourse that are semantic in nature, including semantic argument dependencies and scope relations, while retaining enough information from the language data for its (partial) recovery.

## References


Banarescu, L. et al. 2013. Abstract Meaning Representation for Sembanking. In *Proceedings of the 7th Linguistic Annotation Workshop and Interoperability with Discourse*, pages 178-186.

Butler, Alastair. 2022. The Treebank Semantics Parsed corpus (TSPC) Web Site. Hirosaki University. Available at: entrees.github.io.

Dekker, Paul. 2012. *Dynamic Semantics*, vol. 91 of *Studies in Linguistics and Philosophy*. Dordrecht: Springer Verlag.

Kamp, Hans and Uwe Reyle. 1993. *From Discourse to Logic: Introduction to Model-theoretic Semantics of Natural Language, Formal Logic and Discourse Representation Theory*. Dordrecht: Kluwer.

Mel'čuk, Igor A. 1988. *Dependency Syntax : Theory and Practice*. SUNY series in Linguistics. Albany: State University Press of New York.

Nonnengart, Andreas. 1996. Strong Skolemization. Technical Report MPI-I-96-2-010, Max-Plank-Institut für Informatik, Saarbrücken, Germany.

Nonnengart, Andreas, Georg Rock, and Christoph Weidenbach. 1998. On generating small Clause Normal Forms. In *Automated Deduction CADE-15*, pages 397–411. Berlin, Heidelberg: Springer.

Ohlbach, Hans Jürgen and Christoph Weidenbach. 1995. A Note on Assumptions about Skolem Functions. *Journal of Automated Reasoning 2(15)*, Kluwer, pages 267–275.



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## Associating with covert focus: An *even*-like semantics for Mandarin *gèng*

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**0 The challenge** Mandarin *gèng* (literally, '*even more*') has been mostly studied with respect to its combination with gradable adjectives (e.g., Liu 2010a; Zhang 2019), where it triggers a comparative plus an evaluative inference (in the sense of Rett 2014). Consider (1). (1-a) does not imply that both Bill and John are tall but (1-b) does, indicating that *gèng* triggers an evaluative inference. Then, consider (2), where *gao* ('*tall*'), modified by *gèng*, only has a comparative reading, indicating that *gèng* necessarily triggers a comparison. Note that an evaluative inference also arises in (2), i.e., both Bill and some contextually salient individual in the discourse, namely *John* in this context, are tall.

(1) Bi'er bi Yuehan (**gèng**) gao.
Bill than John gèng tall
a. **Without** *gèng*: Bill is taller than John. ⇝ **no evaluative inference**
b. **With** *gèng*: Bill is even taller than John. ⇝ **evaluative inference**

(2) (Yuehan hen gao.) Bi'er **gèng** gao.
John HEN tall Bill gèng tall.
(John is tall.) Bill is even taller. ⇝ **comparative**

Observations of this kind led Liu (2010a), among others, to take *gèng* to be a comparative marker, but with an evaluative presupposition, as in (3).

(3) $\|g\grave{e}ng_{\text{phrasal}}\| = \lambda x_{<e>}\lambda P_{<d,<et>>}\lambda y_{<e>}.[\iota max P(d)(y) > \iota max P(d)(x)] \wedge$
$\underline{\text{the properties predicated of } x \text{ and } y \text{ are true in the absolute sense}}$ (Liu, 2010a)

But Liu (2010a) notes, in footnotes, that *gèng* can also combine with non-gradable predicates ((4)-(5), sentences and glosses are Liu's (2010a) and translations ours). We point out that in such cases *gèng* is most naturally paraphrasable with *shènzhì*, the unmarked *even* in Mandarin, and is translated as English *even*. This observation and the extent to which it can be integrated with cases where *gèng* is combined with gradable adjectives as in (1) are understudied.

(4) tamen liang, yi-ge da-le ren, ling yi-ge **gèng** sha-le ren.
they both one-CLF hit-ASP people other one-CLF gèng kill-ASP people
"Of them two, one hit persons and the other one even killed persons."

(5) zhe-suo xuexiao, laoshi shou ren liwu, xiaozhang **gèng** na ren hongbao.
this-CLF school teacher receive people gift president gèng take people cash-gift
"Of this school, teachers take grafts, and the president even takes cash-gift."

**1 Goal and Main Proposal** Our goal is to propose a unified analysis for capturing the effects of *gèng* in both gradable expressions (e.g., (1)) and non-gradable ones (e.g., (4)-(5)). To do that, we take *gèng* to be an *even*-like particle, like *shènzhì*, but to differ from it along two parameters identified in the literature for other *even*-like particles: **(a) anaphoricity / degree of context dependency**, which explains the distinct behaviors between *gèng* and *shènzhì* when combining with non-gradable expressions; and more crucially **(b) ability to associate with covert focus**, which explains their distinct behavior with gradable expressions.

Concretely, we adopt for *gèng* Greenberg (2018)'s gradability-based scalar presupposition of *even*, as in (6). This is an alternative to the traditional likelihood-based presupposition (e.g., Rooth 1985) which has been shown to face issues (Kay 1990; Rullmann 1997; Herburger 2000; Greenberg 2016, 2018). Entry (6) has two components: a) a comparative component, that some non-focused item $x$ in the prejacent $p$ has a higher degree on a scale related to a contextually supplied gradable property $G$ in the accessible $p$ worlds than in the accessible alternative $[q \wedge \neg p]$ worlds; b) an evaluative component, that the degree $x$ holds in $[q \wedge \neg p]$ worlds is above the standard on the $G$ scale:

(6) For the *gèng*-hosting proposition $p$ and all discourse-salient alternatives $q$ ($q \neq p$) in $C$, $g\grave{e}ng(C)(p)(w)$ presupposes: $\forall w1 \forall w2[w1Rw0 \wedge w2Rw0 \wedge w1 \in p \wedge w2 \in [q \wedge \neg p]] \rightarrow [max(\lambda d1.G(d1)(x)(w1)) > max(\lambda d2.G(d2)(x)(w2)) \wedge max(\lambda d2.G(d2)(x)(w2)) > Stand_G]$; if defined, $p(w)$.

**1.1 Accounting for *gèng* with non-gradable predicates** In e.g., (4) $G$ can be taken to measure guiltiness. Thus, (4) presupposes that (a) the other guy was more guilty in the $p$ worlds where he killed persons than in the $[q \wedge \neg p]$ worlds where he hit but did not kill persons, and (b) he was POS guilty in the latter worlds (and of course in the former as well), as in (7).

(7) **The interpretation of (4) by applying (6):**
$\forall w1 \forall w2[w1Rw0 \wedge w2Rw0 \wedge w1 \in [(\|\text{kill persons}\|)(\|\text{the other guy}\|)] \wedge$
$w2 \in [(\|\text{hit persons}\|)(\|\text{the other guy}\|) \wedge \neg(\|\text{kill persons}\|)(\|\text{the other guy})\|)]] \rightarrow$

a. **Comparative presupposition**: $max(\lambda d1.\text{GUILTINESS}(d1)(\text{the other guy})(w1)) > max(\lambda d2.\text{GUILTINESS}(d2)(\text{the other guy})(w2)) \wedge$
b. **Evaluative presupposition**: $max(\lambda d2.\text{GUILTINESS}(d2)(\text{the other guy})(w2)) > Stand_{\text{GUILTINESS}}$
c. If defined, the other guy killed persons in $w$ .

This analysis is supported by the similarity of *gèng* to *shènzhì* and *even* in two more regards. (a) Reversing the predicates causes infelicity (8), due to violating the comparative component in (6): The prejacent $p$ ends up with a lower degree of guiltiness than its alternative $q$. (b) Inserting *zhǐ-bú-guò* (scalar *only*) into the proposition before the *gèng*-hosting proposition also causes infelicity (9). We derive that from the interaction between the well-known 'below the standard / expectation' property of scalar *only* (e.g., Zeevat 2009; Beaver and Clark 2008; Greenberg 2022), and the evaluative component of *gèng* in (6), requiring that both $p$ and $q$ indicate a degree above the salient standard.

(8) tamen liang, yi-ge sha-le ren, ling yi-ge (#**gèng**) / (#**shènzhì**)
they both one-CLF kill-ASP people other one-CLF gèng even
da-le ren.
hit-ASP people
"Of them two, one killed the person, and the other one (#even) hit the person."

(9) tamen liang, yi-ge **zhǐ-bú-guò** da-le ren, ling yi-ge #**gèng** /
they both one-CLF only hit-ASP people other one-CLF gèng
#**shènzhì** sha-le ren.
even kill-CLF people
"Of them two, one only hit persons, and the other (#even) killed persons."

One anonymous reviewer raised the concern of over-generation that entry (6) might lead to unintended interpretations regarding the value of $G$. As addressed in Greenberg 2018, this can be avoided by context manipulation. Consider (10) where movie-goers are discussing whether the two buses available (Blue Line and Red Line) are suitable to take. Without further contextual information, $G$ could equally measure suitability and unsuitability of the buses: The two buses are too early and thus **unsuitable** or early enough and thus **suitable**. But with context manipulation ((10-a) vs. (10-b)), the value of $G$ is fixed.

(10) lanse xianlu che qi-dian chufa, hongse xianlu che **gèng** (shi) / **shènzhì**
blue lane bus seven-o'clock leave red line bus gèng COP even
qi-dian [**bu-dao**]$_F$ chufa.
seven-o'clock NEG-reach after leave
The blue line leaves at seven, and it is even the case that the red line leaves [before]$_F$ seven.

a. Context 1: A and B are going to the movie. If they take a bus leaving at 7 or earlier, they can arrive on time. A asks B what time the buses leave. B checks the time and replies as above. $\rightsquigarrow$ $G$: suitability/#unsuitability
b. Context 2: A and B are discussing whether to go to the movie by bus or by taxi. If the two buses leave before seven, they would have to rush everything, e.g., dinner. A asks B what time the two buses are leaving. B checks the time, and replies as above. $\rightsquigarrow$ $G$: unsuitability/#suitability

Despite the similarity between *gèng* and *shènzhì*, we note that they are not totally identical when interacting with non-gradable predicates. We suggest that they differ w.r.t the first parameter, i.e., **anaphoricity / context-dependency**. This parameter was already observed to be relevant for inter and intra-linguistic variations of *even*-like particles. For example, Spanish *incluso*, Hindi *-bhii* and Russian *daže*, were reported to be anaphoric / strongly context-dependent, i.e., to require the alternative to the prejacent to be based on salient material present in the discourse, whereas Spanish *hasta*, Hindi *-tak* and Russian *voošče* are not (see Schwenter and Vasishth (2000) for Spanish and Hindi; Miashkur (2017) for Russian). We suggest that *gèng* is anaphoric / strongly context-dependent, while *shènzhì* is not. This is supported by the contrast (11) vs. (12).

(11) Yadang nanguo de jujue shuohua, Bi'er nanguo de **gèng** (shi) / **shènzhì**
Adam sad DE refuse speak Bill sad DE gèng COP even
ku-le.
cry-ASP
"Adam was so sad that he refused to talk; Bill was so sad that he even cried."

(12) Yadang nanguo de ??**gèng** (shi) / **shènzhì** ku le.
Adam sad DE gèng COP even cry ASP
Intended: "Adam was so sad that he even cried."

**1.2 Accounting for *gèng* with gradable predicates** Our proposal's main novel part concerns its application to *gèng* with gradable predicates, which we suggest capturing by keeping the same semantics of *gèng* in entry (6), but taking it to differ from *shènzhì* and *even* regarding a second parameter of variation, i.e., **(in)ability to associate with covert focus**: We suggest that unlike *shènzhì* and English *even*, which can only associate with overt focused material, *gèng* can associate with covert focus as well, akin to what has been argued for the Hebrew *even*-like particle *bixlal* (Greenberg, 2020), and the *only*-like particle *be-sax ha-kol* (Orenstein and Greenberg, 2021), both of which can associate with the covert degree modifier POS (in the sense of Kennedy and McNally 2005).

Specifically, we propose that *gèng* can associate with the covert comparative operator **COMP**. The existence of this covert operator in Mandarin was independently argued for by e.g., Xiang (2005), Grano and Kennedy (2012), Lin (2014) (but cf. Lin 2009; Erlewine 2018; Zhang 2019), and was motivated by, among other obervations, the observation that bare adjectives in Mandarin (e.g., *gao* (tall) as in '*Bill gao*'), uttered in isolation, most saliently trigger a comparative reading (Sybesma 1999; Grano 2012; Zhang 2019). In contrast, the addition of unstressed *hěn* (literally '*very*'), claimed by some to be an overt realization of POS in Mandarin (e.g., Liu 2010b), unambiguously yields a positive reading. We propose, then, that in sentences like (1) *gèng* associates with the covert COMP, yielding a comparative reading, whereas the evaluative reading is the result of the evaluative component in the semantics of the *even*-like *gèng* in (6). For simplicity, we adopt for our *gèng* entry the assumption that Mandarin comparatives are clausal (e.g., Liu 1996; Erlewine 2018), but it is not crucial for our main proposal (a phrasal analysis is possible with type shifting). Assuming the presupposition of *gèng* in (6), we take (1) to presuppose that (a) Bill's height in all $p$ worlds where Bill is taller than John ranks higher than in all $[q \wedge \neg p]$ worlds where he is as tall as but not taller than John (which is trivially met), and the nontrivial requirement that (b) in the $[q \wedge \neg p]$ worlds, Bill is POS tall. This is formalized in (13), which captures both the comparative and evaluative inferences in (1).

(13) **The interpretation of (1) by applying (6):**
$\forall w1 \forall w2[w1Rw0 \wedge w2Rw0 \wedge w1 \in [\text{the max } \mathrm{d}_b(\lambda d_b.TALL(d_b)(Bill)) >$
$\text{the max } \mathrm{d}_j(\lambda d_j.TALL(d_j)(John))] \wedge w2 \in [\text{the max } \mathrm{d}_b(\lambda d_b.TALL(d_b)(Bill)) \geqslant$
$\text{the max } \mathrm{d}_j(\lambda d_j.TALL(d_j)(John)) \wedge \neg(\text{the max } \mathrm{d}_b(\lambda d_b.TALL(d_b)(Bill)) >$
$\text{the max } \mathrm{d}_j(\lambda d_j.TALL(d_j)(John)))]] \rightarrow$

a. **Comparative presupposition:** $max(\lambda d1.TALL(\mathrm{d1})(\mathrm{Bill})(\mathrm{w1})) > max(\lambda d2.TALL(d2)(Bill)(w2)) \wedge$
b. **Evaluative presupposition:** $max(\lambda d2.TALL(d2)(Bill)(w2)) > Stand_{tall}$
c. If defined, Bill is taller than John in $w$.

This second parameter along which *gèng* and *shènzhì* differ also accounts for the distinct readings they trigger when combined with bare adjectives, as shown in (14) vs. (15).

(14) Bi'er **gèng** gao.
Bill gèng tall
Bill is even taller (than some contextually salient individual).

(15) Bi'er **shènzhì** ??(hen) gao.
Bill even HEN tall
Bill is even tall.

In (14), *gèng*, associating with covert COMP, triggers a comparative reading. But in (15), *shènzhì*, unable to associate with COMP, only triggers a positive reading; this also explains why the presence of the semantically bleached modifier *hen*, assumed by e.g., Liu (2010b) to be the overt realization of POS in Mandarin, is preferred in (15).[1]

[1] An anonymous reviewer asked whether our analysis implies that *gèng* cannot co-occur and then associate with unstressed *hěn* and, if the answer is negative, why not. The answer is indeed negative: Adding unstressed *hěn* immediately before '*gao*' in (14) would render (14) to be ungrammatical. Entry

Our analysis has another advantage. That is, it naturally captures our new observation related to *gèng*'s stress pattern with gradable predicates. Specifically, we observe that unlike cases with non-gradable predicates ((4)-(5)), in cases like (1), with gradable predicates, *gèng* is stressed by default. Our analysis naturally captures this: Since *gèng*'s associate, COMP, is covert, it cannot bear stress; the stress thus shifts to *gèng* (cf. Umbach 2009; Wagner 2012). Note that *gèng*'s strong anaphoricity is also relevant with gradable predicates. Consider (14), again. We note that if uttered in isolation, (14) feels incomplete. We argue that this is due to *gèng*'s anaphoric nature .

**2. A Prediction** *Even*-like particles were argued to presuppose that their prejacent is stronger than all distinct alternatives in $C$ (Rooth 1992; Greenberg 2022; but cf. Kay 1990; Xiang 2020). If *gèng* is *even*-like, we would predict it to trigger this presupposition with both non-gradable and gradable predicates. This seems to be borne out, as seen in the infelicity of (16-b) and (17) where a salient weaker alternative exists in the discourse (cf. similar infelicities with English *even* as in Greenberg (2016, 2022)). In contrast, if *gèng* is a comparative operator, this observation remains unexplained.

(16) a. "How many papers did your faculty members write?"
b. "They all did great. Jim wrote 3, Bill 6, Ray 4, John #**gèng** (shi) / #**shènzhì** xie-le 5 pian."
They all did great. Jim wrote 3, Bill 6, Ray 4, John gèng COP even write-ASP 5 piece
Intended: "They all did great. Jim wrote 3, Bill 6, Ray 4, (and) it is (#even) the case that John wrote 5."

(17) tamen san-ge dou hen gao. qizhong Bi'er zui gao, Yuehan hen gao, Gelei bi Yuehan (???**gèng**) gao.
they three-CLF all very tall among Bill most tall John very tall Gray than John gèng tall
Intended: "They three are all tall. Among them, Bill is the tallest, John is very tall, and is even taller than John.

**3. One open issue** An old puzzle about *gèng* is its mixed (in)compatibility pattern with differentials (see e.g., Lu 1985), as in (18). With *gèng* omitted, all differentials become fine. Neither Liu's (2010a) proposal ( entry (3)) nor ours captures this.

(18) Bi'er bi Yuehan **gèng** gao *san-gongfen / *hen-duo / yidianer / yixie.
Bill than John gèng tall three-centimeter very-much a-little some
Intended: "Bill is even *3 centimeters* / *much* / *a little* / *some distance* taller than John."

---

(6) can actually capture this non-grammaticality. Suppose that *gèng* associates with unstressed *hěn* which assumes the function of POS in English; then, the triggered alternatives would be other degree modifiers that indicate a degree either above POS, e.g., '*feichang*' ('*very*'), or below POS, e.g., '*bu-tai*' (literally 'negation-much', which can be paraphrased as '*barely*'), as in (i). With (i-a) as the alternative set, *gèng*'s comparative requirement is violated: Bill is taller in the $q$ worlds than in the $p$ worlds. With (i-b) as the alternative set, *gèng*'s evaluative requirement is violated: In the $q$ worlds, Bill is below the POS level. This explains why *gèng* is unable to associate with unstressed *hěn*.

(i) a. Possible alternative set 1: {Bill is very tall, Bill is POS / hen$_{unstressed}$ tall.}
b. Possible alternative set 2: {Bill is not very / barely tall, Bill is POS / hen$_{unstressed}$ tall.}

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# References


Beaver, D. I. and Clark, B. Z. (2008). *Sense and Sensitivity: How Focus Determines Meaning*. Explorations in Semantics. Wiley-Blackwell, Oxford, UK.

Erlewine, M. Y. (2018). Clausal comparison without degree abstraction in Mandarin Chinese. *Natural Language & Linguistic Theory*, 36(2):445–482.

Grano, T. (2012). Mandarin *hen* and universal markedness in gradable adjectives. *Natural Language & Linguistic Theory*, 30(2):513–565.

Grano, T. and Kennedy, C. (2012). Mandarin transitive comparatives and the grammar of measurement. *Journal of East Asian Linguistics*, 21(3):219–266.

Greenberg, Y. (2016). A novel problem for the likelihood-based semantics of even. *Semantics and Pragmatics*, 9:2–1.

Greenberg, Y. (2018). A revised, gradability-based semantics for *even*. *Natural Language Semantics*, 26(1):51–83.

Greenberg, Y. (2020). An overt even operator over covert-based focus alternatives: The case of Hebrew BIXLAL. *Journal of Semantics*, 37(1):1–42.

Greenberg, Y. (2022). On the scalar antonymy of *only* and *even*. *Natural Language Semantics*, 30(4):415–452.

Herburger, E. (2000). *What counts: Focus and quantification*. MIT Press.

Kay, P. (1990). Even. *Linguistics & philosophy*, 13:59–111.

Kennedy, C. and McNally, L. (2005). Scale structure, degree modification, and the semantics of gradable predicates. *Language*, pages 345–381.

Lin, J.-W. (2009). Chinese comparatives and their implicational parameters. *Natural Language Semantics*, 17(1):1–27.

Lin, J.-W. (2014). The adjective of quantity *duo* 'many/much' and differential comparatives in Mandarin Chinese. *International Journal of Chinese Linguistics*, 1(2):163–191.

Liu, C.-S. L. (1996). A note on Chinese comparatives. *Studies in the Linguistic Sciences*, 26(1-2):217–235.

Liu, C.-S. L. (2010a). The Chinese *geng* clausal comparative. *Lingua*, 120(6):1579–1606.

Liu, C.-S. L. (2010b). The positive morpheme in chinese and the adjectival structure. *Lingua*, 120(4):1010–1056.

Lu, J. (1985). *Hai* he *geng* [Hai and geng]. In Lu, J. and Ma, Z., editors, *Xiandai hanyu xuci sanlun [The Discussion of Function Words in Modern Mandarin]*. Beijing University Press, Beijing, China.

Miashkur, L. (2017). A parametric comparison of two scalar particles in Russian. *IATL33*.

Orenstein, D. and Greenberg, Y. (2021). Approximation derived from a scalar exclusive particle associating with covert focus: The case of Hebrew be-sax ha-kol. *Glossa: a journal of general linguistics*, 6(1).

Rett, J. (2014). *The semantics of evaluativity*. OUP Oxford.

Rooth, M. (1992). A theory of focus interpretation. *Natural language semantics*, pages 75–116.

Rooth, M. E. (1985). *Association with focus (montague grammar, semantics, only, even)*. PhD thesis.

Rullmann, H. (1997). Even, polarity, and scope. *Papers in experimental and theoretical* *linguistics*, 4(40-64).

Schwenter, S. A. and Vasishth, S. (2000). Absolute and relative scalar particles in spanish and hindi. In *Annual meeting of the Berkeley linguistics society*, volume 26, pages 225–233.

Sybesma, R. (1999). *The Mandarin VP*, volume 44 of *Studies in Natural Language and Linguistic Theory*. Springer Science & Business Media.

Umbach, C. (2009). Comparatives combined with additive particles: The case of German 'noch'. In *Proceedings of Sinn und Bedeutung*, volume 13, pages 543–558.

Wagner, M. (2012). Focus and givenness: A unified approach. *Contrasts and positions in information structure*, pages 102–47.

Xiang, M. (2005). *Some Topics in Comparative Constructions*. PhD thesis, Michigan State University.

Xiang, Y. (2020). Function alternations of the Mandarin particle *dou*: Distributor, free choice licensor, and 'even'. *Journal of Semantics*, 37(2):171–217.

Zeevat, H. (2009). "*Only*" as a mirative particle. In Riester, A. and Onea, E., editors, *Focus at the Syntax-Semantics Interface*, volume 3 of *Working Papers of the SFB 73*. University of Stuttgart.

Zhang, L. (2019). The semantics of comparisons in Mandarin Chinese. In Cho, S.-Y., editor, *Proceedings of GLOW in Asia XII & SICOGG XXI: Universal Grammar and Its Cross-linguistic Instantiations*, pages 643–652.

**Comparing Degree-Based and Argumentative Analyses of *Even***

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**1. Introduction**: One of the debates concerns the nature of the scale along which the alternatives to the 'prejacent' of *even* are ordered: whether the scale is based on the dimension of unlikelihood (see [1], [2], [3], [4], [5]) informativeness [6], [7]), unexpectedness [8], noteworthiness [9], etc. In this paper we compare two rather recent characterizations of *even* which contribute to this debate, namely the degree-based approach proposed by Greenberg ([10], [11], [12], [13]) and the argumentative approach proposed by Winterstein ([14], [15], [16]). We conclude that both approaches are equally successful in accounting for various felicitous and infelicitous cases with *even* (in particular cases which the popular unlikelihood-based approach to *even* cannot capture). Nonetheless, we believe that there is an advantage of the argumentative approach, as it turns out to be less stipulative than the degree-based one.

**2. Background**

***2.1 In a nutshell: The degree-based approach by Greenberg***

Traditionally, *even* is taken to trigger a scalar presupposition [1], [2], [19], [10], [12] along the lines of (1):

**(1)** $||\text{even}||^{g,c}$: $\lambda C.\ \lambda p.\ \lambda w : \forall q \in C\ q \neq p \rightarrow p > q.\ p\,(w) = 1$, where $C \subseteq ||p||^{F} \wedge ||p||^{O} \in C \wedge \exists q\ q \neq p \wedge q \in C$,

In prose: *even C p*, presupposes that the prejacent *p* is stronger than all distinct alternatives *q* in *C* (where *C* in a set of contextually relevant focus alternatives, which differ from *p* in that the focused element is replaced by an element of the same semantic type [18], [2]). Notice that the 'stronger than' relation, > ,in (1) is unspecified. A popular way to characterize it is in terms of *unlikelihood* [1], [2], [21], [4], where (1) is re-written as in (1a):

**(1a)** $||\text{even}||^{g,c}$: $\lambda C.\ \lambda p.\ \lambda w : \forall q \in C\ q \neq p \rightarrow p >_{unlikely} q$

However, (1a) seems problematic (for detailed discussion see e.g. [10]). Greenberg proposes an alternative, gradeability-based characterization of the scalar presupposition of *even,* with the following two components:

**(2) A degree-based presupposition of even:**

(a) Evaluative component: *x*'s degree on a *G* scale in *p* worlds and in *q*-and-not-*p* worlds is at least as high as the standard of *G.*

(b) Comparative component: *x*'s degree on a *G* scale in the (accessible) *p* worlds is higher than in the accessible *q*-and-not-*p* worlds (where *G* is a contextually salient property, and it is determined by the QUD (cf. [17]).

The following example shows how the degree-based approach accounts for felicitous cases of *even.*

**(3)** *Client*: I need a strong tool for this work. What materials are these two tools made of?

*Seller*: Both are strong enough for what you need. The red one is made of strong aluminum and the blue one is even [made of steel]$_F$ (cf. [10]).

Notice that instead of comparing the propositions *p* ('*the red tool is made of strong aluminum*') and *q* ('*the blue tool is made of strong aluminum'*), there is an indirect comparison of the degrees of an element *x* in the alternatives (*the blue tool*) on a scale based on a *G* property – which, in this case, is '*suitability for the work'*. In particular, given (22) *even* presupposes that (a) both tools are suitable for the purpose of the client, i.e., both have a degree above the standard of suitability; and that (b) being made of steel the blue tool is more suitable, i.e. has a higher degree on the suitability scale than being made of strong aluminum. The analysis also successfully captures infelicitous cases of *even*, as in (4):

**(4)** *Context*: John and Bill want to join our basketball team, where the standard height is 1.90m.

A: What about John and Bill? Should we take them?
B1: Well, John is 1.95m tall. Bill is (even) $[2.10]_F$. (We can take both)
B2: Well, John is 1.65m tall. Bill is (??even) $[1.75]_F$ (We shouldn't take them)
B3: Well, John is 1.75m tall. Bill is (??even) $[1.95]_F$. (We can take Bill)

In all three cases the comparative requirement in (2b) is met ($p$ indicates a degree of suitability for joining the team which is higher than in $q$). The felicity contrasts are due to the evaluativity requirement in (2a): *even* is felicitous in B1 since both $p$ and $q$ indicate degrees which are above the contextual standard. Response B2 fails to satisfy (2a), since both alternatives indicate degrees which are below the contextual standard. Response B3 is also infelicitous, since only $p$ indicates a degree above the standard.

***2.2 In a nutshell: the argumentative approach by Winterstein* ([14], [15], [16])**

The argumentative approach goes back to the work of Anscombre and Ducrot [20], who argue that the argumentative component of meaning is more crucial that the truth-conditional one. Here's a probability-based modeling of the relation "*is an argument for*" suggested in [15]:

**(5)** A set of premises $R$ is an *argument for a hypothesis H* iff $P(H|R) > P(H)$, i.e., the probability of $H$ after learning $R$ (the posterior probability) is higher than before learning $R$ (the prior probability).

For an utterance containing *even p* to be felicitous, the prejacent must be a stronger argument for a hypothesis than the antecedent. In probability-based terms this requirement is composed of two claims:

**(6) An argumentative presupposition of *even*:**

(a) Argumentative co-orientation: $P(H|q) > P(H)$ and $P(H|p) > P(H)$, i.e., both the prejacent and the antecedent are arguments for the same hypothesis.

(b) Argumentative superiority: $P(H|p) > P(H|q)$, i.e., the prejacent is a stronger argument than the antecedent.

The following if the analysis of (3) in the argumentative terms, assuming that *even* is focus-sensitive. We assume that the salience of the previously uttered sentence forces the focus alternatives constructed based on it into $C$ (see e.g., [13]). In this case, then, the set of contextually supplied focus alternatives of $p$ $C$ can be taken to be {*The blue tool is made of steel*, *the blue tool is made of strong aluminum*, …}:

**(7)** *Hypothesis:* The blue tool is suitable for gardening.
*Argument q*: The blue tool is made of strong aluminum.
*Argument p*: The blue tool is made of steel.

Example (3) is, then, felicitous because both (6a) and (6b) are met: In particular, argumentative co-orientation is a conjunction of the following two statements: (i) *For argument q*: $P(H| q) > P(H)$, i.e., being made of strong aluminum makes this tool suitable for gardening. And (ii) *For argument p:* $P(H| p) > P(H)$, i.e., being made of steel makes this tool suitable for gardening. In addition, argumentative superiority - $P(H| p) > P(H| q)$ is met as well, i.e., the fact that the tool is made of steel (the case of $p$) would raise the probability that it is a suitable tool for gardening, more than for the case of $q$, where the tool is made of a less strong, and thus less suitable, material.

The argumentative approach also captures the infelicity of *even* in (4). Notice that since we assume that all alternatives here are focus alternatives to the prejacent, all the arguments and the hypothesis are about Bill. In argumentative interpretation of example (4), then, the hypothesis is *Bill is eligible to join the basketball team where the standard height is 1.90m.* There are three sets of arguments, which are listed below:

| (8) | Case B1 (felicitous) | Case B2 (infelicitous) | Case B3 (infelicitous) |
|---|---|---|---|
| | *Argument q:* Bill is 1.95m tall. *Argument p:* Bill is 2.10 m tall. | *Argument q:* Bill is 1.65m tall. *Argument p:* Bill is 1.75m tall. | *Argument q:* Bill is 1.75m tall. *Argument p:* Bill is 1.95m tall. |
| | (6a) satisfied | (6a) fails | (6a) fails |

In all three cases (6b) is satisfied: the prejacents in each case are better arguments than the antecedents for the hypothesis. However, (6a) is satisfied only in B1, where both the prejacent and the antecedent are arguments for the hypothesis, i.e., both elevate the probability of *Bill is eligible to join the team*. In B2, neither *p* nor *q* are arguments for the hypothesis *H.* In B3 only the prejacent is an argument for the hypothesis *H,* and the antecedent is not. Therefore, only B1 is felicitous.

## 3. The Degree-based vs the argumentative analysis of *even*: A comparison

### *3.1 Similarity*

We have shown that both the degree-based and the argumentative approaches successfully account for the same data (felicitous cases (3) and (7) and infelicitous cases (4) and (8). This fact makes both the degree-based and the argumentative approaches more successful than the popular unlikelihood-based approach to *even,* which was argued to fail capturing the data presented in (3) and (4) (see [11], [16]).

Moreover, we argue that the two approaches are structurally similar. For instance, there seems to be the following correspondence: the evaluative component (2a) in the degree-based approach corresponds to the argumentative co-orientation requirement (6a) in the argumentative approach, and the comparative component (2b) in the degree-based approach corresponds to the argumentative superiority requirement (6b) in the argumentative approach.

### *3.2 An advantage of the argumentative approach*

Despite the similarities between the degree-based and argumentative approaches described above, we claim that there is an advantage of the argumentative approach over the degree-based one**.** In particular, we propose that whereas in the degree-based approach both requirements (2a and 2b) need to be hardwired to account for the data with *even,* in the argumentative approach only the argumentative superiority requirement (6b) needs to be hardwired, while the argumentative co-orientation (6a) can be derived. If this is indeed the case, then the argumentative approach is better because it stipulates less.

To show that this is indeed the case, we propose that *even* can be taken to operate on **an interval argumentative scale**, defined in terms of intervals (and not in terms of points). Each interval on such a scale gets associated with the numeric value which represents the effect that each argument has on the hypothesis (measured as the difference between the posterior probability and the prior probability of the hypothesis). The intervals are presented as the following (where $\ell$ stands for 'length', and *I* stands for 'interval'):

**(9)** (a) $\ell(I_p) = \mathrm{P}(H|p) - \mathrm{P}(H)$

(b) $\ell(I_q) = \mathrm{P}(H|q) - \mathrm{P}(H)$

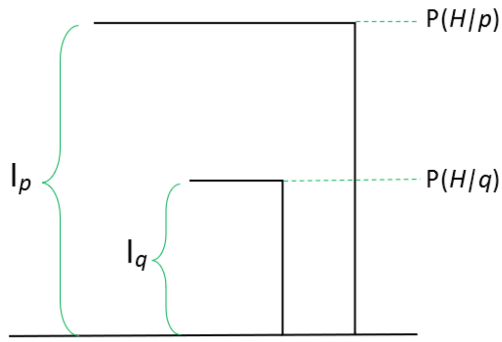
Based on the notion of intervals the argumentative co-orientation and superiority requirements in the presupposition of *even* can be reformulated, as in (10) and (11), respectively:

**(10) An interval-based argumentative presupposition of *even*:**

(a) Argumentative co-orientation: both $\ell(I_p)$ and $\ell(I_q)$ are positive numbers

(b) Argumentative superiority: $\ell(I_p) > \ell(I_q)$

The following illustration visually sketches the interval argumentative scale. The intervals represent the amounts of 'impact' that each argument has on a hypothesis, thus such scale can be seen as lower closed (in the sense of [22]). Since both $p$ and $q$ are arguments for $H$, they both elevate the posterior probability of $H$, so in any case the posterior probability cannot be lower than the prior probability $P(H)$ and cannot equal it.




To show that the argumentative presupposition of *even* can be formulated using only one – argumentative superiority – requirement (6b), we need to show that (10a) can be derived from (10b). In other words, we must prove that if $p$ is a stronger argument for $H$ than $q$, then it is presupposed that both $p$ and $q$ are arguments for $H$ to start with. This can be proven by the contradiction: if $q$ is not an argument for $H$, then one of the following is true:

**(11)** $P(H) > P(H \mid q)$, i.e., $q$ is an argument against the hypothesis

**(12)** $P(H) = P(H \mid q)$ i.e., $q$ is irrelevant for the hypothesis

Thus, if (11) is the case, the length of the interval $I_q$, is a negative number. But this requires placing $P(H \mid q)$ lower than $P(H)$ on the scale in the illustration. If (12) is the case, the length of the interval $I_q$ is zero. Crucially, it seems that neither of these requirements is satisfiable: since $P(H)$ is at the very bottom of the scale, in both these cases the interval $I_q$ would not be on the interval argumentative scale to start with. In particular, an interval whose length is negative (representing an argument against $H$), or zero (representing an irrelevant argument), could not be on a scale which measures the strength of arguments for $H$.

If indeed the right way to characterize the scale for *even* is using an interval argumentative scale, it is enough to postulate just the superiority requirement (6b), re-casted as (10b), to account for the distribution of *even:* the argumentative co-orientation requirement (6a) would get derived from it. We conclude, then, that the minimal interval-based argumentative presupposition of *even* can be characterized as in (13):

**(13) A minimal interval-based argumentative presupposition of *even***: *even*($C$)($p$) presupposes that for any focus alternative $q$ in $C$ $\ell(I_p) > \ell(I_q)$, or, put differently, $(P(H \mid p) - P(H)) > (P(H \mid q) - P(H))$.

In prose, the length of the interval showing the impact of the argument $p$ on $H$ must be bigger than the length of the interval corresponding to the impact of the argument $q$ on $H$.

## 4. Conclusion and future directions

Following the ideas in Winterstein's work, we proposed that the presupposition of *even* operates on an interval argumentative scale. This claim was proven to make correct predictions regarding the (in)felicity of *even,* similarly to the degree-based approach to *even*, but has the advantage: only one requirement (argumentative superiority) needs to be hardwired, while the other (argumentative co-orientation) can get derived. This claim allowed us to formulate the minimal version of the interval-based argumentative presupposition of *even*.

Time permitting, we will examine the following two open questions / directions for future research:

**(A)** ***Definitely*:** Greenberg [10] argues that the felicity of *even* in (14) constitutes a problem for argumentative approaches to this particle. Assume that my hat got stuck on a 1.50m high branch:

**(14)** John is 1.70 m tall. He is *definitely* tall enough to fetch the hat. And Bill is even [taller]$_F$.

Greenberg assumes that *definitely* would raise $P(H \mid q)$ here to maximality, i.e., to 1. But then it is not clear how the superiority requirement (that $p$ raises it to a higher extent) can be met. We will examine several directions for solving this issue: One is to assume that *definitely* is a part of the hypothesis. Another is that there might be another salient hypothesis for which the argumentative superiority constraint is satisfied (e.g., *Bill is suitable for fetching* *the hat* with the multidimensional adjective *suitable* [29]. In such a case, not only the ability of Bill (given his height) would be considered, but also the ease in which he fetches the hat, the gracefulness with which he would do it, or his ability to keep his clothes clean while doing this, etc.

**(B)** '*Mirative' even*: Winterstein [15] points out the infelicity of *even* in (15a), both the argumentative co-orientation and the argumentative superiority requirements seem to be met (cf. the felicity of *even* in (15b)):

**(15)** (a) # Conference X is very attractive. You get a nice hat, and the organizers *even* invited interesting keynote speakers.

(b) Conference X is very attractive. The organizers invited interesting keynote speakers and you *even* get a nice hat.

Having interesting talks is indeed a stronger argument for attending a conference, compared to receiving a hat, and both are clearly arguments for attending a conference. However, (15a) is infelicitous.

As a response to this challenge, Winterstein suggests redefining the unlikelihood account in terms of probability. Thus, the unlikelihood requirement (1a) means that the prior probability of the prejacent is lower than the prior probability of the antecedent, i.e., $P(p) < P(q)$. In (15a), then, *even* is infelicitous, because although indeed having keynote speakers is a better argument for the conference's success than getting nice hats, the former is less unlikely than the latter. The new requirements for such 'mirative' cases of *even* are thus the following:

**(16)** (a) *argumentative co-orientation requirement:* $P(H \mid p) > P(H)$ and $P(H \mid q) > P(H)$, i.e., both the prejacent and the antecedent of even are arguments for the same hypothesis

(b) *comparative component*: $P(p \mid H) < P(q \mid H)$, i.e., assuming the hypothesis is true, the prejacent is less likely to be true than the antecedent

In the talk we will discuss this idea and the extent to which it can be applied to all cases of *even* (including those where *even* does not seem to have a mirative effect, e.g., (3) above). We also discuss the intuition that in (15b), the prejacent $p$ by itself is not an argument for the hypothesis, i.e., getting a nice hat is not a good enough reason to attend a conference. However, it is a *relevant* argument. In this sense, getting a hat would be the *least* cause to attend a conference, which, however, being summed up with another good argument, becomes 'the straw that broke the camel's back', the *last* cause convincing a person to attend a conference. We will compare this intuition with a similar case cited in Fauconnier [28]:

**(17)** Georges has drunk a little wine, a little cognac, a little rum, a little calvados and *even* a little armagnac.

The hypothesis for (17) is *Georges drunk too much.* What makes the listener convinced that *Georges drunk too much* is the sum of the arguments, where the prejacent of *even* might be not the strongest but necessarily the crucial argument. We will consider the idea that *even* sometimes has an incremental effect, similarly to *'in addition'* or *'moreover'*, etc.

**References**:


1. Karttunen, L., & Peters, S. (1979). Conventional lmplicature. In Presupposition (pp. 1-56). Brill.
2. Rooth, M. (1992). A theory of focus interpretation. *Natural language semantics, 75-116.*
3. Lahiri, U. (2008). The semantics and pragmatics of some scalar expressions in Spanish. Anuario del Seminario de Filología Vasca" Julio de Urquijo", 42(2), 359-389
4. Chierchia, G. (2013). *Logic in grammar: Polarity, free choice, and intervention. OUP Oxford.*
5. Horn, L. R. (1969, April). A presuppositional analysis of only and even. In *Proceedings from the Annual Meeting of the Chicago Linguistic Society (Vol. 5, No. 1, pp. 98-107). Chicago Linguistic Society.*
6. Kay, P. (1990). Even. Linguistics and philosophy, 13, 59-111.
7. Gast, V., & Van der Auwera, J. (2011). Scalar additive operators in the languages of Europe. Language, 2-54.
8. Zeevat, H. (2009). " Only" as a mirative particle.
9. Herburger, E. (2000). *What counts: Focus and quantification. MIT Press.*
10. Greenberg, Y. (2015). Even, comparative likelihood and gradability. In Proceedings of the Amsterdam colloquium (Vol. 20, pp. 147-156).
11. Greenberg, Y. (2016). A novel problem for the likelihood-based semantics of even. Semantics and Pragmatics, 9, 2-1.
12. Greenberg, Y. (2018). A revised, gradability-based semantics for even. Natural Language Semantics, 26(1), 51-83.
13. Greenberg, Y. (2022). On the scalar antonymy of only and even. Natural Language Semantics, 30(4), 415-452.
14. Winterstein, G. (2015). Layered Meanings and Bayesian Argumentation: The Case of Exclusives. In H. S. Zeevat, Bayesian Natural Language Semantics and Pragmatics (Vol. 2, pp. 179 - 200 ). Springer, Cham.
15. Winterstein, G. (2018). A Bayesian approach to Argumentation within Language. Semantics Archive. Retrieved from Semantics Archive: https://semanticsarchive.net/Archive/mFkZGM0N/Argumentation.pdf
16. Winterstein et al. (2018). From additivity to mirativity: The Cantonese sentence final particle tim1. Glossa: a journal of general linguistics. Glossa: a journal of general linguistics, 3(1).
17. Roberts, C. (1996). Information structure: Towards an integrated theory of formal pragmatics, volume 49 of. Technical report, OSU Working Papers in Linguistics.
18. Rooth, M. E. (1985). *Association with focus (montague grammar, semantics, only, even). University of Massachusetts Amherst.*
19. Wilkinson, K. (1996). The scope of even. Natural language semantics, 4(3), 193-215.
20. Anscombre; Ducrot. (1983). Argumentation dans la langue. Languages, 42, Argumentation et discours scientifique, 5 - 27. Retrieved from https://www.jstor.org/stable/i40078942
21. Rooth, M. E. (1985). Association with focus (montague grammar, semantics, only, even). University of Massachusetts Amherst.
22. Kennedy, C., & McNally, L. (2005). Scale structure, degree modification, and the semantics of gradable predicates. *Language*, 345-381.

# Perspective and the Self in Experiential Attitude Reports

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**Abstract.** It is often assumed that self-directedness (i.e. *de se*-ness) and first-person perspective (1pp) can be jointly captured through individual centers (s.t. 1pp- and *de se*-contents both take the form of centered propositions). This assumption is challenged by instances of 'outside' (i.e. *objective*, or *observer*) remembering/imagining, which intuitively combine *de se* with a third-person [= non-actual/-original] perspective. My paper answers this challenge: It argues that perspective can be captured through a classical propositional account of attitudes that identifies (experiential) attitude content with a set of situations. Individual centers are only required to account for the *de se*-status of these attitudes. The separation of modelling mechanisms for perspectivity and *de se*-ness challenges the common view that 'inside' remembering is immune to error through misidentification. It enables an account of an inverse phenomenon to outside imagining (that combines 1pp with NON-*de se*), viz. walking in s.o. else's shoes.

**1. Background.** Experiential attitudes are mental/perceptual experiences (e.g. episodic remembering, experiential imagining) that agents have of an event or scene [2, 7, 10, 16, 17]. Like the more familiar propositional attitudes (e.g. believing, desiring; see (1)), experiential attitudes can be self-directed or self-locating [8] in the sense that they are essentially about oneself (i.e. they can be *de se*). This possibility is overt in (2a), which is analyzed through the obligatorily *de se* silent pronoun PRO [3] – just like the familiar (1b).[1]

(1) a. Berta believes that she (herself) is swimming in the ocean.
b. Berta is hoping to swim in the ocean.
(*analysis:* Berta is hoping PRO to swim in the ocean.)

(2) a. Zeno {remembers, imagines} swimming in the ocean.
(*analysis:* Zeno {remembers, imagines} PRO swimming in the ocean.)
$\overset{c}{\equiv}$ b. Zeno {remembers, imagines} what it was/is like to be swimming in the ocean: the water was/is cold and tasted salty, the current was tugging on his legs ...

It is commonly assumed that *de se*-attitude reports are first-person perspectival in the sense that they capture the (visual, proprioceptive, emotional, or other) viewpoint of the attitude holder. Since perception and emotion are typically 1pp, first person perspective is the original viewpoint (i.e. the viewpoint from which the remembered event was experienced) in remembering. The assumption '*de se* ⇒ 1pp' is supported by the observation that (2a) is intuitively equivalent to the overtly first person-perspectival report in (3):

(3) Zeno {remembers, imagines} PRO swimming in the ocean *from his own (proprioceptive/swimmer's) perspective.*

(4) $[\![\text{imagine}]\!]\big(\lambda x.[\![x \text{ swims}]\!]\big)(\text{Zeno}) = [\![\text{imagine}]\!]\big(\{\langle x, w\rangle : x \text{ swims in } w\}\big)(\text{Zeno})$

The strong association of 1pp with *de se*-ness is made explicit in the passage from Stephenson [16, p. 150] below. It is reflected in the fact that (2a) and (3) are commonly both interpreted through the use of individual centers (i.e. of individuals $x$ on which the attitude content – in (4): '$x$ swims' – is dependent [5, 8]).

> *[...] for ['John remembered feeding the cat'] to be true, John must be aware that it is his own self that is doing the feeding in his memory. But*

[1] German can report experiential like propositional *de se*-attitudes through a PRO-infinitival construction:

(†) a. Berta {glaubt, hofft}, PRO zu schwimmen. [Berta {believe-3SG, hope-3SG} PRO to swim-INF.]
b. Berta stellt sich vor, PRO zu schwimmen. [Berta imagine-3SG.REFL PRO to swim-INF.]

*beyond being obligatorily* de se*, [it is] also obligatorily interpreted as involving imagining or remembering from the inside in the sense of Vendler [17] [...]. That is, the mental image John builds up must be from the sensory perspective of the person doing the feeding; it is not sufficient that John be able to identify this individual as his* de se *counterpart.*

Interpretations like (4), which associate 1pp with *de se*-ness, have led some researchers to call accounts (like Stephenson's) that use individual centers *perspectivist* (see [18]).

**2. The Challenge.** The assumption '*de se* $\Rightarrow$ 1pp' is challenged by instances of 'outside' [14, 17] (i.e. *objective* [17], or *observer* [13]) remembering or imagining. The latter are experiential attitudes that combine *de se* with a – possibly unoccupied – perspective that is different from the (original, or actual/present) perspective of the attitude holder. In these attitudes, the holder takes a self-distancing stance, in which they perceive themself as if from the perspective of a bystander. Such attitudes are typically expressed through reflexive constructions like (5a) [7, 17]. Since (5a) stands in pragmatic competition with the 1pp report (2a) [$\equiv$ (3)], it saliently receives an 'outside' reading [7, 14] (see (5b)):

(5) a. Zeno {remembers, imagines} *himself* swimming in the ocean.
    b. Zeno {visualizes, imagines} what he (must have) looke(d) like when (he was) swimming in the ocean: his scrawny body was/is being tossed about, bobbing up and down in the foamy waste ... (due to [17, p. 11])

The salient outside reading of (5a) is reinforced by the observation that (5a) only hesitantly allows modification with a 1pp viewpoint adjunct (see the marked status of (6)).

(6) ??Zeno {remembers, imagines} *himself* swimming in the ocean *from his own (proprioceptive/swimmer's) perspective.*

If we assume – with the bulk of the literature – that '*de se* $\Rightarrow$ 1pp', we canNOT capture the intuitive difference in truth-conditions between (5a) ['outside'] and (2a) ['inside' remembering/imagining] (both would receive an interpretation as (4)). This difference is corroborated by the intuition that a scenario in which Zeno pictures his body swimming *from the visual perspective of s.o. on a cliff* will only support the truth of (5a), but not of (2a).

**General Strategy.** We propose to accommodate the difference between 'inside' and 'outside' memory/imagination reports by using separate mechanisms for the modelling of perspectivity and *de se*-ness. Specifically, we assume that individual centers (as in (4)) are only required to model *de se*-ness. Perspectivity (as expressed in (3)) can be modelled through classical (i.e. non-centered) propositions, analyzed as sets of possible worlds/situations. However, the perspectival content that is encoded in these propositions is informationally richer than the content that is expressed in the attitude report, explained below:

**3. Proposal, Part I (perspectivity).** Intuitively, the objects of experiential memory/imagination are not propositions, but situations or events [6, 7, 16]. The latter are entities that may be located at a specific space and/or time, and that can serve as the truthmakers of propositions. Their situation-status is supported by the possibility of substituting the -*ing* construction in (2a) by an overtly situation-/event-denoting expression (see (7a)).

(7) a. Zeno {remembers, imagines} *a situation/event in which he is* swimming.
    b. Zeno {remembers, imagines} *(the fact) that he* swam/was swimming.

The complement in (7a) carries richer information than the proposition 'I swam in the ocean'. In particular, if this proposition were the only content of Zeno's remembering/imagining, his attitude would likely be reported through (7b), rather than (2a)/(7a).

The greater richness of the complement in (2a)/(7a) is further supported by the observation that reports of experiential remembering/imagining allow for the overt expression of (occupied or unoccupied) perspective (see (3) resp. (8)), where perspective is commonly associated with events or situations (Barwise's [2] *scenes*), rather than with propositions.

(8) Zeno {remembers, imagines} himself swimming *from the perspective of a fellow swimmer/from the point of view of an aquaphobiac/from up on a cliff.*

Various recent work has shown that scenes[2] like the ones above have a propositional representation (intuitively: the sum of all propositions that are true of this scene; see Liefke [9]). D'Ambrosio and Stoljar [4] obtain such propositions as an answer to a concealed question of the form 'What is the scene like [to the salient experiencer]?'. For the visual scene depicted in Figure 1,[3] both [4] and [9] yield the same complex proposition, viz. (9):

(9) 'in a body of bubbly teal-blue water, a man's right arm with two bracelets on the wrist is stretched forward, his hand is [/appears] smaller than his upper arm ...'

Fig. 1. 1pp swimming.

The above is propositional as desired. However, as is suggested by the '...' in (9), the scene's informational richness yields unwieldily complex propositions. Since it is further difficult to describe a scene's inherent perspectivity (from a given mode of experience [e.g. vision] – although this can be done by linguistic means; see the reference to proportional size in (9)), we propose to enhance our propositional representation with tools from picture semantics [1, 12].

Picture semantics distinguishes the propositional content of a scene (for Fig. 1: that a man's right arm wears two bracelets, is stretched out, etc.) from the viewpoint (in a given possible world) from which this content is true. This viewpoint (in (10): $y$) can be perceptual (e.g. visual, auditory, proprioceptive), emotional, or agentive. It can be occupied (by the attitude holder, or by another object) or it can be unoccupied. If the targeted scene is specific (w.r.t. a world, location, & time) – s.t. its representing proposition is a singleton set –, so will be the viewpoint, $y$ (its quantifier may then be raised out of the scope of $[\![\text{remember}]\!]$). To obtain sufficient fine-grainedness, I replace worlds by situations, $s$.

(10) $[\![\text{imagine}]\!](\{s : \exists y.\ \text{from (the viewpoint of) } y, \text{ a man swims in } s\})(\text{Zeno})$

The merits of an enrichment of (4) by a viewpoint (s. (10)) come out when (4)'s semantic complement features perspectival contents (e.g. 'the hand is smaller than the upper arm'; s. (11)): only by reference to $y$ can we account for the fact that, in $s$, the swimmer's hand is not *actually* smaller than his arm, but only relative to a particular viewpoint.

(11) $[\![\text{imagine}]\!](\{s : \exists y.\ \text{from } y, \text{ the right hand of a/the swimmer is smaller than his right upper arm in } s\})(\text{Zeno})$

Admittedly, the apparent distortion in size does not hold for any viewpoint whatsoever: It is the product of a particular viewpoint, viz. that of the swimmer himself. In virtue of this observation, (11) [which uses specifically perspectival content] is equivalent to (12a) [which combines non-perspectival content with the identification of a specific viewpoint]. Identifying the viewpoint thus obviates the supplementation of perspectival content.

(12) a. $[\![\text{imagine}]\!](\{s : \exists z.\ \text{swimmer}(z)\ \&\ \exists y.\ \boldsymbol{y = z}\ (z\text{'s straight gaze w. radius } 60°)\ \&\ \text{from } y,\ z \text{ stretches out his right arm in } s\})(\text{Zeno})$

b. $[\![\text{imagine}]\!](\{s : \exists z.\ \text{swimmer}(z)\ \&\ \exists y.\ \boldsymbol{y \neq z}\ (\text{viewpt. of a swimmer 7 ft south/of an aquaphobiac/from a cliff})\ \&\ \text{from } y, \ldots \text{ in } s\})(\text{Zeno})$

In (12), the identification of $y$ with the swimmer's eyes (see '$y = z$' in (12a)) captures a case of 1pp imagination. $y$'s identification with some other viewpoint (see '$y \neq z$' in (12b)) captures an instance of 3pp imagination. The underspecification of '$\exists y$' with respect to the above options directly accounts for the inside/outside ambiguity of (5a).

[2]Unlike Barwise [2], I do not assume that scenes are restricted to the visual modality.

[3]Source: Cristian Palmer. September 20, 2022. `https://unsplash.com/photos/Ra0KzBtN8fI`.

**4. Proposal, Part II (*de se*-ness).** Expectedly, since (12a/b) still interpret the embedded complements as classical propositions (analyzed as sets of possible situations), they still can't capture the difference between (3) [= 1pp, *de se*] and (13) [= 1pp, NON-*de se*].

(13) Z. imagines a man (who looks like himself) swimming *from* THAT MAN'S *perspective*.

To answer this problem, we supplement the propositional representations of scenes from Sect. 3 with individual centers, $x$. This supplementation yields the semantics for (3) in (14a). Using Egan's [5] notion of *boring* centered propositions (i.e. $x$-independent propositions, which are reducible to classical propositions), one can interpret (13) as (14b):

(14) a. $[\![\text{imagine}]\!]\big(\{\langle \boldsymbol{x}, s\rangle : \exists y.\, \text{from } y,\ \boldsymbol{x} \text{ swims in } s\}\big)(\text{Zeno})$ (*de se*)

b. $[\![\text{imagine}]\!]\big(\{\langle \boldsymbol{x}, s\rangle : \exists y.\, \text{from } y,\ \text{a man swims in } s\}\big)(\text{Zeno})$ (non-*de se*)

The use of different modelling mechanisms for perspectivity and *de se*-ness enables us to provide a different truth-conditional semantics for (2a)/the 'inside' reading of (5a) and the 'outside' reading of (5a). It also makes it possible to distinguish between experiential (and, hence, perspectival) attitudes like (2a) (see (14a)) and their non-experiential (and, thus, perspective-free) counterparts (here: (7b); see (15c)).

(15) a. $[\![\text{imagine}]\!]\big(\{\langle x, s\rangle : \exists y.\, y = x \ \&\ \text{from } y,\ x \text{ swims in } s\}\big)(\text{Zeno})$ (1pp, *de se*)

b. $[\![\text{imagine}]\!]\big(\{\langle x, s\rangle : \exists y.\, y \neq x \ \&\ \text{from } y,\ x \text{ swims in } s\}\big)(\text{Zeno})$ (3pp, *de se*)

c. $[\![\text{imagine}]\!]\big(\{\langle x, s\rangle : x \text{ swims in } s\}\big)(\text{Zeno})$ (non-experiential *de se*)

Note that my semantics for (7b) (in (15c)) does not make reference to viewpoints: This explains why existing work associates 1pp with *de se*: Since the contents of non-experiential attitudes lack the kind of modal (e.g. perceptual) perspectivity described above, 'perspective' in this work may be unproblematically taken to be a facet of *de se*-ness. Problems only arise with attitudes (like experiential imagining) that allow for modal perspective.

**5. Outlook.** It is often assumed that experiential remembering is not Immune to Error through Misidentification (IEM) in the sense that the rememberer may be wrong about whether it is *their* experiences that they remember [7, 14]. Higginbotham [7] has argued that IEM follows from the semantic contribution of PRO. However, this view conflicts with the intuitive *de se*-ness of (5a) (as reflected in [13] and (15b)), and with experimental findings about the truth- and assertability-conditions of memory/imagination reports [15]. I will close my talk by arguing that, in virtue of the latter, even 'inside' (or *field*) memory is not IEM. I assume (with [11]) that the source of this error lies within the semantics of *remember* itself. However, for experiential *de se*-reports, my semantics carries another source of possible misidentification: the equation of the viewpoint with the individual center (see (15a)). This equation characterizes the perspective of the attitude holder as 1pp. Only 'inside' – but not 'outside' remembering and imagining – is IEM in this sense.

## References


[1] Abusch, D.: Possible worlds semantics for pictures. In: Comp. to Semantics (2020)
[2] Barwise, J.: Scenes and other situations. Journal of Philosophy **78**(7), 369–397 (1981)
[3] Chierchia, G.: Anaphora and attitudes *de se*. Semantics & Context. Expr. (1989)
[4] D'Ambrosio, J., Stoljar, D.: Imagination, fiction, & perspectival displacement (2023)
[5] Egan, A.: Secondary qualities & self-location. Philos. Phenom. Res. **72**, 97–19 (2006)
[6] Grimm, S., McNally, L.: The *-ing* dynasty. SALT **25**, 82–102 (2015)
[7] Higginbotham, J.: Remembering, imagining, and the first person. pp. 496–533 (2003)
[8] Lewis, D.: Attitudes *de dicto* and *de se*. Philosophical Review **88**(4), 513–543 (1979)
[9] Liefke, K.: Experiential attitudes are propositional. Erkenntnis **online first** (2022)
[10] Liefke, K.: Experiential attitude reports. Philosophy Compass **e12913**, 1–17 (2023)
[11] Liefke, K., Werning, M.: Factivity variation in exp. *remember*-reports. LNCS (2023)
[12] Maier, E., Bimpikou, S.: Shifting perspectives in pictorial narratives. SuB **23** (2019)

[13] McCarroll, C.: Remembering from the Outside. Oxford University Press (2018)
[14] Pryor, J.: Immunity to error through misidentification. Phil. Topics **27** (1999)
[15] Rosina, E.: Die 'Familientratsch'-Studie: Teil I. Qualtrics (ongoing)
[16] Stephenson, T.: Vivid attitudes: Centered situations . . .. SALT **20**, 147–160 (2010)
[17] Vendler, Z.: Vicarious experience. Revue de Métaphysique et de Morale **84**(2) (1979)
[18] Zimmermann, T.E.: Remarks on propositionalism(s). Handout (1 February, 2023)

**Actions and beliefs**

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In this paper, I look at two problems that the traditional analysis of rational *want* (Heim 1992; von Fintel 1999) confronts when we take into consideration recent observations that licensing of strong Negative Polarity Items (NPIs) and anti-licensing of weak Positive Polarity Items (PPIs) in the infinitival complement of *not want* are sensitive to the interpretation of an action as intentional versus accidental (Szabolcsi 2004; Goncharov 2020). The solution I propose is based on the recognition of two kinds of beliefs: *beliefs proper* that are affected by the fact that future is open and beliefs in a weaker sense, which I will call *beliefs*$'$, that are oblivious to the openness of the future. Adopting *beliefs*$'$ as the modal base for rational *want* will allow us to bypass the two problems with the traditional analysis of *want*. We will also be able to clarify the connection between linguistically relevant notions of beliefs, desires, and actions.

§1 **Two problems.** It has been recently observed in the linguistic literature that licensing of strong NPIs, such as *a red cent*, in the complement of *not want* is sensitive to the interpretation of the embedded predicate. If the predicate expresses an intentional action, as in (1)a, strong NPIs are fully acceptable. If the predicate expresses an accidental action, as in (1)b, strong NPIs are degraded (Goncharov 2020). 'Intentional' and 'accidental' are used as descriptive, pre-theoretic notions here. An action is intentional if the agent acts the way he decided to act and he (mostly) controls the outcome of his actions. For example, spending money and calling a friend are intentional in this sense. An action is accidental if the agent makes no decision about how to act or he cannot control the outcome of his actions (i.e., the outcome is are partly due to luck). Winning a lottery or (unintentionally) breaking a vase are accidental in this sense. In the same configuration, weak NPIs, such as *any money*, are not sensitive to the interpretation of the embedded predicate as intentional versus accidental, see (1). Weak PPIs formed with *some* exhibit a mirror image pattern. They are fully acceptable with accidental actions, see (2)b, and degraded with intentional actions, see (2)a (Szabolcsi 2004).

(1) a. I don't want to spend any money/a red cent on this project.
    b. I don't want to win any money/??a red cent in this lottery.

(2) a. I don't want to call someone. (*$\neg > \exists$)
    b. I don't want to break something. ($\neg > \exists$)

These observations create two problems for the traditional analysis of *want*, according to which '$\alpha$ want $\phi$' is true in $w$ only if $\phi$ is true in any of $\alpha$'s preferred doxastic alternatives to $w$ and it is presupposed that $\alpha$'s doxastic alternatives are such that $\alpha$'s decisions on how to act are not taken into consideration and $\alpha$ is uncertain whether $\phi$, see (3) (Heim 1992; von Fintel 1999).

(3) '$\alpha$ want $\phi$' in $w$ is defined only if
  (a) $Dox_\alpha(w)$ = { $w' \in W$ : $w'$ is compatible with everything that $\alpha$ in $w$ believes to be the case *no matter how he chooses to act* } and
  (b) $Dox_\alpha(w) \cap \phi \neq \emptyset$ and $Dox_\alpha(w) \cap \neg\phi \neq \emptyset$,
  whenever defined '$\alpha$ want $\phi$' in $w$ is true iff
  for any $w' \in Best - Dox_\alpha(w), \phi$ is true in $w'$

The first problem created by the observations in (1) and (2) concerns the condition that $\alpha$'s beliefs are insensitive to the way $\alpha$ decides to act, see the part in italics in (3)a. This condition is required to block the unwelcome result that examples, such as in (4), where John believes that he will go to the movies tonight, constantly lead to a presupposition failure, because the uncertainty presupposition in (3)b is not satisfied. The uncertainty presupposition itself is needed to block non-existing entailments from '$\alpha$ believe $\phi$' to '$\alpha$ want $\phi$' and from '$\alpha$ want $\phi$' to '$\alpha$ want $\psi$' in case $\phi$ entails $\psi$.

(4) John hired a babysitter because he wants to go to the movies tonight. (Heim 1992)

It appears that we are forced to postulate that $\alpha$'s beliefs are insensitive to the way $\alpha$ decides to act. But, on the other hand, we see in (1) and (2) that the interpretation of an action as intentional versus accidental (which directly relates to how or whether $\alpha$ decides to act) determines acceptability of strong NPIs and weak PPIs. That is to say, to account for (1) and (2), we need to ensure that $\alpha$'s beliefs are affected by the way $\alpha$ decides to act, at least in a way that distinguishes between intentional and accidental actions.

The second problem created by the observations in (1) and (2) is more theory-internal in nature. It turns out that the uncertainty presupposition in (3)b is problematic for strong NPI licensing in the most accepted Gajewski-style analysis of the strong/weak distinction for NPIs (Gajewski 2011). According to Gajewski (2011), a strong NPI is licensed whenever both the truth-conditional and the non-truth-conditional content of an utterance are downward-entailing. For a weak NPI to be licensed, it is enough that the truth-conditional content of an utterance is downward-entailing. As first noted in Romoli (2012), the presupposition in (3)b is not downward-entailing predicting strong NPIs to be unacceptable in the complement of *not want* (contrary to fact). To amend this, Romoli (2012) postulates a weaker conditional presupposition for *want* - if $Dox_\alpha(w) \cap \phi \neq \emptyset$, then $Dox_\alpha(w) \cap \neg\phi \neq \emptyset$ - where a strong NPI in both instances of $\phi$ is in a downward-entailing environment and thus, can be licensed. However, this weaker conditional presupposition is also unsatisfactory. First, it predicts strong NPIs in both (1)a and (1)b to be fully acceptable (contrary to fact). Second, it leads to the following asymmetry: if $\alpha$ believes not-$\phi$, the sentence corresponding to '$\alpha$ want $\phi$' turns out to be false (rather than a presupposition failure). Third, the presupposition no longer serves the purpose for which the uncertainty presupposition in (3)b was introduced in the first place. That is to say, the conditional presupposition does not block the non-existing entailment from '$\alpha$ believe not-$\phi$' to '$\alpha$ want not-$\phi$'. To remedy the first issue with Romoli's presupposition and to account for strong NPI licensing in (1) (and by extension for PPIs in (2)), Goncharov (2020) derives a dynamic presupposition for *want*, which in case of intentional actions results in (5)a (where strong NPIs are licensed and *some* PPIs are anti-licensed) and in case of accidental actions in (5)b (where strong NPIs are not licensed and *some* PPIs are not anti-licensed).

(5) a. For intentional actions: $Dox_\alpha(w) \subseteq \neg\phi$
b. For accidental actions: $Dox_\alpha(w) \cap \phi \neq \emptyset$ and $Dox_\alpha(w) \cap \neg\phi \neq \emptyset$

This dynamic presupposition (if plausible) accounts for the data in (1) and (2), but suffers from the second and third issues with Romoli's presupposition mentioned above.

§2 **Two (kinds of) beliefs.** Informally, I propose to separate the notion of 'beliefs' into two kinds: *beliefs proper* and beliefs in a weaker sense, which I will call *beliefs'*. *Beliefs proper* are mental states that we can attribute to each other and for which we need to have grounds. Important for the purpose of this paper is that *beliefs proper* take into consideration the general assumption that future (unlike present or past) is open. That is to say, the uncertainty about the future (e.g., whether it will be raining tomorrow) is different from epistemic uncertainty (e.g., whether it might be raining right now). *Beliefs'* are mental states that allow participants of a conversation to ignore for some legitimate reason the possibility that a proposition can be false (comparable to the notion of 'acceptance for the purpose of conversation' in Stalnaker 1984). In our case, the aspect that is legitimately ignored in *beliefs'* is the assumption that future is open.

The main difficulty with the traditional analysis of *want* (I think) is that when we talk about doxastic alternatives as part of the presuppositional meaning of *want* and doxastic alternatives in which the content of a belief ascription is true, we assume that the doxastic alternatives are the same. But this does not have to be the case. Consider our babysitter example in (4) again. Because we are interested in John's beliefs about the future and future is open, we can say that John's *beliefs proper* are compatible with both his going to the movies tonight and his not going to the movies tonight. That is to say, John is uncertain (in the *beliefs proper* sense) whether he will go to the movies tonight. However, we can also say that because John has decided to go to the movies tonight and he properly controls his actions, John has *beliefs′* that he will go to the movies tonight. That is to say, we can ascribe John weaker beliefs that for the purpose of the conversation ignore the assumption that future is open.

Recognizing two kinds of beliefs described above, we can reformulate the traditional analysis of *want* in terms of *beliefs′* as in (6), where $Dox'$ represents *beliefs′*.

(6) '$\alpha$ want $\phi$' in $w$ is defined only if
   (a) $Dox'_\alpha(w)$ = { $w' \in W$ : $w'$ is compatible with everything that $\alpha$ in $w$ believes to be the case }
   (b) if the agent of the action in $\phi$ is the same as the attitude holder and $\phi$ describes an intentional action, $Dox'_\alpha(w) \subseteq \phi$, otherwise $Dox'_\alpha(w) \cap \phi \neq \emptyset$ and $Dox'_\alpha(w) \cap \neg\phi \neq \emptyset$,
   whenever defined '$\alpha$ want $\phi$' in $w$ is true iff
   for any $w' \in Best - Dox'_\alpha(w), \phi$ is true in $w'$

In (6), the counter-intuitive condition that $\alpha$'s decisions about how to act are not taken into consideration when determining $\alpha$'s beliefs for the purpose of desire attribution is discarded. This avoids the problem that we were forced to operate on a superset of $\alpha$'s doxastic alternatives which are insensitive to $\alpha$'s decisions about how to act. The action sensitivity needed for strong NPI licensing and weak PPI anti-licensing in the complement of *not want* is captured by the presupposition in (6)b. In case of intentional actions, a downward-entailing presupposition as in (5)a will be derived which licenses strong NPIs and anti-licenses weak PPIs. In case of accidental actions, the presupposition will be not downward-entailing similar to (5)b and strong NPIs will not be licensed whereas weak PPIs will be acceptable. That is, the presupposition in (6)b derives the same results as the dynamic presupposition of *want* in (5) proposed in Goncharov (2020). The problem with the dynamic presupposition in (5) was that in case of intentional actions, it did not block the undesirable entailment from '$\alpha$ believe $\phi$' to '$\alpha$ want $\phi$'. In the new analysis for *want*, this entailment is blocked for future oriented desire attitudes because the presuppositional component of such attitudes is always based on weaker *beliefs′*, whereas the belief ascription '$\alpha$ believe $\phi$' is based on *beliefs propoer*, in which case future actions always result in uncertainty.

As an illustration, consider again Heim's babysitter example in (4). I suggested above that because we are interested in John's beliefs about the future and future is open, we can say that John's *beliefs proper* are compatible with both his going to the movies tonight and his not going to the movies tonight. That is to say, John is uncertain (in this stronger sense of believing) whether he will go to the movies tonight. This belief ascription will never lead to John wanting to go to the movies tonight under the traditional analysis of *want* (as desired). On the other hand, when we attribute desires to John, we can say that because he has decided to go to the movies tonight and he properly controls his actions, John has weaker beliefs (*beliefs′*) that he will go to the movies tonight and the desire attribution is true whenever John goes to the movies in the best of belief′-worlds. That is, for the purpose of our conversation, we ignore the assumption that future is open. Note that this assumption obliterates the distinction between intentional and accidental actions. The agent who decides to act such that to bring it about that $\phi$ can have future beliefs that $\phi$ only if the openness of the future is ignored.

§3 **In histories.** Formally, I propose to capture the separation between *beliefs propser* and *beliefs′* using a system in which propositions are re-defined as sets of histories (e.g., Thomason 1970; MacFarlane 2003; Stalnaker 2014). Our model is a tuple $\langle U, A, E, < \rangle$, where $U$ is a non-empty set of states, $A$ is a non-empty set of agents, $E$ is a binary accessibility relation (transitive, Euclidean, serial), < is a temporal treelike ordering relation on states as in Figure 1. A *history* is a maximal pathway through a model structure. That is to say, a history $h$ is a subset of states in $U$ such that (i) for any $\alpha, \beta \in h$, if $\alpha \neq \beta$, then $\alpha < \beta$ or $\beta < \alpha$ and (ii) if $g$ is any subset of $U$, such that for any $\alpha, \beta \in g$, if $\alpha \neq \beta$, then $\alpha < \beta$ or $\beta < \alpha$, then $g = h$ if $h \subseteq g$ (Thomason 1970). Let us notate $H_\alpha$ a set of histories that pass through some $\alpha \in U$. Let us also notate $H_S$ a set of histories that pass through any $\alpha \in S$ such that $S \subseteq U$.

Let us say that a proposition is a set of histories (see also Stalnaker 2014). That is to say, $\phi$ at state $s$ is a set of histories that go through $s$ such that there is a state $s'$ that stands in a temporal relation $R$ with $s$ and $\phi$ is true at $s'$. $R$ can be the relation of overlap, precedence or succession, which corresponds to the present, past and future expressed by $\phi$ (based on Prior's temporal logic).

(7) $\phi_s := \{h \in H_s :$ there is $s' \in h$ such that $s'Rs$ and $\phi$ is true at $s'$ $\}$

As an illustration consider the picture in Figure 1 and suppose that we evaluate $\phi$ at $s_2$. Let us say that $\phi$ corresponds to the proposition 'it BE raining' where BE can be specified as present, past or future. Suppose that states are discrete representations of worlds-in-time and the facts are as follows: $s_2$ is 'now' and it is raining now, $s_1$ is 'yesterday' and it was raining yesterday, $s_3$ is an alternative now where it is not raining, $s_{4-7}$ are 'tomorrow' and it rains at $s_4$ and $s_6$ but not at $s_5$ and $s_7$. Given the situation described above and depicted in Figure 1, we can represent the three tensed sentences evaluated at $s_2$ as follows: 'it was raining' = { h1, h2 }, 'it is raining' = { h1, h2 }, 'it will be raining' = { h1 }.

Now, we would like to keep the intuition from Stalnaker (1978) that the role of assertion is to select those states from the context set where the asserted proposition is true. For this, we define a set of Context Histories $CH$ as a set of histories that pass through any state in the Context Set $CS \subseteq U$.

(8) CH := { $h \in H_{CS}$ : for any $s \in CS, s \in h$ }

We need to constraint $CS$ to contain only the states with the same time. Then, the meaning of the proposition corresponding to $\phi$ asserted in the context set $CS$ will be defined as follows:

(9) $\phi_{CS}$ := { $h \in H_{CS}$ : for any $s \in CS$ there is $s' \in U$ such that $s, s' \in h, s'Rs$ and $\phi$ is true at $s'$ }

Let us say that the context set $CS$ is $\{s_2, s_3\}$, then the set of Context Histories $CH$ is $\{h1, h2, h3, h4\}$. Then, our three tensed sentences corresponding to $\phi$ uttered in $CS$ can be represented as follows: 'it was raining' = { h1, h2, h3, h4 }, 'it is raining' = { h1, h2 }, 'it will be raining' = { h1, h3 }.

We can similarly define a set of doxastic alternatives as a set of histories that go through a set of states doxastically accessible from the states in the Context Set, as in (10), where $ES = \{s' \in U :$ for any $s \in CS,\ sE_\alpha s'\}$. And then, we can define *beliefs propoper* as in (11).

(10) $Dox_\alpha(CS)$ := { $h \in H_U$ : for any $s \in ES, s \in h$ }

(11) '$\alpha$ believe $\phi$' in $CS$ = $Dox_\alpha(CS) \subseteq \phi_{CS}$

Let us say that $s_2$ and $s_3$ are doxastic alternatives for $\alpha$ at $CS$. Then, $Dox_\alpha(CS) = \{h1, h2, h3, h4\}$. Then, in our picture in Figure 1, the following sentences are true: '$\alpha$ believes that it was raining', '$\alpha$ is uncertain whether it is raining', '$\alpha$ is uncertain whether it will be raining'.

It is important to note here that the two last sentences are uncertainties for a different reason. The first uncertainty is due to the epistemic accessibility relation, whereas the second uncertainty is due to the fact that future is open. We can amend the first uncertainty by changing the accessibility relation. For example, we can say that only $s_2$ is a doxastic alternative for $\alpha$ in $CS$. Then, '$\alpha$ believes it is raining' will become true. The second uncertainty cannot be amended by re-setting the accessibility relation, because to say that, for example, $s_4$ is compatible with everything $\alpha$ believes to be the case at $s_2$ is to say that participants of the conversation know the facts about the future and can determine whether $\alpha$'s beliefs at present are compatible with the facts about the future.

As described in §2, I propose that in case of reasoning about actions we can disregard future contingents. What is important for the communication purposes is whether the action that the agent is committed to take is decided on and whether it is controlled. Let us again look at the babysitter example in (4). In this example, we can ascribe John two kinds of beliefs about his future tonight. The first kind of beliefs is *beliefs proper* as described above, that is, given the openness of the future, John's beliefs are compatible with both his going to the movies tonight and his not going to the movies tonight. The second kind of beliefs - *beliefs*$'$ - is about his own actions that disregard the openness of the future. We say that, '$\alpha$ believe$'$ $\phi$' in $CS$ holds only if $Dox'_{\alpha}(CS) \subseteq \phi_{ES}$, where $Dox'_{\alpha}$ is defined as in (12). In (12), $AS \subseteq U$ such that at any $a \in AS, \alpha$ acts the way he intended to act.

(12) $Dox'_{\alpha}(CS)$ := { $h \in H_U$ : for any $s \in ES,\ s \in h$ and for any $a \in AS$, if $a \succ s'$, then $a \in h$ }

Using our picture in Figure 1, where all rainy states are states where John goes to the movies and all non-rainy states are states where John does not go to the movies, $Dox'_{\alpha}(CS)$ = { h1, h3}. That is, John believes$'$ that he will go to the movies tonight in this weaker sense. But not in the stronger sense that takes into consideration the openness of the future. This shows the distinction between *beliefs proper* and *beliefs*$'$.

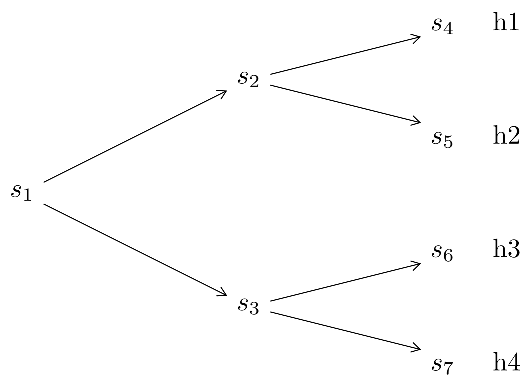


Figure 1: Forward branching time

**References**

Gajewski, Jon. 2011. "Licensing Strong NPIs." *Natural Language Semantics* 19: 109–48. https://doi.org/10.1007/s11050-010-9067-1.

Goncharov, Julie. 2020. "The Dynamic Presupposition of 'Want'." In *Proceedings of SALT 30*, edited by Joseph Rhyne, Kaelyn Lamp, Nicole Dreier, and Chloe Kwon, 779–800. https://doi.org/https://doi.org/10.3765/salt.v30i0.4823.

Heim, Irene. 1992. "Presupposition Projection and the Semantics of Attitude Verbs." *Journal of Semantics* 9: 183–221.

MacFarlane, John. 2003. "Future Contingents and Relative Truth." *The Philosophical Quarterly* 53 (212): 321–36. https://doi.org/10.1111/1467-9213.00315.

Romoli, Jacopo. 2012. "Soft but Strong. Neg-Raising, Soft Triggers, and Exhaustification." PhD thesis, Harvard University.

Stalnaker, Robert C. 1978. "Assertion." *Syntax and Semantics* 9: 315–32.

———. 1984. *Inquiry*. Cambridge: MIT Press.

———. 2014. *Context*. Oxford: Oxford University Press.

Szabolcsi, Anna. 2004. "Positive Polarity – Negative Polarity." *Natural Language and Linguistic Theory* 22: 409–52. http://www.jstor.org/stable/4048063.

Thomason, Richmond H. 1970. "Indeterminist Time and Truth-Value Gaps." *Theoria* 36: 264–81.

von Fintel, Kai. 1999. "NPI Licensing, Strawson Entailment, and Context Dependency." *Journal of Semantics* 16 (2): 97–148.

**A unified analysis of the semantics and pragmatics of Greek polydefinites**

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**Introduction.** Adjectivally modified definite noun phrases in Greek can appear with a second definite determiner between the noun phrase and the modifying adjective, as in (1). The standard assumption w.r.t the semantic interpretation of such polydefinites is that they give rise to a restrictive interpretation of the modified NP (Alexiadou and Wilder 1998, Campos and Stavrou 2004, Kolliakou 2004, Lekakou and Szendrői 2012, Chatzikyriakidis 2015) so that, e.g. (1), signals that there are other cats in the context of the utterance that are not big, as, e.g., in (2).

(1) I mavres i jates itan anisixes.
the black the cats were anxious.
'The black cats were anxious.'

(2) Context: George had six black cats and two gray ones. When he went on a trip, he left the cats in the care of his neighbor.

Even though counterexamples shown to violate this interpretation occasionally do appear (Manolessou 2000, Panagiotidis and Marinis 2011, Lekakou and Szendrői 2012) almost all analyses are built to exclusively derive a restrictive interpretation (but see Tsiakmakis et al. 2021 for a recent attempt to derive both restrictive and non-restrictive readings based on an ambiguity account.) This paper presents (i) the first systematic empirical study of the availability of non-restrictive interpretation, and (ii) proposes the first unified account of Greek polydefiniteness based on the idea that polydefinites are markers of prominence (see von Heusinger and Schumacher, 2019 for a recent overview), in that their pragmatic contribution is to signal out prominence. Under this view, the restrictive interpretation is just a special case of marking prominence.

**The pilot**. The study involved 35 native speakers of Greek. Subjects were presented with a context sentence(s), followed by a sentence that either (exclusive interpretation) involved a polydefinite construction or a monadic. The subjects are asked to judge this last sentence according to their felicitousness given the context and on a scale from 1 (totally infelicitous) to 10 (totally felicitous). Sentences are designed to test semantic felicitousness of polydefinites in contexts where a restrictive interpretation is not possible.

**Non-restrictive uses**. The results of the pilot, which we will present in more detail during the talk, are summarized as follows:

- Polydefinites can readily appear in a number of contexts where a restrictive interpretation is not possible.
- Even when monadics are preferred in these contexts, the mean difference in judgments between monadics and polydefinites is small.
- Polydefinites like (1) are dispreferred in contexts where there is no relative alternative to the referent of the polydefinite, as in (3).

(3) Context: George had six cats, all of them black. When he went on a trip, he left them in the care of his neighbor.

- Polydefinites improve significantly when there are more relevant individuals in the discourse, as in (4), and out-score monadics when they seem to signal topic-shift, as in (5).

(4) Context: George had two parrots and six black cats. When he went on a trip, he left all his pets in the care of his neighbor.

(5) Context: George has two parrots and six black cats. The two parrots are always very quiet.

**Analysis**. We argue that although polydefinites have no distinct semantic contribution (i.e. they receive the same semantics as the corresponding monadic definites), they give rise to the dynamic pragmatic effect of singling-out the referent of the definite phrase among a list of relevant individuals. We adopt the view (based on Centering Theory, Bittner 2014 a.o., Stojnic' et al. 2017 for a recent formalization) that relations of relative prominence can be formalized as a list; i.e. a sequence of individuals ranked by prominence. The first individual in the list is the most prominent one. The list changes as new individuals are introduced in the course of a discourse and grammatical mechanisms can have the effect of altering the list in a dynamic fashion. We assume a context $\Gamma$ that contains discourse referents among other things and progressively adds referents as discourse unfolds. A relevant list $L_{rel}$ keeps track of the relevant referents and adds and removes referents that are not relevant accordingly. An operator $P_{ord}$ of type *list e* $\rightarrow$ *list e* takes a list and returns the same list ranked according to prominence. We then assume $L_{pr}$ to be $P_{ord}(L_{rel})$. Let us assume that the definite has the usual uniqueness semantics:

(6) $\lambda P: e \rightarrow t. \lambda Q: e \rightarrow t. \exists x: e, P\,x \wedge Q\,x \wedge (\forall y: e, P\,y \wedge Q\,y \rightarrow x = y).$

Now, what the second definite is doing is to provide the same uniqueness semantics plus the extra condition that x has to be the head in the prominence list $L_{pr.}$ If this condition is not met then x is made the first element in the list (done by the $make_{fst}$ function):

(7) $\lambda A: (e \rightarrow t) \rightarrow (e \rightarrow t) \rightarrow t. \lambda P: e \rightarrow t. \lambda Q: e \rightarrow t. \exists x: e, P\,x \wedge Q\,x \wedge (\forall y: e, P\,y \wedge Q\,y \rightarrow x = y) \wedge fst(L_{pr}) \neq x \rightarrow make_{fst}(x)(L_{pr})$[1]

Note that in the above account the second polydefinite acts as a large functor taking three arguments (the regular definite and the two sets) and returns uniqueness semantics plus the prominence condition. The list relevant for each update can be affected not only by what are usually taken to be extra-grammatical factors (like Coherence, Stojnic' et al. 2017), but also by grammatical factors. For example, since (1) involves the pluralized predicate *itan anisixes* 'were anxious' the relevant list will only include plural individuals. In the context of (3) where the only relevant and contextually available list includes a single individual (the black cats), the reduced availability of the polydefinite can be attributed to redundancy. When the list includes more than

[1] The account has been formalized in the Coq proof-assistant. Please check the appendix for the code.

one individual, as in (2), (4), and (5), the polydefinite has the effect of placing the referent of the noun phrase (the black cats) on the top of the prominence list. We propose that the increased felicitousness in contexts like (5) is due to the fact that the context forces a re-ordering of the black cats above the two parrots. To explain the slight contrast between (4) and (5), we assume that in (4), the $P_{ord}$ operator, lacking prominence ranking information, takes the relevant list, $L_{rel}$, puts all its elements in a new list, ending up with a list that contains as its sole element a list with all the relevant entities (a list within a list).[2] In (5) on the other hand, where the two parrots occupy the first position in $L_{rel}$, applying (7) forces a re-ordering, where the black cats are put on the top of the list. This is the case of topic-shift. In this set-up the so-called restrictive interpretation of (1) in (2) is just a case in which the relevant list only includes different cat-individuals. Notice that nothing we have said so far explains the fact that (1) achieves higher ratings in the context of (2) than in the context of (4). In both cases the list includes two individuals (the black and the gray cats in (2) and the cats and the parrots in (4)). We show that (1) only achieves higher ratings in (2) than in (4), when the adjective *anisixes* 'anxious' is narrowly focused, as in *I MAVRES I gates itan anisixes*. The contextually relevant set of alternatives for focus interpretation (a subset of the Alternative Semantic Value of *anisixes gates* 'anxious cats') is identified with the relevant prominence list, streamlining all the relevant pragmatic effects of (1).

**Conclusions.** In a sharp divergence from previous literature, this paper focuses on the dynamic pragmatic effects of Greek polydefiniteness arguing that they are markers of prominence. This move allows a unified analysis of all uses of polydefinites and corrects a serious under-generation problem faced by previous analyses. What remains to be seen, is to what extend this account can be generalized to cover all prominence sensitive phenomena.

**References**

Artemis Alexiadou and Chris Wilder. Adjectival modification and multiple determiners. Possessors, Predicates and Movement in the DP, pages 303–332, 1998.

Bittner, M. (2014). *Temporality: Universals and variation*. John Wiley & Sons.

Hector Campos and Melita Stavrou. Polydefinite constructions in Modern Greek and Aromanian. *Balkan syntax and semantics*, 67:137, 2004.

Stergios Chatzikyriakidis. Polydefinites in Modern Greek: the missing link. *Proceedings of ICGL11*, 2015.

Dimitra Kolliakou. Monadic definites and polydefinites: their form, meaning and use. *Journal of Linguistics*, 40, pages 263–323, 2004.

Marika Lekakou and Kriszta Szendrői. Polydefinites in Greek: Ellipsis, close apposition and expletive determiners. *Journal of Linguistics 48*, pages 107–149, 2012.

Io Manolessou. Greek Noun Phrase Structure: *A Study in Syntactic Evolution*. PhD thesis, University of Cambridge, 2000.

E Phoevos Panagiotidis and Theodore Marinis. Determiner spreading as DP-predication.

[2] Applying (7) in this case will result in the fst operator looking into the contents of this new list within $L_{rel}$, taking the most prominent element of that list out and putting it at the head of $L_{rel}$.

*Studia Linguistica, 65(3):*268–298, 2011.
Stojnić, U., Stone, M., & Lepore, E. (2017). Discourse and logical form: Pronouns, attention and coherence. Linguistics and Philosophy, 40, 519-547.
Tsiakmakis, E., Borràs-Comes, J., & Espinal, M. T. (2021). Greek polydefinites revisited: Polydefiniteness as resumed relative clause modification. Journal of Greek Linguistics, 21(1), 151-190.
Klaus Von Heusinger and Petra B Schumacher. Discourse prominence: Definition and application. *Journal of Pragmatics*, 154:117–127, 2019.

## Appendix (Coq Code)

```
Require Import Coq.Lists.List.
Require Import Le.
Require Export Classical. Require Export Description. Require Import ChoiceFacts.
From Coq Require Import Utf8 List.

Definition PTYPE:= Type.
Variable A : Set.
Definition hd  (l:list Set) :=
    match l with
      | nil => A
      | x :: _ => x
    end.
Set Implicit Arguments.
 Parameter e: Type.

Import ListNotations.
(**P_ORD and L_rel. L_pr takes a type e argument and states that the head of the P_ORD(L_rel) list is
x**)
Parameter  P_ORD: forall  A :   PTYPE,   list   A -> list A.
Parameter L_rel:   list ( e).
Definition L_pr:= fun x: option e => head(P_ORD(L_rel)) = x.
Parameter Mavres: (option e -> Prop).
Definition mavres:= fun P : option e -> Prop => fun x :option  e => P x /\ Mavres(x).
Parameter gates: option  e -> Prop.
Parameter to_eskasan: option e -> Prop.
(**this adds an argument to the head of P_ORD(L_rel)**)
Definition add_to_head_of_P_ORD (x: option e) : list e :=
  match x with
  | None => P_ORD(L_rel)
  | Some x' => x' :: (P_ORD(L_rel))
  end.
(**Regular definite**)
Definition iota:= fun P:option  e -> Prop => fun Q: option  e -> Prop=> exists x: option e, P x /\ Q x
/\  forall z : option e,  P z /\ Q z -> x = z.
Axiom decide_L_pr : forall x: option e, {L_pr x} + {~ L_pr x}.
(**Polydefinite**)
Definition pol := fun F: (option e -> Prop) -> (option e -> Prop) -> Prop =>
  fun P: option e -> Prop =>
  fun Q: option e -> Prop =>
    exists x: option e,
    P x /\ Q x /\
    forall z: option e, P z /\ Q z -> x = z /\ head( add_to_head_of_P_ORD x) = head(P_ORD(L_rel)).

(**Two theorems: second states that if the polydefinite holds then there is an x such that x is a black
cat that ran away and the list resulting from adding x to P_ORD is the same as taking the head of
P_ORD(L_Rel)**)
Theorem polydefinite: pol iota (mavres(gates)) to_eskasan -> exists x: option e, head(
add_to_head_of_P_ORD x)= head(P_ORD(L_rel)). cbv. firstorder.
Qed.
```

```
Theorem polydefinite2: pol  iota (mavres(gates)) to_eskasan ->  exists x: option e, (mavres(gates)) x
/\ to_eskasan x/\ head( add_to_head_of_P_ORD x)= head(P_ORD(L_rel)). cbv. firstorder. Qed.
```

# Use, Compositionality and Prior's Puzzle*

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**Abstract:** There is an often-assumed competition between mainstream truth-conditional semantics and more philosophically-oriented use theories of meaning. In this vein, this paper pursues three interrelated goals. First, it argues that use-theoretic approaches do not fall prey to a common objection, namely that they cannot account for the compositionality of meaning. Second, this argument will be based on a specific understanding of the practice of formal semantics. Under this picture, formal semanticists provide mathematical models for the compositionally derived semantic structures found in natural language. It is argued that this is within the limits of what can be reasonably expected from the practice. Third, the resulting picture allows us to comprehensively and conclusively solve Prior's puzzle. In conclusion, given a proper understanding of the practice of formal semantics, neither its use-theoretic competitors nor the issue of Prior's puzzle are a threat to it.

**1. Use Theories and Compositionality** Use theories of meaning try to elucidate the meaning of linguistic expressions by drawing on some salient notion of 'use'. Originally conceived by [19] and his contemporaries, it has been further developed systematically by authors such as [10] and [15]. Under this approach, meaning itself is often *identified* with some salient sense of use, usually either rules that govern the correct use of expressions [e.g. 8], or patterns in the behaviour of speakers [e.g. 10].

As an example, consider the following rule for the use of the expression snoring:

$$\frac{x \text{ is snoring}}{x \text{ is asleep}} *$$

with the presupposition $*$ that x refers. It can be understood as stating a necessary criterion for the *truth* of a statement of the *form* x is snoring.[1] However, especially in the inferentialist tradition, this rule-based approach considers *sentences* with their conventional meaning their semantic unit [cf. 11]. After all, rules *of inference* operate on sentences, not subsentential expressions. This stance has lead to an objection related to the issue of accounting for the compositionality of meaning. To wit: the meaning of a whole – such as a sentence – depends on the meaning of its parts – subsentential expressions – and their syntactic mode of combination [14]. Fodor and Lepore ([4], [5]) have argued against inferentialism on the basis that it cannot account for the compositionality of meaning. In a nutshell, their charge is that since meaning is constituted by rules, yet rules

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[1] As argued for in my [17].

cannot be composed in the way that the principle requires, inferentialism – or any use theory operating under a 'sentence-first' principle – cannot account for such compositionality.

This argument can be defused by recognising the inherent *schematic nature* of rules, which already feature the different syntactic modes of combination, as suggested in [9], [15], and [8]. The use-theoretic approach to specifying the meaning of expressions thus would not only incorporate compositionality in the very way in which the salient rules are stated, but also state genuinely informative truth-conditions beyond disquotational ones [15]. Thus, consider the following 'rule-network' for sentences of the form x is snoring:

$$\dfrac{\dfrac{\dots}{x \text{ is asleep}} \qquad \dfrac{\dots}{x \text{ is making certain sounds}}}{x \text{ is snoring}} \, *$$

$$\dfrac{x \text{ is snoring}}{\dfrac{x \text{ is not dead}}{\dots} \qquad \dfrac{x \text{ is asleep}}{\dots} \qquad \dfrac{x \text{ is making certain sounds}}{\dots}} \, *$$

with the usual presupposition $*$ that x refers. These rules are both compositional in virtue of being schematic for different expressions occupying the position of x, and give genuinely informative explanations of the meaning of snoring.

However, the use theorists that suggested this line of response so far ([15], [8]) also err in some respects. First, Peregrin believes that his *decompositional* route to compositionality is indeterminate – there are many equally valid ways of carving up the contribution of subsentential expressions [15]. This is obviously false with respect to simple sentences such as Peter is snoring, where the semantically thin copula allows only for one way of understanding the composition of meaning. Furthermore, we would not say that the meaning of, say, Peter changes if placed in different syntactic configurations. Thus, if it makes a clear semantic contribution in simple sentences, so too in other cases. Generalising this to other expressions arguably refutes Peregrin's claim. Moreover, his approach is inconsistent with our practice of explaining the meaning of subsentential expressions first and foremost, not sentences [7].

However, Glock also errs in that he takes semantic rules to be stating meaning-contributions of subsentential expressions only, without there being (additional) rules for whole sentences [8]. Consider his example of drake [8, 208]:

($\text{SP}_D$) $\forall x$(it is correct to apply drake to $x \leftrightarrow x$ is a male duck)

This formulation leaves a gap between the correctness of applying drakes to entities and using drake in order to make true claims. This point is relevant, because for Glock specifically, correct, in this instance, is not synonymous with true. Furthermore, this rule clearly does not tell us anything about how drake is to be combined with other expressions to form meaningful sentences. Thus, it seems he would agree with me that rules have a dual role: they specify the meaning of a subsentential expression, yet thereby also "[...] specify how the [expression] can be used within sentences and what contribution it makes to the latter's [meaning]" [8, 201]. That said, formulations such as ($\text{SP}_D$) do not seem to live up to this promise.

However, under the present approach, rules *do* have such a dual role in most cases. For the rules state under which conditions the semantic correctness for the speech act in question is achieved, and speech acts are performed with sentences, in most cases. Thus, rules can only ever state the contribution of a given expression to the unit of communication – the sentence. Therefore, with the potential exception of vocabulary such as referring expressions, greetings, and exclamations, rules are ostensibly tied to specific expressions, but elucidate their meaning in a compositional way vis-à-vis schematic *sentences*, thereby also specifying the meaning of the latter. Thus, drake can be given analogous rules as in ($\mathrm{SP}_D$), but by making clear there position in a sentence:

$$\dfrac{\dfrac{\dots}{x \text{ is male}} \qquad \dfrac{\dots}{x \text{ is a duck}}}{x \text{ is a drake}} *$$

$$\dfrac{x \text{ is a drake}}{\underset{\dots}{\underline{x \text{ is male}}} \qquad \underset{\dots}{\underline{x \text{ is a duck}}}} *$$

while once again presupposing $x$ to refer to something. Here, the rules detail both the role in a sentence, as well as the contribution of drake. Last, but not least, the normativity of meaning can be preserved, along the lines suggested by Glock himself [8] and others (e.g. [15], [9]).

**2. Formal Semantics as Strictly Compositional Semantics** Given the often assumed competition between truth-conditional semantics and use-theoretic approaches, there might still be the impression that these two approaches are necessarily at odds. After all, the ultimate analyses more often than not differ in content. However, there is a reasonable understanding of formal truth-conditional semantics where these two approaches do not stand in competition. The guiding idea is this:

> Formal semantics seeks to explain how the semantic structure of composite expressions is composed out of its parts, by means of mathematical models,[2] whereas use-theoretic approaches try to elucidate the *conceptual content* of expressions.[3]

Understood in this way, there is no competition between these approaches, given their differing explanatory ambitions.

Thus, if we use the above 'network' for x is snoring to elucidate the meaning of Peter is snoring, we get a *rule* of the following form:

(1) Peter is snoring is used to say something true just in case Peter refers to something that can be snoring (presupposition), that something is asleep and it is making certain sounds [those characteristic of snoring] (cf. my [17]).[4]

Contrasting this with a compositional analysis from intensional semantics:

(2) $\big(\lambda x_e.\lambda w_s.snore_{<e,<s,t>>}(x)(w)\big)(peter)$.[5]

[2] By model, I do not necessarily mean the Tarksian models of model theory, but in the sense of 'scientific models' (cf. [20]).

[3] This is similar in spirit to what [6] suggests, *pace* the role for use theories.

[4] Assuming truth-conditions to be stated using bi-conditionals, hence ignoring 'one-sided' entailments to propositions such as that $x$ is not dead, etc.

[5] This is a clear simplification, given the intended reading of Peter is snoring as an event concurrent with the utterance. However, none of my points hinge on this, and the example serves its purpose at least as well, if not better, given its simplified nature.

Two observations are important. First, nothing prevents us from reading (2) as a statement of a rule: given an index of evaluation ($w$), the sentence is true just in case Peter is snoring in $w$. Second, this analysis (2) is wholly uninformative: clearly, the meaning of snoring is not adequately captured in this formulation, but rather tacitly 'subsumed' under *snore*. Thus, I suggest we can accept (2) as an elucidation of how Peter and is snoring *compose* to generate a proposition with truth-conditional content, but also accept (1) on the grounds that it tells us more about the content of snoring.

Not only is the view of formal semantics coherent with the actual research results of formal semanticists, but is within limits of what can be reasonably expected from the practice. First, the many conceptual observations about the pre-theoretical concept of meaning – and hence about the subject matter of semantics – yield that the actual meaning of an expression can be explained to and learned by other speakers. However, the results of formal semantics arguably do not allow this, hence it might be thought that their results are not about meaning [e.g. 9]. While that might be true, formal semantics can still provide accurate mathematical models of *compositionality*. For $\lambda x_e.\lambda w_s.snore_{<e,<s,t>>}(x)(w)$ might not tell you anything about snoring, but does say how the meaning of the word can interact with the meaning of other expressions. Second, the many equivalence results concerning different type-systems can now be explained [e.g. 22]. For if formal semantics is ultimately occupied with giving a mathematical model of the semantic structure of composite expressions, then the same structure can obviously be accounted for using different underlying type-systems – structures are unique up to isomorphism, after all.

One might object to my characterisation of formal semantics on the grounds that some semantic theories are focussed on explaining entailment relations, not compositionality. For example, in modern developments ([12], [13]) of Davidsonian event semantics [3], the focus lies on explaining 'diamond entailments' such as from John buttered a toast at midnight in the bathroom to John buttered a toast at midnight. Against this, three points can be brought forth. First, on a pre-theoretical level, modifier-dropping is a *structural* entailment: it merely removes a part of a proposition. This phenomenon is clearly compositional, albeit on a *sentential* level. Second, modern versions of event semantics *are* also compositional on a *subsentential* level [e.g. 1], hence there is no incompatibility between these approaches. On the contrary, the endeavours to combine event semantics with compositional semantics showcases the importance of the latter as a central research paradigm. Lastly, even if formal semanticists draw upon lexical semantics, they do not *practice* it, and use theorists would readily agree that, as a matter of conceptual truth, events and actions have a location in space and time, and can be described with modifiers in myriad ways. Thus, even in the rare instance when these two enterprises share an explanatory goal, incompatibility need not arise.

**3. Prior's Puzzle** Most crucially, it allows us to conclusively solve Prior's puzzle [16].[6] Under the picture sketched above, the failure of substituting in proposition within propositional attitude reports is no longer a surprise. Proposition, as used by semanticists, refers to the semantic value assigned to the that-clause in, for example, Sara knows that 2 + 2 = 4. This value is not the meaning of the expression, but at best a formal representation of it. Thus, to say that knowledge is a relation to a proposition is not to be taken literally – unlike [18] – but as an account of how the meaning of such sentences depends on the content of the that-clause. On the other hand, in natural language, proposition means as much as offer, recommendation, or plan of action. Thus, Sara knows that 2 + 2 = 4 and Sara knows the proposition that 2 + 2 = 4 could not mean the same thing

[6] Along similar lines as in [21]. However, I approach the solution from a distinct angle and hence obtain a different formulation, albeit of the same basic thought: the problem does not require a substantial, technical solution.

*in natural language.*[7] However, this is precisely where the substitution test is carried out, and it constitutes yet another piece of evidence that formal semantics does not provide an analysis of meaning, viz. an elucidation of what expressions mean, but formally accounts for compositionally derived semantic structures.

Lastly, just as Prior's puzzle generalises [2], so does this solution. The technical terms used by formal semanticists to refer to the semantic values assigned to expressions will rarely, if ever, correspond to that same expression's meaning in natural language. For example, we should not be surprised to find that Sally seeks a unicorn does not mean the same thing as Sally seeks the generalized quantifier denoted by "a unicorn" – not that it ever could. Generalized quantifier is a *technical* term hailing from the *mathematical machinery* used to explain the semantic structure of a sentence, not what a unicorn means. In other words, it is to be expected that the salient substitutions will (almost) always fail. This, again, is no issue if the practice of formal semantics is understood properly. If the ambition is to provide mathematical models for the semantic structures of sentences, the failure of such substitutions is of no concern, and henceforth requires no technical solution. We should not confuse the mathematical models and tools with the actual meanings of terms, which are more aptly captured by use-theoretic analyses. Nevertheless, we ultimately ignore each approach only at our own peril – given their complementary explanatory ambitions.

# References


[1] Champollion, L.: The interaction of compositional semantics and event semantics **38**, 31–66 (2015)

[2] D'Ambrosio, J.: Prior's puzzle generalized. Philosophy and Phenomenological Research **106**(1), 196–220 (2023)

[3] Davidson, D.: The logical form of action sentences. In: Essays on Actions and Events: Philosophical Essays of Donald Davidson, pp. 105–121, Clarendon Press, Oxford and New York (2001)

[4] Fodor, J.A., Lepore, E.: Brandom's burdens: Compositionality and inferentialism. Philosophy and Phenomenological Research **63**, 465–481 (2001)

[5] Fodor, J.A., Lepore, E.: Brandom beleaguered. Philosophy and Phenomenological Research **74**, 677–691 (2007)

[6] Glanzberg, M.: Explanation and partiality in semantic theory. In: Sherman, A., Burgess, B. (eds.) Metasemantics. New Essays on the Foundations of Meaning, pp. 259–292, Oxford University Press, Oxford (2014)

[7] Glock, H.J.: Quine and Davidson on Language, Thought and Reality. Cambridge University Press, Cambridge (2003)

[8] Glock, H.J.: What is meaning? a wittgensteinian answer to an un-wittgensteinian question. In: Conant, J., Sunday, S. (eds.) Wittgenstein on Philosophy, Objectivity, and Meaning, pp. 185–210, Cambridge University Press, Cambridge (2019)

[9] Hacker, P.M.S.: The Intellectual Powers: A Study of Human Nature. Wiley Blackwell, Malden/Oxford/West Sussex (2013)

[10] Horwich, P.: Meaning. Oxford University Press, Oxford (1998)


[7] Also, sentences of the form x knows o usually express acquaintance with the object $o$, not propositional knowledge [9]. Hence, it is no surprise that in German, I know the city of Berlin is not translated with the German word for knowing (wissen), but with kennen – 'being acquainted with sth.'.

[11] Murzi, J., Steinberger, F.: Inferentialism. In: Hale, B., Wright, C., Miller, A. (eds.) A Companion to the Philosophy of Language, vol. 1, pp. 197–224, Wiley-Blackwell, 2 edn. (2017)
[12] Parsons, T.: Events in the Semantics of English. MIT Press, Cambridge (Mass.) (1990)
[13] Parsons, T.: Thematic relations and arguments. Linguistic Inquiry **26**(4), 635–662 (1995)
[14] Partee, B.H.: Compositionality. In: Compositionality in Formal Semantics. Selected Papers, Blackwell Publishing Ltd (2004)
[15] Peregrin, J.: Inferentialism: Why Rules Ought to Matter. Palgrave Macmillan, Basingstoke/New York (2014)
[16] Prior, A.: Objects of Thought. Clarendon Press, Oxford (1971)
[17] Vonlanthen, S.D.: Inferential roles and truth: Conceptual foundations for modest inferentialism (2023), manuscript invited for the postproceedings of the 14th Tbilisi Symposium on Logic, Language and Information
[18] Williamson, T.: Knowledge and Its Limits. Oxford University Press, Oxford (2002)
[19] Wittgenstein, L.: Philosophische Untersuchungen. Suhrkamp, Frankfurt am Main (1953)
[20] Yalcin, S.: Semantics as model-based science. In: Ball, D., Rabern, B. (eds.) The Science of Meaning: Essays on the Metatheory of Natural Language Semantics, pp. 334–360, Oxford University Press (2017)
[21] Zimmermann, T.E.: The values of semantics. In: Brandt, P., Fuß, E. (eds.) Form, Structure, and Grammar, Studia Grammatica, vol. 63, pp. 383–397, Akademie Verlag, Berlin (2006)
[22] Zimmermann, T.E.: Equivalence of semantic theories. In: Schantz, R. (ed.) Prospects for Meaning, vol. 3, pp. 629–650, De Gruyter (2012)

# Are Language Models Capable of Detecting the Topoi in Argumentative Statements?

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**Abstract:** Investigating the question whether or to what extent language models can detect the argumentative meaning of natural language utterances can be an important area of research as it has implications for several areas around computational linguistics and artificial intelligence. In this research, using the ARCT dataset designed for argument reasoning, we investigate the capability of the RoBERTa and GPT-3.5 language models to detect the general relational statements (topoi) that underpin natural arguments, and which are part of common knowledge. Since topoi are assumed by some theories to be part of the lexical meaning of linguistic expressions, we investigate to what extent replacing some words in the premises can affect the capability of language models to detect the topoi. The selected language models for this research display moderate performances in detecting in topoi, achieving an accuracy of 71.5 percent. Moreover, paraphrasing the premises did not affect the performance of our models significantly, suggesting that the topoi at hand are not strictly lexically based.

**Keywords:** Language Model, Argumentation, Topoi, RoBERTa, GPT

## Introduction

Most of the arguments found in natural conversations are lacunary, which means that premises that refer to shared common knowledge are usually not explicitly stated. In fact, what makes it acceptable for the speaker to omit the unstated parts is that they refer to topoi, i.e., general relational statements which are part of common knowledge, and which are assumed to be part of the lexical meaning of linguistic expressions (Anscombre, 1995). In this research, based on the fact that large language models learn from distributional information that reflects argumentative possibilities and discourse cohesion (Ducrot, 2016), we hypothesize that transformer-based large language models like BERT (Devlin et al., 2018) and GPT (Radford et al., 2018) can identify the unstated premises and the underlying existing topoi involved in argumentation. In addition, studies show that conclusion quality and the existing lexicon in conclusion can affect the quality of argumentation (Skitalinskaya et al., 2021). However, from a logical perspective, two utterances that convey the same information in the same situation have identical semantic effects (Raccah, 2000). Therefore, we will also investigate in this research whether paraphrasing the premises by replacing some words in them with their synonyms will affect the performance of our models. Following the terminology used in the dataset used in this research, in the rest of the article, the terms *claim* and *warrant* will be used to refer respectively to argumentative *conclusion* and *topoi*.

## Method

The data used for the experiments in this research was the ARCT dataset (Habernal et al., 2017). In this dataset, which is designed for the argument reasoning comprehension task, given an argument with a claim and a premise or reason, the goal is to choose the correct implicit warrant from two options provided in the data, which are lexically similar, but lead to contradicting claims (Habernal et al., 2017). In total, there are 1,970 observations in this dataset, and the amount of data in different classes is balanced.

*Table 1. An example of the data in ARCT dataset*

| | |
|---|---|
| warrant0 | scholarships would give women a chance to study |
| warrant1 | scholarships would take women from the home |
| correctLabel | 0 |
| reason | Miss America gives honors and education scholarships. |
| claim | Miss America is good for women |

## Models

To approach the ARCT task, we developed two types of models based on transformers (Vaswani et al., 2017; Clark et al., 2020): (1) Finetuning a RoBERTa (Liu et al., 2019) language model, (2) Prompt engineering a GPT-3.5 (Radford et al., 2018) autoregressive language model. In this section, a detailed explanation of these models will be provided, along with a description of how the paraphrased dataset was produced.

**Finetuning RoBERTa:** We use the *RoBERTa base* language model (Liu et al., 2019), which is a bidirectional language model based on BERT (Devlin et al., 2018). RoBERTa was pretrained on a dataset weigh 160 GB of text, including books, English Wikipedia, news article, stories, and the WebText dataset (Radford et al., 2018) used to train the GPT-2 model as well (Hugging Face, n.d.). We finetuned this model for a binary classification task, namely, to predict the correct warrants based on the reasons and the claims that come before them. To prepare the training and testing datasets, for each observation in the ARCT dataset, the reason, claim, and true warrant were concatenated and labelled based on the provided label, obtaining 3940 inputs and the target labels. An example of the data used in the classifiers is shown in Table 2—90% of the data was used for training, and the rest of it for testing the model.

*Table 2. Two examples of labelled inputs prepared for finetuning*

| Input | Label |
|---|---|
| Miss America gives honors and education scholarships. Miss America is good for women. Scholarships would give women a chance to study. | 1 |
| Miss America gives honors and education scholarships. Miss America is good for women. scholarships would take women from the home. | 0 |

**Prompt Engineering GPT-3.5:** In this phase of the research, the GPT-3.5-turbo pretrained language model (Radford et al., 2018) was used to generate an answer saying which warrant is true based on the provided reason and the claim. This model is the most capable GPT-3.5 model family and optimized for chat (OpenAI, n.d). In general, the GPT-3 model was trained with about 45 TB text data, including books and Wikipedia texts, and supports many languages (Flensted. 2022; Radford et al., 2018). To build the input data, the reasons, claims and both warrants in ARCT dataset were concatenated, obtaining a set of 1970 samples. Next, following an error-and-trial approach, the best description of the task was provided and added to each of the developed inputs, obtaining the final prompts. We used methods to evaluate the ability of the GPT-3.5 language model to detect the correct warrants: (1) zero-shot learning (2) few-shot learning. In zero-shot learning, the prompt only described the task while we added a couple of examples to the prompt when we followed the few-shot-learning approach (Table 3).

*Table 3. The prompts used in the models based on prompt engineering*

| Model | Prompts |
|---|---|
| Zero-shot | Kindly review the provided "reason," "claim," "warrant0," and "warrant1" information in the question. Your task is to predict the warrant that best aligns with and logically supports the "reason" and "claim." Choose either "warrant0" or "warrant1" as your answer. If you are uncertain, please select the option that appears most probable based on the extracted logic from the "reason" and "claim." |
| Few-shot | Please carefully read the "reason", "claim", "warrant0", and "warrant1" in the question. Like the examples provided below, predict the most probable warrant that logically supports the "reason", and "claim". Your answer must be either "warrant0" or "warrant1".<br>Example 1 …<br>Example 2 … |

Finally, using Python and the OpenAI API, the dataset was given to GPT-3.5 language model, and it was asked to generate an answer to predict the correct warrant.

**Paraphrasing:** In addition, to investigate to what extent the topoi are related to the lexical meaning of the reasons and claims, using the GPT-3.5 language model, we automatically paraphrased the claims and the reasons in the 400 observations used as the testing set in the finetuning-based models (an example is shown in Table 4). In more detail, first, a description was prepared and added to the beginning of the claims and reasons, obtaining the required prompt. Then, using OpenAI API, the prompt was given to the language model, asking it to paraphrase the reasons and the claims based on the instructions provided in the description. Finally, by joining *warrant1* to *warrant0* in the same 400 paraphrased samples, a testing dataset containing 200 observations was obtained to be used in the model based on prompt engineering.

*Table 4. An example of the prompts used for text paraphrasing and the generated texts*

| | |
|---|---|
| Original | reason: Polls results create a public narrative rather than reality.<br>claim: Pollings undermine democracy. |
| Paraphrased | reason: The opinion of the public as indicated by polls is not necessarily reflective of the truth.<br>claim: Voting polls erode democratic principles. |

The comparison of the original and paraphrased reasons and claims showed that the paraphrased texts were on average 24% longer than the original ones. Moreover, after paraphrasing, only 27% of the words existing in the paraphrased texts were also present in the original ones.

## Experimental Results

As the results obtained from our models show (Table 5), the RoBERTa and GPT-3.5 language models used in this research showed similar performance in predicting the correct warrants. In fact, the accuracy and f1-score achieved from all of models were very close to each other, achieving a moderate performance. In addition, our results (Table 6) showed that the topoi did not appear to be related to specific lexical items in the original reasons and claims, since paraphrasing does not appear to have a negative effect on our models' performance in detecting the correct warrants. On the contrary, in both types of models, after paraphrasing, there was a small improvement in the results, which can be evidence of the fact that the length of the claims can affect the quality of the argument (Skitalinskaya et al., 2021).

*Table 5. Comparison of the results obtained from the developed models in this research*

| Model | | Accuracy | Precision | Recall | F1_score |
|---|---|---|---|---|---|
| few-shots | gpt-3.5-turbo | 0.705 | 0.730 | 0.668 | 0.698 |
| | gpt-3.5-turbo-16k | 0.705 | 0.729 | 0.669 | 0.698 |
| zero-shot | gpt-3.5-turbo | 0.698 | 0.761 | 0.59 | 0.666 |
| Finetuned | RoBERTa | 0.715 | 0.736 | 0.670 | 0.701 |

*Table 6. Comparison of the results of the developed models before and after paraphrasing the reasons and the claims*

| Model | data | Accuracy | Precision | Recall | F1_score |
|---|---|---|---|---|---|
| gpt-3.5-turbo | original | 0.665 | 0.631 | 0.596 | 0.613 |
| | paraphrased | 0.685 | 0.644 | 0.652 | 0.648 |
| RoBERTa | original | 0.715 | 0.736 | 0.670 | 0.701 |
| | paraphrased | 0.727 | 0.738 | 0.705 | 0.721 |

## Conclusion

The models developed in this research based on large language models showed moderate performance in detecting the implicit warrants provided in the data given an argument with a claim and a premise or reason. Moreover, paraphrasing the reasons and the claims by replacing the words and phrases in them did not significantly affect the performance of our models, which can be evidence of that there was not a direct relationship between the topoi at hand and the lexical meaning of linguistic expressions. However, there are still many apparent synonyms that probably differ in terms of the topoi they activate. For example, excuse and justification or thrifty and miser may be used as synonyms and refer to the same objective situations, but the topoi they can appear in are quite distinct. Thus, though our results suggest that the topoi at hand might not be strictly lexical, that does not necessarily mean that this is true of all topoi.

## References


Breitholtz, E. (2020). Enthymemes and Topoi in Dialogue: the use of common sense reasoning in conversation (p. 161). Brill.

Clark, P., Tafjord, O., & Richardson, K. (2020). Transformers as soft reasoners over language. arXiv preprint arXiv:2002.05867.

Cooper,k. (2021, November 1). OpenAI GPT-3: Everything You Need to Know. Springboard. https://www.springboard.com/blog/data-science/machine-learning-gpt-3-open-ai/

Devlin, J., Chang, M. W., Lee, K., & Toutanova, K. (2018). Bert: Pre-training of deep bidirectional transformers for language understanding. *arXiv preprint arXiv:1810.04805*.

Ducrot, O. (2016) La théorie des blocs sémantiques. *Verbum XXXVII (1-2): 53-65.*

Flensted, T., (2022, August, 22). How Many Languages Does ChatGPT Support? The Complete ChatGPT Language List. https://seo.ai/blog/how-many-languages-does-chatgpt-support

Habernal, I., Wachsmuth, H., Gurevych, I., & Stein, B. (2017). The argument reasoning comprehension task: Identification and reconstruction of implicit warrants. arXiv preprint arXiv:1708.01425.

Liu, Y., Ott, M., Goyal, N., Du, J., Joshi, M., Chen, D., ... & Stoyanov, V. (2019). Roberta: A robustly optimized bert pretraining approach. *arXiv preprint arXiv:1907.11692*.

No Author. (n.d.). Roberta Base. Hugging Face. https://huggingface.co/roberta-base

OpenAI. (n.d.). GPT-3.5. OpenAI Platform. https://platform.openai.com/docs/models/gpt-3-5

Raccah, P. Y. (2000). Lexical and dynamic topoi in semantic description: A theoretical and practical differentiation between words and terms ‘. *Language, Text, and Knowledge: Mental Models of Expert Communication*, *2*, 11.

Radford, A., Narasimhan, K., Salimans, T., & Sutskever, I. (2018). Improving language understanding by generative pre-training. Technical Report. OpenAI.

Skitalinskaya, G., Klaff, J., & Wachsmuth, H. (2021). Learning from revisions: Quality assessment of claims in argumentation at scale. arXiv preprint arXiv:2101.10250.

Vaswani, A., Shazeer, N., Parmar, N., Uszkoreit, J., Jones, L., Gomez, A. N., ... & Polosukhin, I. (2017). Attention is all you need. Advances in neural information processing systems, 30.

Wachsmuth, H., Naderi, N., Hou, Y., Bilu, Y., Prabhakaran, V., Thijm, T. A., ... & Stein, B. (2017, April). Computational argumentation quality assessment in natural language. In Proceedings of the 15th Conference of the European Chapter of the Association for Computational Linguistics: Volume 1, Long Papers (pp. 176-187).

# Negation and information structure in Tree-Wrapping Grammar

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In this paper, we introduce a uniform account of the information structural contribution of different ‘types’ of negation, with a strong emphasis on formal grammar modeling. The starting point of our discussion is the differentiation of two ‘types’ of negation. Dating back to the earliest discussions on negation, two major ‘types’ are generally distinguished, which both reflect the intuition that negation can operate on different domains, or in more technical terms: it can have a wide or a narrow scope. Wide scope negation is generally referred to as *sentential* (or *propositional*) *negation* (1), and the narrow scope negation as *constituent negation* (2). While the notion of sentential negation is used in a rather uniform way across languages, the notion of constituent negation is used less consistently. Nevertheless, all uses of constituent negation reflect the intuition that the negation operator scopes over (or applies to) a single constituent instead of the whole sentence.

(1) *Sam did not kiss Kris in Paris.*

(2) a. *Sam did not kiss KRIS in Paris.* $\approx$ it was not Kris, but someone else whom Sam kissed in Paris
b. *Sam did not kiss Kris in PARIS.* $\approx$ it was not in Paris, but somewhere else that Sam kissed Kris

In compositional analyses, maintaining a logical semantics, the scope of an operator is the semantic content of the expression that stands in a given structural relation with it. In ‘traditional’ approaches to the syntax-semantics interface this relation is often captured within the LF, and in terms of c-command. For sentential negation this leads to the insertion of the logical operator above the predicate, which provides the intended interpretation. The reading of sentential negation is thus straightforwardly captured, and reflects the core semantic contribution of negation: it changes the polarity of the sentence. In the examples in (2), negation applies to the focal constituent only and not to the rest of the sentence. What counts as the ‘scope of negation’ here is, however, not simply the semantic content of the focal constituent. In truth-conditional terms, both sentences in (2) are true under the same conditions as (1). The difference rather lies in the target of negation at the level of Information Structure (IS): their *communicative function.*

## 1 Communicative functions

Given that sentences like (2) and their corresponding sentence with ‘sentential negation’ are true under the same circumstances, the difference between them should be captured beyond the (logical) semantics of the sentence. Following a proposal of Vallduví (1990), we argue for a two-level approach, where negation operates both at the level of semantics and at the level of IS. In the semantics, we assume a ‘standard’ negation operator, that applies to the proposition in all cases. At the level of IS, negation targets the *newly conveyed information*, determined by the *focus structure* of the utterance. This captures the differences in interpretation between the two ‘types’ of negation. We argue for the cross-linguistic validity of the claim that negation has a direct access to the focus structure of the utterance (Van Valin, 2005), and it operates on the contribution by focusing. Determining what is understood under this contribution, we build upon Lambrecht’s (1994) theory of IS. Lambrecht (1994) argues that beyond the semantic content of the sentence, focusing leads to a *pragmatic structuring*, that reflects the *communicative function* of the utterance: what information is conveyed and how this information is transferred between the discourse participants. The core aspect is the transfer of information and its relation to the Common Ground, the set of propositions shared by the interlocutors. The ‘pragmatic presupposition’ of the sentence is the information content that is part of the discourse context shared by the discourse participants (see also Stalnaker, 1974), and the ‘pragmatic assertion’ is the newly conveyed information, in relation to the presupposition. Both concepts are lexico-grammatically defined, hence pragmatic structuring is determined by the grammatical organization of the sentence. Lambrecht (1994: 22) defines focus structure as ”*the conventional association of a focus meaning with a sentence form*” and distinguishes three basic types: narrow/argument, predicate and sentence focus, based on the domain of the focus in the sentence. He also presents the systematic ways natural languages encode these structures in their morphosyntax. These focus structures differ in their communicative functions. According to Lambrecht's (1994) theory narrow/argument focus signals the identification of an entity with respect to an open proposition, predicate focus provides some information of a given topic and sentence focus introduces an event or a referent. All these functions reflect the relation between the pragmatic presupposition and the focus, a relation which is determined as the newly conveyed information, i.e., the *pragmatic assertion.* We propose that at the level of IS natural language negation targets the proposed pragmatic assertion by the given focus structure, expressing a denial of it. In this paper, we discuss the contribution of negation at the level of IS and how that can be formally derived and represented within a well-defined formal grammar.

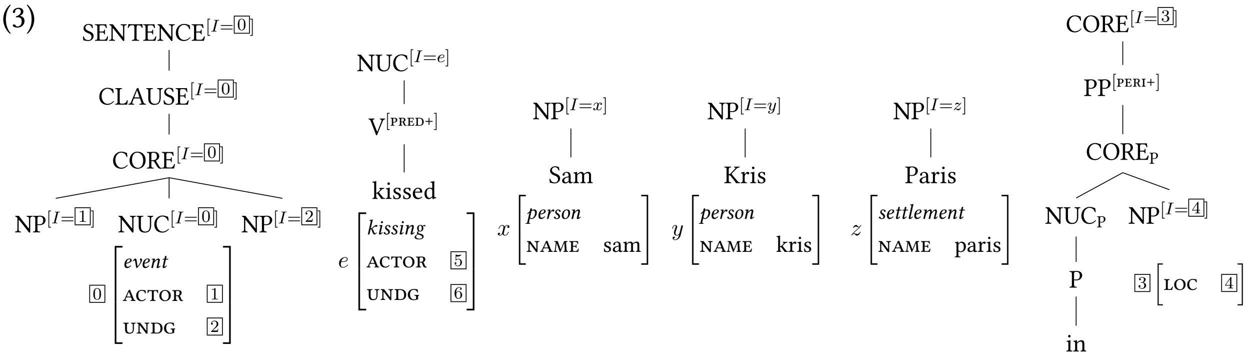
## 2 Formal grammar modeling

According to the above view, the semantic content and the IS interpretation must be represented at distinct, but yet related levels. To formally capture such an analysis, a grammatical model is required that provides access to these levels and explains the relation between them. In our analysis, we use the formalized version of Role and Reference Grammar (RRG; Van Valin &LaPolla, 1997; Van Valin, 2005, 2023) as introduced by Kallmeyer et al. (2013) and Kallmeyer &Osswald (2023). This formal grammar is based on the solid grounds of RRG, a surface oriented grammar theory, developed from a strong typological and theoretical perspective. The general architecture of RRG is modular, with different levels of representation called 'Projections' and well-defined linking between them to model the interfaces. The center of the grammatical model is the bi-directional *linking algorithm* between the syntactic and the semantic representations. In the general architecture of RRG, as part of the discourse pragmatics of the sentence, the focus structure is represented in a separate Projection, which is essentially orthogonal to syntax and semantics. A formal grammar based on the theoretical grounds of RRG offers the appropriate means to satisfy the requirements of our analysis and modeling purposes.[1]

### *2.1 Syntax and semantics in formalized RRG*

The specification of the syntax of our formal grammar is defined in terms of *Tree-Wrapping Grammar* (Kallmeyer et al., 2013; Osswald &Kallmeyer, 2018; Kallmeyer &Osswald, 2023), strongly inspired by *Tree-Adjoining Grammar* (Joshi &Schabes, 1997). Semantic representations are given as decompositional frames (Löbner, 2015; Petersen, 2015), formally defined as *base-labelled typed feature structures* (Kallmeyer &Osswald, 2013). To model the syntax-semantic interface, the elementary structures are taken as pairs of elementary trees and their semantic representation (3).

(3)



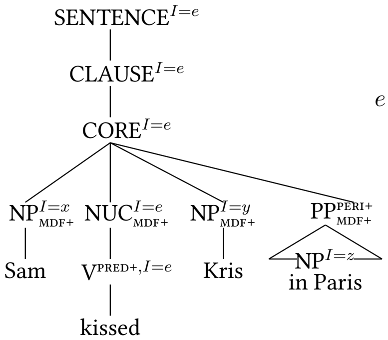

The nodes in the syntactic trees are supplemented with index features (e.g., $I = \boxed{1}$), that link syntax and semantics. The semantic composition is on a par with the syntactic composition, mediated by these index features pointing to parts in the semantic representation. The syntactic operations (wrapping substitution and sister adjunction; Kallmeyer et al., 2013) trigger the composition (i.e., unification) of the semantic representations, thereby deriving the meaning representation of the sentence.

[1]Note that we do claim that RRG is the only theoretical framework to capture our phenomenon. Notwithstanding, the architecture of RRG, and its expressional and explanatory potential are highly beneficial for the given phenomenon.

### *2.2 Information structure in TWG*

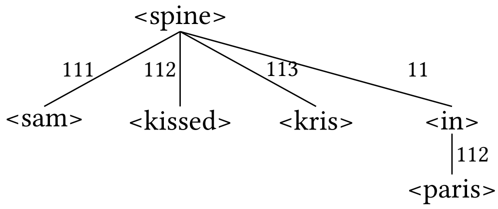
Following Van Valin (2005) and Lambrecht (1994), the basic components of the IS-Projection are the *information units* (IUs). These units make up the *actual focus domain* and the *non-focus domain*, taken as subsets of the set of IUs. The first crucial point is formally deriving the set of IUs. Information units correspond to the information content of the syntactic domains: the NUCLEUS, the (possibly complex) core argument NPs/PPs and the periphery PPs (Van Valin, 2005, 77). This is grounded by the relation to *wh*-question formation (Van Valin, 2005, 180). An IU carries both the information regarding the given syntactic position, and the corresponding semantic content together. The syntactic domain of an IU can be marked as a minimal focus domain (MFD+) on the given node. The pieces of semantic information corresponding to the syntactic domain of the IUs are encoded in the *derivation tree*, a tree structure proposed in TAG that registers all operations on the elementary structures. The IUs in a sentence correspond to the daughters of the root node in the derivation tree, carrying the necessary information from syntax, semantics and their composition.

(4) a. derived structure (syntax + semantics):
(proper name representations abbreviated)



$$e\begin{bmatrix} \textit{kissing} & \\ \text{ACTOR} & x\big[\textit{sam}\big] \\ \text{UNDG} & y\big[\textit{kris}\big] \\ \text{LOC} & z\big[\textit{paris}\big] \end{bmatrix}$$

b. derivation tree:



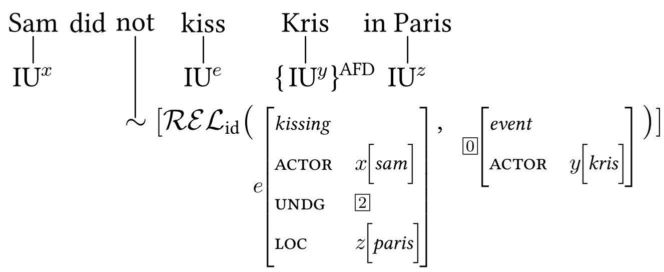
c. $\text{IUS} = \left\{ \boxed{0}\begin{bmatrix} \textit{event} & \\ \text{ACTOR} & x\big[\textit{sam}\big] \end{bmatrix}, e\begin{bmatrix} \textit{kissing} & \\ \text{ACTOR} & \boxed{1} \\ \text{UNDG} & \boxed{2} \end{bmatrix}, \boxed{0}\begin{bmatrix} \textit{event} & \\ \text{UNDG} & y\big[\textit{kris}\big] \end{bmatrix}, \boxed{0}\begin{bmatrix} \text{LOC} & z\big[\textit{paris}\big] \end{bmatrix} \right\}$

Having derived the set of IUs, the information content of the focus domains (AFD and NFD) are calculated by the unification of their elements, i.e., the IUs within the given set. This provides us the structuring to the pragmatic presupposition ($^{\sqcup}$NFD) and the focus ($^{\sqcup}$AFD), considered as the focus structure of the sentence.

### *2.3 Negation at the level of IS*

The pragmatic assertion (i.e., newly conveyed information) of a given focus structure is a special relation between the pragmatic presupposition and the focus. In narrow/argument focus structure, this relation is the specification of the value of an argument or adjunct, corresponding to Lambrecht's (1994) notion of 'identification'. In *Sam kissed* [*Kris*]$^{\text{FOC}}$ *in Paris*, based on the derivations above, this leads to $\boxed{2} = y$, i.e., the value of the UNDERGOER attribute within the pragmatic presupposition is specified by the focus. Within the IS-Projection of the sentence, natural language negation targets this (proposed) newly conveyed information. The IS interpretation of negation in sentences with a narrow focus structure is the rejection of the "identification relation" expressed/suggested by the focus structure: $\sim[\mathcal{REL}_{\text{id}}(^{\sqcup}\text{NFD},^{\sqcup}\text{AFD})]$. In the sentence, *Sam did not kiss* [*Kris*]$^{\text{F}}$ *in Paris*, this leads to the rejection of $\boxed{2} = y$.

(5)



In the 'standard' predicate focus structure, the pragmatic presupposition only contains the information that the given participant is the ACTOR of an unspecified event. In these cases, focus provides this 'missing' information. Hence, it specifies the type and the description of the event that involves the participant given in the pragmatic presupposition. This is a different relation from $\mathcal{REL}_{\text{id}}$, nevertheless captures the same insights as relating the unspecified information in the pragmatic presupposition to the focus. As before, negation targets this contribution in the IS. Finally, in case the AFD is the whole clause (i.e., sentence focus structure) and the NFD is empty, the communicative function and hence the pragmatic assertion is the introduction of the event described in the semantics, which must be added to the Common Ground. A negated sentence with sentence focus structure evokes the mental representation of the given event, described by the frame in the semantics, and its pragmatic assertion is that such an event does not exist, hence it should not be part of the Common Ground.

## 3 Further applications

In this paper, we introduce the basic ideas towards a uniform analysis and formal grammar modeling of the relation between negation and focusing, reflecting the cross-linguistic claim that negation generally relates to the focus structure of the utterance. We argue for a more complex meaning contribution of negation, such that it has access to and operates on the communicative function determined by the given focus structure, rather than it merely enters the semantics. Based on solid theoretical grounds (Lambrecht, 1994; Van Valin &LaPolla, 1997; Van Valin, 2005, 2023), we introduce the formal modeling of the IS component of such a two-level analysis. We propose a uniform analysis of the relation between focus structure and negation in a formalized grammatical model within Tree-Wrapping Grammar (Kallmeyer et al., 2013; Osswald &Kallmeyer, 2018), of which we propose an extension to a formalization of the IS-Projection.

Next to the discussion of the core formal grammatical model, we will explore its application to different phenomena regarding negation. From the numerous issues to resolve for a comprehensive analysis of negation at the syntax-semantics-IS interface (all of that we obviously cannot address), we will discuss the application of the proposed analysis to constructions that distinguish narrow and wide scope negation in the morphosyntactic structure. We will explore the English *not ... but ...* construction, containing a corrective *but*, as well as negation in Hungarian, a language that structurally distinguishes the relevant focus structures and the different 'types' of negation.

**References:** Joshi, A. K. & Y. Schabes. 1997. Tree-Adjoining Grammars. In Rozenberg & Salomaa (eds), *Handbook of formal languages*, 69–123. Berlin: Springer. • Kallmeyer, L. & R. Osswald. 2013. Syntax-Driven Semantic Frame Composition in Lexicalized Tree Adjoining Grammars. *Journal of Language Modelling* 1(2). 267–330. • Kallmeyer, L. & R. Osswald. 2023. Formalization of RRG Syntax. In Bentley et al. (eds), *The Cambridge Handbook of Role and Reference Grammar*, 737–784. Cambridge University Press. • Kallmeyer, L., R. Osswald & R. D. Van Valin, Jr. 2013. Tree Wrapping for Role and Reference Grammar. In Morrill & Nederhof (eds), *Proceedings of Formal Grammar 2012 and 2013*, 175–190. Berlin: Springer. • Lambrecht, K. 1994. *Information structure and sentence form.* Cambridge University Press. • Löbner, S. 2015. Functional Concepts and Frames. In Gamerschlag et al. (eds), *Meaning, Frames, and Conceptual Representation*, 13–42. Düsseldorf University Press. • Osswald, R. & L. Kallmeyer. 2018. Towards a Formalization of Role and Reference Grammar. In Kailuweit et al. (eds), *Applying and Expanding Role and Reference Grammar*, 355–378. Freiburg: Albert-Ludwigs-Universität, Universitätsbibliothek. • Petersen, W. 2015. Representation of concepts as frames. In Gamerschlag et al. (eds), *Meaning, Frames, and Conceptual Representation*, 43–67. Düsseldorf University Press. • Stalnaker, R. 1974. Pragmatic presuppositions. In Munitz & Unger (eds), *Semantics and philosophy*, 197–214. New York University Press. • Vallduví, E. 1990. Information Structure and Scope of Sentential Negation. In Hall et al. (eds), *Proceedings of the 16th Annual Meeting of the Berkeley Linguistics Society*, 325–337. Berkeley Linguistics Society. • Van Valin, R. D., Jr. 2005. *Exploring the syntax-semantics interface.* Cambridge University Press. • Van Valin, R. D., Jr. 2023. Principles of Role and Reference Grammar. In Bentley et al. (eds), *The Cambridge Handbook of Role and Reference Grammar*, 17–177. Cambridge University Press. • Van Valin, R. D., Jr. & R. J. LaPolla. 1997. *Syntax: Structure, Meaning and Function.* Cambridge University Press.

**Cumulative questions and structured witnesses**

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**Introduction** Questions with plural arguments allow *pair-list* responses (1) exemplifies.

(1) a. Who do the students like?

b. Ann likes Professor Jones and Ben likes Professor Smith.

It is fairly clear that this response is natural, but it is controversial whether this is semantically defined 'answer' or pragmatically enriched 'response'. Krifka (1992); Srivastav (1992) took the latter path: they argue that the denotation of (1a) is *cumulative*, i.e. (1a) asserts that there exists a correspondence between men and those who they love, but which correspondence is true in this world is underspecified. Sauerland (1998); Beck (2000); Beck and Sauerland (2000, a.o.) postulate the **-operator to derive cumulative readings. (2c) shows the denotation of (2b) if Prof. Jones and Prof. Smith are the ones that the students like.

(2) a. $[\![\mathrm{R}^{**}]\!] = \lambda x \lambda y \forall x \in X \rightarrow \exists y \in Y [\mathrm{R}(x)(y)] \,\&\, \forall y \in Y \rightarrow \exists x \in X [\mathrm{R}(x)(y)]$

b. [who $\lambda_{x_1}$ the students **(like) $x_1$ ]

c. $[\![(2b)]\!] = \{\forall x \in \{z : z \in [\![\text{the student}]\!]\} \rightarrow \exists y \in \{\text{Jones,Smith}\} [\mathrm{R}(x)(y)] \,\&$
$\forall y \in \{\text{Jones,Smith}\} \rightarrow \exists x \in \{z : z \in [\![\text{the student}]\!]\} [\mathrm{R}(x)(y)]\}$

Thus, the denotation of (1a) is too weak to request pair-list answers. And yet, it is reasonable to assume that the addressee may offer more information than is required. In this case, clarification of who likes whom is over-informative, but still natural. Although this analysis is theoretically parsimonious, Johnston (2023) convincingly argues that this should not be the case. A crucial piece of data is that such a question can be asked even when the context already entails an existence of such correspondence.

(3) Scenario: The head coach of a basketball team had five jerseys made, numbered 1-5, for the five players on the team. Each player chose a jersey. The assistant coach knows all five players on the team, knows the numbers that were available, and believes that each of those players chose exactly one jerseys. However, the assistant coach was not present for the choosing, and so doesn't yet know which player selected which jersey.

a. #Who are the players?

b. Which numbers did the players pick? (Johnston, 2023)

(3a) serves as a baseline: since the context already tells who the players are, it is infelicitous to ask it in this context. On this point, this context already supports a cumulative relation between the players and the numbers. Thus, if *wh*+a definite plural only induces a cumulative reading, (3b) should be infelicitous, just like (3a). However, this is not the case. Thus, Johnston (2023) argues that a pair-list answer should be semantically enabled in the denotation of (3b). He achieves it in a straightforward way: definite plurals may perform distributive quantification with a covert distributivity operator and this derives a pair-list reading on a par with a pair-list reading with distributive quantifiers.

I agree that (3b) is compelling evidence against a simple cumulativity analysis. However, his analysis raises a problem with respect to difference between distributive quantifiers and definite plurals. Especially, Johnston (2023) mentions that the number sensitivity of *wh* questions with definite plurals has been used as evidence for cumulation-only hypotheses.

(4) Which **professors** do the students like?

a. They like Professor Jones and Professor Smith.

b. Ann likes Professor Jones, and Ben likes Professor Smith. (Johnston, 2023)

(5) Which **professor** do the students like?

a. They like Professor Jones.

b. # Ann likes Professor Jones, and Ben likes Professor Smith. (Johnston, 2023)

In contrast, *wh*-questions with distributive quantifiers do not show such number-sensitivity.

(6) Which **professor** does every student like?

a. Every student likes Professor Jones.

b. Ann likes Professor Jones, and Ben likes Professor Smith. (Johnston, 2023)

The problem is as follows: Johnston (2023) successfully derives a pair-list reading of *wh* with definite plurals by assimilating it to *wh* with distributive quantifiers via a covert distributivity operator. However, this blurs their distinction in terms of number sensitivity.

I aim to maintain a fine distinction between distributive quantifiers and definite plurals while maintaining Johnston's (2023) argument against a simple cumulativity analysis of *wh*+a plural definite. I propose that cumulative questions require a *structured witness set*: the speaker requests the witness of *wh*-variable including how its value corresponds to the values of other variables. The core intuition is that pair-list answers may arise from two different types of distributivity. One is the *operator distributivity* that comes from distributive universal quantification and the other is the *lexical distributivity* that comes from the lexical semantics of predicates. I implement this idea with a simple partition semantics with *Dynamic Plural Logic* (DPlL) (van den Berg, 1996, *et seq*).

**Background** In this section, I set up the technical background for the proposal account. First, I introduce Dynamic Plural Logic (DPlL.) DPlL is an extension of Dynamic Predicate Logic (Groenendijk and Stokhof, 1991) with *plural information states* (PIS), i.e. sets of variable assignments. This allows an explicit treatment of quantificational dependencies. I follow the convention to call variables *discourse referents* (drefs). The formal definition of dependencies is given in (7b) (van den Berg, 1996). Consider Table 1:

(7) a. $G_{u_n=d} = \{g : g \in G \,\&\, g(u_n) = d\}$ and $G(u_n) = \{x | g \in G \,\&\, g(u_n) = x\}$

b. In a PIS $G$, $u_m$ is dependent on $u_n$ iff $\exists d, e \in G(u_n)\,[G_{u_n=d}(u_m) \neq G_{u_n=e}(u_m)]$

| $H$ | $u_1$ | $u_2$ | $u_3$ | $u_4$ |
|---|---|---|---|---|
| $h_1$ | $a$ | $x_2$ | $x_3$ | $x_4$ |
| $h_2$ | $b$ | $y_2$ | $x_3$ | $x_4$ |
| $h_3$ | $c$ | $z_2$ | $z_3$ | $x_4$ |

Table 1: Dependency storage

With respect to $u_1$, $u_2$ shows total co-variation, $u_3$ shows partial co-variation and $u_4$ shows no co-variation. By (7b), $u_2$ and $u_3$ are dependent on $u_1$, but $u_4$ is not.

Brasoveanu (2008, a.o.) adopts a definition of assignment extension which allows new values to be dependent to old values as defined in (8). It can produce both contexts in Table 2 and 3: the point-wise addition of new values is satisfied both context.

(8) $G[u]H \Leftrightarrow \forall g[g \in G \rightarrow \exists h[h \in H \& g[u]h]] \& \forall h[h \in H \rightarrow \exists g[g \in G \& g[u]h]]$

| $G$ | $u_1$ |
|---|---|
| $g_1$ | $x_1$ |
| $g_2$ | $x_2$ |

$\xrightarrow[G[u_2]H]{}$

| $H$ | $u_1$ | $u_2$ |
|---|---|---|
| $h_1$ | $x_1$ | $y_1$ |
| $h_2$ | $x_2$ | $y_2$ |

Table 2: Dependent

| $G$ | $u_1$ |
|---|---|
| $g_1$ | $x_1$ |
| $g_2$ | $x_2$ |

$\xrightarrow[G[u_2]H]{}$

| $H$ | $u_1$ | $u_2$ |
|---|---|---|
| $h_1$ | $x_1$ | $y_1$ |
| $h_2$ | $x_1$ | $y_2$ |
| $h_3$ | $x_2$ | $y_1$ |
| $h_4$ | $x_2$ | $y_2$ |

Table 3: Independent

I construct a question semantics in this setting. First of all, I take the context to be a set of *possibilities*, i.e. world-PIS pairs, and a formula denotes a function from an input context to the output context. One may define the context in different ways, but it is easier to demonstrate the gist of my analysis with this assumption. Assignment extension is defined as (9).

(9) $c[u] = \{\langle w, H\rangle : \exists G[\langle w, G\rangle \in c \& [\forall g \in G \exists h \in H[g[u]h] \& \forall h \in H \exists g \in G[g[u]h]]]\}$

I take evaluation of lexical relations to be distributive as default (Brasoveanu, 2008).

(10) $c[R(u_1, ..., u_n)] = \{\langle w, G\rangle : \langle w, G\rangle \in c \& \forall g \in G[\langle g(u_1), ..., g(u_n)\rangle \in I_w(R)]\}$

The (non-)atomicity condition is defined collectively (Brasoveanu, 2008).

(11) a. $\text{Atom}(x) \Leftrightarrow \forall y[y \subseteq x \rightarrow y = x]$
b. $c[\text{atom}(u)] = \{\langle w, G\rangle : \langle w, G\rangle \in c \& \text{Atom}(G(u))\}$
c. $c[\text{non-atom}(u)] = \{\langle w, G\rangle : \langle w, G\rangle \in c \& \neg\text{Atom}(G(u))\}$

Lastly, the dynamic distributivity operator $\delta$ (van den Berg, 1996; Brasoveanu, 2008, a.o.) is defined in (12). $\delta_{u_n}$ evaluate $\phi$ with respect to each $G_{u_n=d}$.

(12) $c[\delta_{u_n}(\phi)] =$
$\{\langle w, H\rangle : \exists G[\langle w, G\rangle \in c \& G(u_n) = H(u_n) \& \forall d \in G(u_n)[G_{u_n=d} \in c \& H_{u_n=d} \in c[\phi]]]\}$

Note that I underspecify its compositional implementation for reasons of space. This can easily be done by regarding dynamic representations as abbreviations of expressions in many-sorted classical logic (Muskens, 1996; Brasoveanu, 2008; Dotlačil and Roelofsen, 2021).

So far, I illustrated a Heimian version of DPlL. Now, I build a question semantics based on this. I do not aim to propose an analysis that applies to various issues in questions in natural language semantics, but I aim to provide a proof of the concept of structured witness sets. As a crucial ingredient, I borrow the witness requesting operator $?u$ (Dotlačil and Roelofsen, 2021). It raises a new issue regarding the value of $u$.

(13) $c[?u] = \{s \in c : \exists x_e \forall w \in s_w \exists G[\langle w, G\rangle \in c \& G(u) = x\}$

Modifying Dotlačil and Roelofsen's (2021) paraphrase, $?u$ asks "Which individual $x$ has the properties ascribed to $u$?" The context is split into several sets of possibilities along with the value of $u$, e.g., a (downward closed) set of possibilities in which $x = a$ and another (downward closed) set of possibilities in which $x = b$. I assume that it is the denotation of C or an operator that occurs somewhere at the left periphery. (14a) and (14b) are the LFs of (4) and (6).

(14) a. [ $?u_2$ [ the students$^{u_1}$ like which professors$^{u_2}$ ] ]

b. [ $?u_2$ [ every student$^{u_1}$ $\delta_{u_1}$(like which professor$^{u_2}$) ] ]

I do not aim to implement it under the setting of inquisitive semantics and assume that a set of alternatives expands after $?u$ is introduced, i.e. I do not attempt to unify declaratives and interrogatives. Then, the question is how the $\delta$ operator contributes to pair-list answers and how (14a) derives pair-list answers. At this point, the $?u$ operator is sensitive to the cumulative value of $u$ and thus it does not discriminate situations that involve the same values, but different correspondence. For example in (3), there can be only one set of possibilities in which $x$ is the sum of five numbers. However, the intuition is that (3b) can specify the exact correspondence between the numbers and the players which describes the true correspondence. To solve this, I refine the $?u$ operator so that it is not only sensitive to the value of $u$, but also to the dependencies that the value of $u$ participates with respect to other drefs.

**Proposal: structured witness set** I propose a generalised version of the $?u$ operator that is sensitive to dependencies. To achieve this, I refine the $?u$ operator as defined in (15). Here, $?u*$ is dependent on another dref $u_n$ as defined in (15).

(15) $c[?u*_{u_n}] = \{s \in c : \exists f_{\langle e,e \rangle} \forall w \in s_w \exists G [\langle w, G \rangle \in c \,\&\, \forall d \in G(u_n) [f(d) = G_{u_n=d}(u)]\}$

(15) partitions the context based on a function $f$ and it is equivalent to (13) when $G$ is a singleton set of variable assignments. However, if $G$ is non-singleton, (15) distinguishes two possibilities that agree on the value of $G(x)$ but disagree on how its value is distributed across the members of $G$. Thus, each $s$ in $c$ expresses different dependencies with respect to the value of $u$. There are two ways to make $G$ non-singleton: one is to evaluate a singular *wh*-expression under the scope of $\delta$ operator and the other is to use a plural *wh*-expression. This explains the difference between *wh*-question with quantifiers and *wh*-questions with plural arguments in terms of number (in)sensitivity of *wh*-expressions.

Now, consider the example (4) again. Henceforth, I use the superscript $^{u_n}$ for an assignment of a new value to $u_n$ and the subscript $_{u_n}$ for anaphoric reference to $u_n$. In this case, $[\![\text{which}]\!]$ is dependent on $[\![\text{the students}]\!]$. I put aside the issue of *wh*-movement in compositional variants of dynamic semantics and assume that resolution of the dependent variable in $?u*_{u_n}$ takes place before *wh*-movement. Whatever dynamic system that can handle with weak crossover effects can resolve the dependent variable in $?u*_{u_n}$ without problems even after *wh*-movements. See Chierchia (2020); Elliott (2020) for dynamic analyses of weak crossover effects.

(16) Which professors do the students like?

a. the students$^{u_1}$ like which$^{u_2}_{u_1}$ professors

b. $c[u_1$,student$(u_1)$,non-atom$(u_1), u_2$,professor$(u_2)$,non-atom$(u_2)$,like$(u_1,u_2), ?u_2*_{u_1}]$

(16b) partitions the context based on possible functional dependencies between the students and the professors. Crucially, the output is a set of sets of world-PIS pairs that match not only in the values of $u_1$ and $u_2$, but also the exact functional dependencies between them. Thus, (16b) semantically derives pair-list answers, i.e. $\{\langle$Ann, Jones$\rangle, \langle$Ben, Smith$\rangle\}$ and $\{\langle$Ann, Smith$\rangle, \langle$Ben, Jones$\rangle\}$ are two distinct answers. On this point, it is important that the $?u{*}_{u_n}$ operator itself does not perform distributive quantification. Consider the example (5). In this case, ⟦which professor⟧ only introduces a singular value to $u_2$ simply because it is singular. As a result, there is no possibility that $u_2$ co-varies with $u_1$, by definition.

(17) Which professor do the students like?

a. the students$^{u_1}$ like which$^{u_2}_{u_1}$ professor

b. $c[u_1$,student$(u_1)$,non-atom$(u_1), u_2$,professor$(u_2)$,atom$(u_2)$,like$(u_1, u_2), ?u_2{*}_{u_1}]$

The situation is different if the subject is a quantifier: it introduces its own δ operator. Consider the example (6). For an explanatory sake, I simplify the content of dynamic generalised quantification (see van den Berg, 1996; Brasoveanu, 2007, for more details).

(18) Which professor does every student like?

a. every student$^{u_1}$ like which$^{u_2}_{u_1}$ professor

b. $c[u_1$,student$(u_1)$,non-atom$(u_1), \delta_{u_1}(u_2$,professor$(u_2)$,atom$(u_2)$,like$(u_1, u_2)), ?u_2{*}_{u_1}]$

In (18b), the value of $u_2$ is constrained to be singular just like it is in (17b). However, it is under the scope of δ in (18b). As a result, this atomicity constraint is evaluated with respect to each subset of information states, i.e. $G_{u_1=d}$, and $u_2$ may still have plural values under the sum of those subsets, i.e. $G$. Therefore, (18b) may have pair-list answers by virtue of the δ operator. Note that this 'neutralisation' of the atomicity condition is fully in parallel with an account of *quantificational subordination* in van den Berg (1996, *et seq*).

Johnston (2023) argues for a subject-object asymmetry in *wh*-questions with a definite plural. He precludes the possibility of genuine cumulative questions with the context (3). In this context, Johnston (2023) shows that pair-list answers are not possible with a subject *wh*.

(19) # Which players picked the numbers? (Johnston, 2023)

In the proposed account, it is simply because the assignment extension with ⟦the numbers⟧ takes place at the right of the assignment extension with ⟦which players⟧. Intuitively speaking, the value of the former has not been introduced yet when the latter looks for its antecedent.

**Taking stock** I aimed to derive pair-list answers with non-quantificational plural expressions without conflating them with questions that involve quantifiers. I illustrated a DPlL-based question semantics in which the witness requesting operator $?u$ can derive pair-list answers if the context entertains possibilities with dependencies between two drefs. For this, one may either introduce the δ operator with a quantifier or assign a plural value to a dref with a plural argument. This can capture Johnston's (2023) intuition about *wh*+definite plural without conflating them with *wh*+quantifier. Although I did not choose to implement it in inquisitive semantics, one may implement it with *Dynamic Inquisitive Semantics* (Dotlačil and Roelofsen, 2021). For this, one just needs to refine a context as a downward closed set of sets of world-PIS pairs. This refinement does not affect the main idea of this paper.

There remain several issues. For example, the interaction between the $?u{*}_{u_n}$ operator and maximisation, dependency between a definite plural and *wh*-phrase across clausal boundary, anaphoric potential of *wh*-questions with quantifiers and those with definite plurals, interaction between a definite plural and multiple *wh*-phrases and so on. I leave them for future research.

## References


Beck, Sigrid. 2000. Star operators. Episode 1: Defense of the double star. Umop 23:1–23.

Beck, Sigrid, and Uli Sauerland. 2000. Cumulation is needed: A reply to Winter (2000). Natural language semantics 8:349–371.

van den Berg, Martin. 1996. Some aspects of the internal structure of discourse. the dynamics of nominal anaphora. Doctoral Dissertation, University of Amsterdam.

Brasoveanu, Adrian. 2007. Structured nominal and modal reference. Doctoral Dissertation, Rutgers University Newark, New Jersey.

Brasoveanu, Adrian. 2008. Donkey pluralities: Plural information states versus non-atomic individuals. Linguistics and philosophy 31:129–209.

Chierchia, Gennaro. 2020. Origins of weak crossover: when dynamic semantics meets event semantics. Natural Language Semantics 28:23–76.

Dotlačil, Jakub, and Floris Roelofsen. 2021. A dynamic semantics of single-*wh* and multiple-*wh* questions. In Semantics and Linguistic Theory, volume 30, 376–395.

Elliott, Patrick. 2020. Crossover and accessibility in dynamic semantics. Manuscript, MIT.

Groenendijk, Jeroen, and Martin Stokhof. 1991. Dynamic predicate logic. Linguistics and philosophy 39–100.

Johnston, William. 2023. Pair-list answers to questions with plural definites. Semantics and Pragmatics 16:2–EA.

Krifka, Manfred. 1992. Definite nps aren't quantifiers. Linguistic Inquiry 23:156–163.

Muskens, Reinhard. 1996. Combining montague semantics and discourse representation. Linguistics and philosophy 19:143–186.

Sauerland, Uli. 1998. Plurals, derived predicates and reciprocals. In The Interpretative Tract, ed. Sauerland Uli and Percus Orin, volume 25 of MIT Working Papers in Semantics, 177–204.

Srivastav, Veneeta. 1992. Two types of universal terms in questions. In North East Linguistics Society, volume 22, 30.

# Extending Abstract Categorial Grammars with Feature Structures: Theory and Practice

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## 1 Introduction

Abstract Categorial Grammars (ACGs) are a categorial formalism, developed with the intent of being a kernel for a grammatical framework. They can represent several grammar models [3, 4] such as context-free grammars or tree-adjoining grammars [5].

An ACG is distinguished by its capacity to generate two distinct languages: the abstract language, specifying the underlying derivation structure, and the object language, representing the surface forms of linguistic expressions. They are defined using a small common mathematical foundation: typed linear $\lambda$-calculus and high-order signatures. Various paradigms of grammar composition are available in the ACGs, which allows for the construction of complex architectures for natural language modeling. A further key feature is their inherent reversibility, which enables their utilization for both linguistic analysis and generation tasks.

However, modeling morphosyntactic phenomena, such as agreement, results in a substantial enlargement of grammars. Consequently, creating and maintaining wide-coverage grammars become time-consuming. In addition, syntactic analysis becomes less efficient due to the number of grammar rules to consider. To illustrate this point, suppose that we want to define the derivation structures that allow for the construction of the following sentence: *The leverage increases*. Such abstract language may be defined as presented in Figure 1a. However, if we aim to introduce the plural version of this sentence and reject the agrammatical ones, we will need a notion of morphological number in the types, which will double the grammar size as shown in Figure 1b.

Although the size of this toy example is small, it demonstrates the combinatorial explosion that occurs when introducing morphosyntactic constraints. ACGs lack a commonly utilized mechanism in grammatical engineering: feature structures. These structures are advantageous for succinctly describing the morphosyntactic rules of languages, such as agreement. The main goals of this paper are both theoretical and practical. We aim to: (i) introduce a conservative extension to the core ACGs that incorporates feature structures; (ii) experimentally demonstrate the benefits of the extension through a rewrite of a wide-coverage grammar; (iii) empirically confirm that the size reduction impacts positively syntactic analysis.

$$\begin{aligned} \mathrm{S}, \mathrm{N}, \mathrm{NP} &:: \mathsf{TYPE} \\ \textit{the} &: \mathrm{N} \multimap \mathrm{NP} \\ \textit{leverage} &: \mathrm{N} \\ \textit{increases} &: \mathrm{NP} \multimap \mathrm{S} \end{aligned}$$

(a) Abstract language definition

$$\begin{aligned} \mathrm{S}, \mathrm{N}_{sg}, \mathrm{N}_{pl}, \mathrm{NP}_{sg}, \mathrm{NP}_{pl} &:: \mathsf{TYPE} \\ \textit{the} : \mathrm{N}_{sg} \multimap \mathrm{NP}_{sg}; \textit{the} &: \mathrm{N}_{pl} \multimap \mathrm{NP}_{pl} \\ \textit{leverage} : \mathrm{N}_{sg}; \textit{leverages} &: \mathrm{N}_{pl} \\ \textit{increases} : \mathrm{NP}_{sg} \multimap \mathrm{S}; \textit{increase} &: \mathrm{NP}_{pl} \multimap \mathrm{S} \end{aligned}$$

(b) Abstract language definition with morphological variants

Figure 1: Abstract language examples

# 2 Proposed Extension

The questions that arise from the introductory example are how to represent feature structures and how to link them with syntactic categories. In this regard, our proposition involves the representation of feature structures by incorporating well-established constructs, namely records. To annotate syntactic categories with feature structures, we advocate for the adoption of dependent types. Extending ACG with dependent types has already been explored [2, 8]. However, it has been demonstrated that parsing becomes undecidable with fully fledged dependent types. Our primary objective is to propose an extension that does not augment the inherent expressive power of the framework. Particularly for parsing in second-order ACG which can be reduced to the polynomial evaluation of a Datalog program [6, 7].

Our extension, ACG with feature structures (f-ACG), utilizes typed feature structures, where the types of feature structures, denoted as $\mathcal{F}$, can only be either an enumeration or a record type. On the side of type dependency on terms, only feature structure terms $F$ are allowed. This constraint is formulated using an upper level above types, referred to as *kind*, symbolized by $\mathcal{K}$. Furthermore, we extend ACG types written $\mathcal{T}$ with two new constructors: type abstraction and type application. Given our objective to express concisely morphosyntactic combinations using feature variables, it is necessary to add dependent products. However, great care needs to be taken in order to prevent undecidability. These dependent products are restricted to always appear in prenex form through the introduction of a new type level, referred to as *generalized types* ($\mathcal{D}$). The inclusion of dependent products in the kernel leads at the term level to the introduction of feature abstractions, feature applications, and case analysis. Figure 2 succinctly summarizes these principles through the definition of a fragment of f-ACG abstract syntax. Due to space constraints, we are unable to present the full details. However, we present in Figure 3, a formulation of the introductory example written in this extension.

The notion of a f-ACG signature $\Sigma$, the basis of the languages, is redefined to take into account the kinding relation and type constants with generalized types. In core ACGs, the lexicon $\mathcal{L}$ interprets the abstract language into the object language through homomorphisms. A noteworthy aspect of the f-ACG lexicon lies in the sharing of feature structures between the two languages, which are consequently interpreted as they are. The kinds of atomic types within the abstract signature and their corresponding interpretations in the object signature are equivalent. In

$$
\begin{aligned}
\mathcal{F} &::= \{e_1 \mid \cdots \mid e_n\} \mid \left[l_1 : \mathcal{F}, \ldots, l_n : \mathcal{F}\right] \\
F &::= e \mid x \mid \left[l_1 = F, \ldots, l_n = F\right] \mid F.l \\
\mathcal{K} &::= \mathsf{TYPE} \mid \mathcal{F} \to \mathcal{K} \\
\mathcal{D} &::= \mathcal{T} \mid \Pi x : \mathcal{F}.\mathcal{D} \\
\mathcal{T} &::= a \mid \mathcal{T}F \mid \mathcal{T} \multimap \mathcal{T} \mid \Lambda x : \mathcal{F}.\mathcal{T} \\
t &::= c \mid x \mid t\,t \mid t \bullet F \mid \lambda^\circ x : \mathcal{T}.t \mid \lambda x : \mathcal{F}.\, t \mid \mathsf{case}\ f\ \{e_1 \to t \mid \cdots \mid e_n \to t\} \\
\Sigma &::= () \mid \Sigma; a :: \mathcal{K} \mid \Sigma; c : \mathcal{D}
\end{aligned}
$$

Figure 2: Abstract syntax of f-ACG components

$$
\begin{aligned}
\mathrm{S} &:: \mathsf{TYPE} \\
\mathrm{N}, \mathrm{NP} &:: \left[\mathit{number} : \{sg, pl\}\right] \to \mathsf{TYPE} \\
\textsc{the} &: \mathrm{N}\left[\mathit{number} = \ \ x\right] \multimap \mathrm{NP}\left[\mathit{number} = \ \ x\right] \\
\textsc{increase} &: \mathrm{NP}\left[\mathit{number} = x\right] \multimap \mathrm{S} \\
\textsc{leverage} &: \mathrm{N}\left[\mathit{number} = \ \ x\right]
\end{aligned}
$$

Figure 3: Abstract language definition with f-ACG

addition, the interpretation of dependent products always preserves the feature type parameter. The overall definition of a grammar remains unaltered, except for the distinguished type denoted as $S$. To allow types with a feature dependency as distinguished types, it is imperative that $S$ represents a proper type in its normal form, devoid of any instances of linear implications.

# 3 Theoretical Results

This extension does not augment the expressive power of ACG, as it can be established that any f-ACG is transformable into a core ACG. The transformation relies on the finite nature of our definition of feature structures. It involves partial generation and a dependency-less translation of proper types. Formally, the following proposition holds.

**Proposition.** *Let $\mathcal{G}$ be a f-ACG grammar, there exists a transformation that enables the construction of a core ACG grammar, $\mathcal{G}'$, wherein the abstract and object languages generated by $\mathcal{G}'$ are isomorphic to those generated by $\mathcal{G}$.*

Nonetheless, this transformation exhibits inefficiency when applied to practical real-world applications since factorizations are completely eliminated. One potential alternative approach involves utilizing the underlying context-free barebone and subsequently filtering out inappropriate solutions. However, encoding feature structures directly into the Datalog reduction for second-order ACG is more natural and likely more efficient. To extend the Datalog reduction, we rely on the following principles to integrate feature structures: (i) atomic feature structure terms are encoded as Datalog constants; (ii) records are flattened and eliminated; (iii) feature types are encoded as predicates.

# 4 Experiments

To measure the performance and factorization gains of the overall extension and reduction, we have developed a f-ACG compiler in Java and conducted a complete rewrite of a proprietary French grammar [9]. This grammar is based on the encoding of a wide-coverage French tree-adjoining grammar [1]. It is constructed from the composition of two ACGs where the level of derivation trees is the pivot. The first ACG defines the correspondence between the derivation and the semantic level, while the other establishes the interpretation of the derivation tree into a derived tree. This grammar is used for text generation from data.

As Figure 4 shows, the grammar of the French language without feature structures consists of 51,246 unanchored trees, whereas the translation in f-ACG comprises 2,792 trees. It corresponds to a reduction of the grammar by eighteen. The parts of the grammar that are the most impacted by the addition of feature structures are the verbal, prepositional and nominal phrases. The category 'other' is also significantly affected. It includes trees for various purposes, such as punctuation and linking words between sentences.

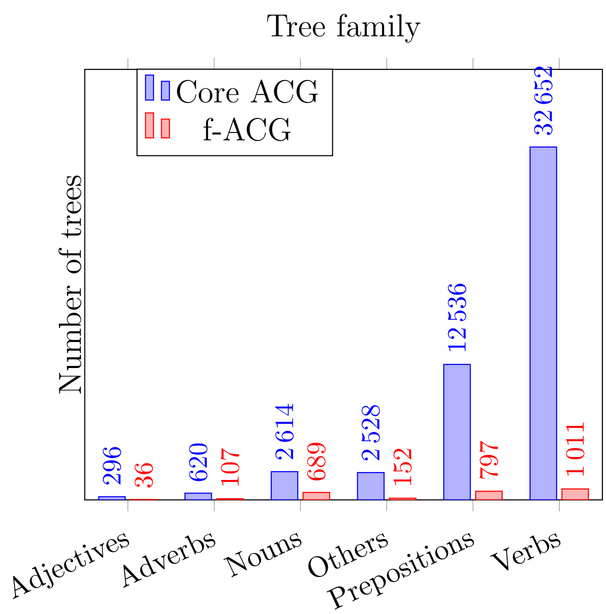


Figure 4: Comparison of the numbers of trees in the two grammars

In terms of performances, the latency of text generation using this grammar heavily depends on the size of the input semantic graph and the number of used lexicalizations. However, we have found that using the compiler mentioned above, when comparing the time spent on generation with a core ACG and its factorized version in f-ACG, the latency is reduced by four, which shows that in addition to an interesting factorization power, the proposed extension also has a positive effect on performances.

In conclusion, the proposed extension offers substantial benefits in terms of grammar size reduction and improved performances while retaining the formal properties of core ACG. However, our definition of feature structures may seem unconventional since certain aspects of feature structures, such as reentrancy and unification, remain unaddressed in this work. These elements offer promising avenues for future development, as they could further increase the factorization power.

# References


[1] Anne Abeillé. *Une grammaire électronique du français*. Sciences du langage. CNRS Éditions, 2002.

[2] Ph. de Groote and S. Maarek. Type-theoretic Extensions of Abstract Categorial Grammars. In *New Directions in Type-theoretic Grammars (NDTTG 2007), ESSLLI 2007 workshop*, Dublin, 2007.

[3] Philippe de Groote. Towards Abstract Categorial Grammars. In *Proceedings of 39th Annual Meeting of the Association for Computational Linguistics*, pages 148–155, 2001. ACL anthology: P01-1033.

[4] Philippe de Groote and Sylvain Pogodalla. On the expressive power of Abstract Categorial Grammars: Representing context-free formalisms. *Journal of Logic, Language and Information*, 13(4):421–438, 2004.

[5] Aravind K. Joshi and Yves Schabes. Tree-adjoining grammars. In Grzegorz Rozenberg and Arto K. Salomaa, editors, *Handbook of formal languages*, volume 3, chapter 2. Springer, 1997.

[6] Makoto Kanazawa. Parsing and generation as datalog queries. In *Proceedings of the 45th Annual Meeting of the Association of Computational Linguistics (ACL 2007)*, pages 176–183, Prague, Czech Republic, 6 2007. Association for Computational Linguistics. ACL anthology: P07-1023.

[7] Makoto Kanazawa. Parsing and Generation as Datalog Query Evaluation. *IfCoLog Journal of Logics and their Applications*, 4(4):1103–1211, 2017. Special Issue Dedicated to the Memory of Grigori Mints.

[8] Florent Pompigne. *Modélisation logique de la langue et Grammaires Catégorielles Abstraites*. PhD thesis, Université de Lorraine, 12 2013.

[9] Raphael Salmon. *Natural Language Generation Using Abstract Categorial Grammars*. PhD thesis, Sorbonne Paris Cité, 2017.

# Compositional Account of Event Quantification in Dependent Type Semantics


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## 1 Introduction: Event Quantification

Event semantics, where the logical form of a sentence contains an event variable and an existential quantifier binding the variable (an event quantifier), was first developed by Davidson [6]. Parsons [16] later reformulated Davidson's event semantics as Neo-Davidsonian event semantics to analyze thematic roles as functions that take event variables.

However, it is known that combining (Neo-)Davidsonian event semantics with Montague's treatment of quantification [15] may produce unexpected semantic interpretations. Consider sentence (1), which under Neo-Davidsonian event semantics[1] with **teach** : $\mathsf{e} \to \mathsf{e} \to \mathsf{t}$, has two possible interpretations: (2a) or (2b).

(1) John taught every student.

(2) (a) $\forall x(\mathbf{student}(x) \to \exists e(\mathbf{teach}(e) \wedge \mathbf{ag}(e) = \mathbf{j} \wedge \mathbf{th}(e) = x))$

(b) $\exists e(\mathbf{teach}(e) \wedge \mathbf{ag}(e) = \mathbf{j} \wedge \forall x(\mathbf{student}(x) \to \mathbf{th}(e) = x))$

The problem here is that when the event quantifier takes a wider scope, event semantics gives an incorrect interpretation as in (2b), which forces quantificational noun phrases to take scope over event quantifiers. De Groote and Winter [7] called this the *event quantification* problem. There have been several proposals regarding how to avoid such incorrect interpretations as (2b) [9, 2, 8, 22, 7, 5, 1, 13, 21].

## 2 Solution in Dependent Event Types

Among such proposed solutions, Luo and Soloviev [13] provided one with dependent event types (we will henceforth call this solution DET), which formalizes a treatment of the event semantics by using dependent types in Modern Type Theories [12, 1]. While there is only one semantic type (event type) for events in (Neo-)Davidsonian event semantics [6, 16], event types in DET depend on thematic roles of the events. For example, let agent and theme be the types of agents and themes, respectively. Then, for $\mathbf{a}$ : agent and $\mathbf{t}$ : theme, the dependent type $\mathsf{evtat}(\mathbf{a}, \mathbf{t})$ is the type of events whose agent is $\mathbf{a}$ and whose theme is $\mathbf{t}$. We can define functions $\mathbf{agent}_{\mathsf{at}}[\mathbf{a}, \mathbf{t}]$ and $\mathbf{theme}_{\mathsf{at}}[\mathbf{a}, \mathbf{t}]$ such that for any event $e$ : $\mathsf{evtat}(\mathbf{a}, \mathbf{t})$, $\mathbf{agent}_{\mathsf{at}}[\mathbf{a}, \mathbf{t}](e) = \mathbf{a}$ and $\mathbf{theme}_{\mathsf{at}}[\mathbf{a}, \mathbf{t}](e) = \mathbf{t}$.

[1] In this paper, we write a thematic role function for an agent as **ag** and those for a theme as **th**, respectively.

In this analysis, events have a natural subtyping relationship between them. For example, the type $\mathsf{evtat}(\mathbf{a},\mathbf{t})$ is a subtype of $\mathsf{evta}(\mathbf{a})$ for $\mathbf{a} : \mathsf{agent}$ and $\mathbf{t} : \mathsf{theme}$. The event types $\mathsf{event}$, $\mathsf{evta}(\mathbf{a})$, $\mathsf{evtt}(\mathbf{t})$ and $\mathsf{evtat}(\mathbf{a},\mathbf{t})$ have the subtyping relationships

$$\mathsf{evtat}(\mathbf{a},\mathbf{t}) \leq \mathsf{evta}(\mathbf{a}) \leq \mathsf{event},$$
$$\mathsf{evtat}(\mathbf{a},\mathbf{t}) \leq \mathsf{evtt}(\mathbf{t}) \leq \mathsf{event}.$$

In DET, the event quantification problem is explained by the ill-typedness of the incorrect semantic interpretation. We thus interpret (2a) as (3a), where the event type $\mathsf{evtat}$ is dependent on the agent and theme types.

(3) (a) $\forall x : \mathsf{entity}.(\mathbf{student}(x) \rightarrow \exists e : \mathsf{evtat}(\mathbf{j},x).(\mathbf{teach}(e)))$

(b) (#) $\exists e : \mathsf{evtat}(\mathbf{j},x).(\mathbf{teach}(e) \wedge \forall x : \mathsf{entity}.(\mathbf{student}(x))$

The incorrect interpretation (3b) is not available because $x$ in $\mathsf{evtat}(\mathbf{j},x)$, which is outside the scope of $\forall x$, is an undeclared free variable.

While DET offers a simple account for the event quantification problem, the previous work has not explained the lexicalization of semantic components and how to obtain their semantic representations, and it is unclear whether we can compositionally construct semantic representations of sentences from their syntactic structures.

In addition, DET wrongly blocks semantic interpretations involving frequency adverbs. Consider the following sentence:

(4) John taught two students three times.

This sentence can be true when John taught different pairs of students for each time. In this reading, the frequency adverb *three times* takes scope over the object noun phrase *two students*. In a compositional setting, this reading requires the adverb *three times* to be quantified outside the object noun phrase. However, since the event type is dependent on the theme in DET, the semantic representation (5) for the reading where the frequency adverb takes scope above the object noun phrase becomes ill-typed.

(5) (#) $\mathbf{three}(\lambda e : \mathsf{evtat}(\mathbf{j},x).(\mathbf{teach}(e) \wedge \mathbf{two}(\lambda x : \mathsf{entity}.(\mathbf{student}(x)))))$

In summary, there are two issues in the solution to the event quantification problem in DET. First, it is not clear how to compositionally handle event quantification problems in dependent type theories. Second, DET fails to account for scope interactions between frequency adverbs and quantifiers.

# 3 Proposal

To resolve these issues, we propose a compositional account of the event quantification problem with Dependent Type Semantics (DTS) [4, 3] and Champollion's continuation semantics for event predicates [5]. DTS is an extended framework of discourse semantics based on Martin-Löf's intuitionistic type theory [14], which follows the constructive, proof-theoretic approach to semantics established by Sundholm [20] and Ranta [17]. We select Combinatory Categorial Grammar (CCG) [19] as a syntactic theory of DTS and adopt the version of DTS proposed in [3] as a semantic theory.

| Example | CCG category | Semantic representation |
|---|---|---|
| John | $NP$ | $\mathbf{j}$ |
| student | $N$ | $\lambda x.\mathbf{student}(x)$ |
| taught | $S\backslash NP/NP$ | $\lambda yxK.(e : \text{entity}) \times \mathbf{event}(e) \times \mathbf{teach}(e) \times (\mathbf{ag}(e) = x) \times (\mathbf{th}(e) = y) \times K(e)$ |
| every$_{\text{OBJ}}$ | $(S\backslash NP)\backslash(S\backslash NP/NP)/N$ | $\lambda nPxK.(v : (x : \text{entity}) \times n(x)) \to P(\pi_1 v)xK$ |
| two$_{\text{OBJ}}$ | $(S\backslash NP)\backslash(S\backslash NP/NP)/N$ | $\lambda nPxK.\mathbf{two}(n)(\lambda y.PyxK)$ |

Table 1: Lexical entries for our analysis. We omit the analysis of tense in this abstract.

$$\dfrac{\text{every}}{\begin{array}{c}(S\backslash NP)\backslash(S\backslash NP/NP)/N\\ \lambda nPxK.(v : (x : \text{entity}) \times n(x)) \to P(\pi_1 v)xK\end{array}} \quad \dfrac{\text{student}}{\begin{array}{c}N\\ \lambda x.\mathbf{student}(x)\end{array}} \;\Rightarrow_{>}\; \begin{array}{c}(S\backslash NP)\backslash(S\backslash NP/NP)\\ \lambda PxK.((v : (x : \text{entity}) \times \mathbf{student}(x)) \to P(\pi_1 v)xK)\end{array}$$

$$\dfrac{\text{taught}}{\begin{array}{c}S\backslash NP/NP\\ \lambda yxK.(e : \text{entity}) \times \mathbf{event}(e) \times \mathbf{teach}(e)\\ \times(\mathbf{ag}(e) = x) \times (\mathbf{th}(e) = y) \times K(e)\end{array}} \;\Rightarrow_{<}\; \begin{array}{c}S\backslash NP\\ \lambda xK.((v : (x : \text{entity}) \times \mathbf{student}(x)) \to (e : \text{entity}) \times \mathbf{event}(e) \times \mathbf{teach}(e) \times (\mathbf{ag}(e) = x) \times (\mathbf{th}(e) = \pi_1 v) \times K(e))\end{array}$$

$$\dfrac{\text{John}}{\begin{array}{c}NP\\ \mathbf{j}\end{array}} \;\Rightarrow_{<}\; \begin{array}{c}S\\ \lambda K.((v : (x : \text{entity}) \times \mathbf{student}(x)) \to (e : \text{entity}) \times \mathbf{event}(e) \times \mathbf{teach}(e) \times (\mathbf{ag}(e) = \mathbf{j}) \times (\mathbf{th}(e) = \pi_1 v) \times K(e))\end{array}$$

$$\Rightarrow_{\text{CC}}\; \begin{array}{c}S[dcl]\\ (v : (x : \text{entity}) \times \mathbf{student}(x)) \to (e : \text{entity}) \times \mathbf{event}(e) \times \mathbf{teach}(e) \times (\mathbf{ag}(e) = \mathbf{j}) \times (\mathbf{th}(e) = \pi_1 v) \times \top\end{array}$$

Figure 1: CCG derivation and semantic composition for (1). The CC (continuation closure) rule is a unary rule to fill the argument $K$ with the term $\lambda e.\top$ to make the semantic type for a declarative sentence type.

Table 1 shows lexical entries for our analysis. The source of the problem in DET lies in the fact that event types are dependent on thematic role types. Instead, we employ Champollion's analysis using event continuation [5] and interpret verbs as generalized existential quantifiers over events. In this analysis, the existential closure is put into the lexical entry of a verb, which forces the event quantification to take the lowest scope. We thus do not need to make the type **event**($e$) dependent on thematic roles. Since some common nouns, such as *destruction* and *singing*, characterize events [16], we represent an event type as a $\Sigma$-type and treat both verbs and nouns as a set of entities. We can obtain the semantic composition for (1) according to the CCG derivation as in Figure 1.

Consider the sentence (4), which involves frequency adverbs. When the object noun phrase takes scope below the frequency adverb, the lexical entry for the adverb *three times* can be considered as (12).

(12) $[\![\text{three times}_{\text{OBJ}<\text{ADV}}]\!] = \lambda PxK.\mathbf{three}(\mathbf{event})(\lambda e.Px(\lambda e'.((e = e') \times K(e'))))$

Figure 2 shows that our analysis with this lexical entry provides a compositional account for the reading in which the adverb takes scope over the object noun phrase.

# 4 Conclusion and Future Work

We showed that the previous analysis of event semantics based on dependent event types has two issues: it does not define the process of semantic composition, and it does not explain interactions between quantifications of frequency adverbs and event quantification. We proposed a compositional semantics that combines dependent type semantics and event continuations, and demonstrated the process from syntactic structures to semantic representations for readings in which the object noun phrase takes scope below the frequency adverb.

Two open questions remain as interesting problems for future investigations. The first is a possible account for the reading where the object noun phrase takes scope above the frequency adverb. To obtain this reading, the three operator must take scope under *two* and over the existential quantification of the event. However, it is difficult to explain this reading by just providing

$$\frac{\text{two}}{\begin{array}{c}(S\backslash NP)\backslash(S\backslash NP/NP)/N \\ \lambda nPxK.\mathbf{two}(n)(\lambda y.PyxK)\end{array}} \qquad \frac{\text{students}}{\begin{array}{c}N \\ \lambda x.\mathbf{student}(x)\end{array}}$$

$$\frac{\begin{array}{c}(S\backslash NP)\backslash(S\backslash NP/NP)/N \\ \lambda nPxK.\mathbf{two}(n)(\lambda y.PyxK)\end{array} \qquad \begin{array}{c}N \\ \lambda x.\mathbf{student}(x)\end{array}}{\begin{array}{c}(S\backslash NP)\backslash(S\backslash NP/NP) \\ \lambda PxK.\mathbf{two}(\mathbf{student})(\lambda y.PyxK)\end{array}} >$$

$$\frac{\text{taught}}{\begin{array}{c}S\backslash NP/NP \\ \lambda yxK.(e:\text{entity})\times\mathbf{event}(e)\times\mathbf{teach}(e) \\ \times(\mathbf{ag}(e)=x)\times(\mathbf{th}(e)=y)\times K(e)\end{array}}$$

$$\frac{\begin{array}{c}S\backslash NP/NP \\ \lambda yxK.(e:\text{entity})\times\mathbf{event}(e)\times\mathbf{teach}(e) \\ \times(\mathbf{ag}(e)=x)\times(\mathbf{th}(e)=y)\times K(e)\end{array} \qquad \begin{array}{c}(S\backslash NP)\backslash(S\backslash NP/NP) \\ \lambda PxK.\mathbf{two}(\mathbf{student})(\lambda y.PyxK)\end{array}}{\begin{array}{c}S\backslash NP \\ \lambda xK.\mathbf{two}(\mathbf{student})(\lambda y.(e:\text{entity})\times\mathbf{event}(e)\times\mathbf{teach}(e) \\ \times(\mathbf{ag}(e)=x)\times(\mathbf{th}(e)=y)\times K(e))\end{array}} <$$

$$\frac{\text{three times}}{\begin{array}{c}(S\backslash NP)\backslash(S\backslash NP) \\ \lambda PxK.\mathbf{three}(\mathbf{event})(\lambda e.Px(\lambda e'.((e=e') \\ \times K(e'))))\end{array}}$$

$$\frac{\begin{array}{c}S\backslash NP \\ \lambda xK.\mathbf{two}(\mathbf{student})(\lambda y.(e:\text{entity})\times\mathbf{event}(e)\times\mathbf{teach}(e) \\ \times(\mathbf{ag}(e)=x)\times(\mathbf{th}(e)=y)\times K(e))\end{array} \qquad \begin{array}{c}(S\backslash NP)\backslash(S\backslash NP) \\ \lambda PxK.\mathbf{three}(\mathbf{event})(\lambda e.Px(\lambda e'.((e=e') \\ \times K(e'))))\end{array}}{\begin{array}{c}S\backslash NP \\ \lambda xK.\mathbf{three}(\mathbf{event})(\lambda e.\mathbf{two}(\mathbf{student})(\lambda y.(e':\text{entity})\times\mathbf{event}(e')\times\mathbf{teach}(e')\times(\mathbf{ag}(e')=x)\times(\mathbf{th}(e')=y)\times(e=e')\times K(e')))\end{array}} <$$

$$\frac{\frac{\text{John}}{\begin{array}{c}NP \\ \mathbf{j}\end{array}} \qquad \begin{array}{c}S\backslash NP \\ \lambda xK.\mathbf{three}(\mathbf{event})(\lambda e.\mathbf{two}(\mathbf{student})(\lambda y.(e':\text{entity})\times\mathbf{event}(e')\times\mathbf{teach}(e')\times(\mathbf{ag}(e')=x)\times(\mathbf{th}(e')=y)\times(e=e')\times K(e')))\end{array}}{\begin{array}{c}S \\ \lambda K.\mathbf{three}(\mathbf{event})(\lambda e.\mathbf{two}(\mathbf{student})(\lambda y.(e':\text{entity})\times\mathbf{event}(e')\times\mathbf{teach}(e')\times(\mathbf{ag}(e')=\mathbf{j})\times(\mathbf{th}(e')=y)\times(e=e')\times K(e')))\end{array}} <$$

$$\frac{\begin{array}{c}S \\ \lambda K.\mathbf{three}(\mathbf{event})(\lambda e.\mathbf{two}(\mathbf{student})(\lambda y.(e':\text{entity})\times\mathbf{event}(e')\times\mathbf{teach}(e')\times(\mathbf{ag}(e')=\mathbf{j})\times(\mathbf{th}(e')=y)\times(e=e')\times K(e')))\end{array}}{\begin{array}{c}\overline{S}[dcl] \\ \mathbf{three}(\mathbf{event})(\lambda e.\mathbf{two}(\mathbf{student})(\lambda y.(e':\text{entity})\times\mathbf{event}(e')\times\mathbf{teach}(e')\times(\mathbf{ag}(e')=\mathbf{j})\times(\mathbf{th}(e')=y)\times(e=e')\times\top))\end{array}} \;\text{cc}$$

Figure 2: CCG derivation and semantic composition for (4) when the object noun phrase takes scope below the frequency adverb.

another lexical entry for *three times* that is different from (12). The second question is how to account for different readings for plural noun phrases. Sentence (4) has not only scope ambiguity for the frequency adverb *three times* but also distributive, collective, and cumulative readings for the plural object *two students*. Our current proposal fails to explain the cumulative reading, which becomes true if John taught Student A, Student B, and Student A again. There have been different accounts for plurality [11, 18, 10], so one possible way of obtaining the cumulative reading is to explore how to combine these accounts and DTS.

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# References

[1] Asher, N., Luo, Z.: Formalization of coercions in lexical semantics. In: Proceedings of Sinn und Bedeutung, vol. 17, pp. 63–80 (2012)

[2] Beaver, D., Condoravdi, C.: On the logic of verbal modification. In: Proceedings of the 16th Amsterdam Colloquium Conference on Logic, Language and Meaning (2007)

[3] Bekki, D.: A proof-theoretic analysis of weak crossover. In: Proceedings of the 18th International Workshop on Logic and Engineering of Natural Language Semantics (LENLS18), pp. 75–88 (2021)

[4] Bekki, D., Mineshima, K.: Context-Passing and Underspecification in Dependent Type Semantics, pp. 11–41. Springer International Publishing, Cham (2017)

[5] Champollion, L.: The interaction of compositional semantics and event semantics. Linguistics and Philosophy **38**, 31–66 (2015)

[6] Davidson, D.: The logical form of action sentences. In: N. Rescher (ed.) The Logic of Decision and Action, pp. 81–95. University of Pittsburgh Press (1967)

[7] De Groote, P., Winter, Y.: A type-logical account of quantification in event semantics. In: T. Murata, K. Mineshima, D. Bekki (eds.) New Frontiers in Artificial Intelligence, pp. 53–65. Berlin, Heidelberg (2015)

[8] Eckardt, R.: A logic for easy linking semantics. In: Proceedings of the 17th Amsterdam Colloquium Conference on Logic, Language and Meaning, p. 274–283. Berlin, Heidelberg (2009)

[9] Landman, F.: Plurality. In: S. Lappin (ed.) The Handbook of Contemporary Semantic Theory, pp. 425–458. Blackwell (1996)

[10] Landman, F.: Events and Plurality: The Jerusalem Lectures. Studies in linguistics and philosophy. Kluwer Academic Publishers (2000)

[11] Link, G.: The Logical Analysis of Plurals and Mass Terms: A Lattice-theoretical Approach, pp. 302–323. De Gruyter, Berlin, Boston (1983)

[12] Luo, Z.: Computation and Reasoning: A Type Theory for Computer Science. Oxford University Press, Inc., USA (1994)

[13] Luo, Z., Soloviev, S.: Dependent event types. In: Proceedings of the 28th Workshop on Logic, Language, Information and Computation (2017)

[14] Martin-Löf, P.: Intuitionistic Type Theory. Studies in proof theory. Bibliopolis (1984)

[15] Montague, R.: The Proper Treatment of Quantification in Ordinary English, pp. 221–242. Springer Netherlands, Dordrecht (1973)

[16] Parsons, T.: Events in the Semantics of English: A Study in Subatomic Semantics. MIT Press (1990)

[17] Ranta, A.: Type-theoretical Grammar. Clarendon Press (1994)

[18] Scha, R.J.: Distributive, Collective and Cumulative Quantification, pp. 131–158. De Gruyter Mouton, Berlin, Boston (1984)

[19] Steedman, M.J.: Surface Structure and Interpretation. The MIT Press, Cambridge (1996)

[20] Sundholm, G.: Proof Theory and Meaning, pp. 471–506. Springer Netherlands, Dordrecht (1986)

[21] Tomita, Y.: Solving event quantification and free variable problems in semantics for Minimalist Grammars. In: Proceedings of the 30th Pacific Asia Conference on Language, Information and Computation: Oral Papers, pp. 219–227. Seoul, South Korea (2016)

[22] Winter, Y., Zwarts, J.: Event semantics and abstract categorial grammar. In: M. Kanazawa, A. Kornai, M. Kracht, H. Seki (eds.) The Mathematics of Language, pp. 174–191. Berlin, Heidelberg (2011)

# Making Commitment Explicit: Case Study from the Japanese Discourse Particle *Ne* in Interrogatives

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**Observation** This article focuses on the Japanese discourse particle *ne* in interrogative sentences. See (1) below adapted from Northrup (2014, 80).

(1) S Ano hito, kono hon kau ka *ne*?
that person-NOM this book buy Q *ne*
'I wonder if that person will buy this book.'
A (Soo) *ne*. that-way *ne* 'Yeah.'
A' Kau *yo*! buy *yo* 'Yes they do, of course!'[1]
S' Nande wakaru no?
why figure.out Q
'How do you know that?'

Northrup 2014 makes an interesting observation. It is pointed out that when the particle is used in an interrogative sentence, the entire linguistic expression no longer holds its regular, answer-seeking meaning. To be more precise, Northrup (2014, 80) claims that with interrogatives with *ne*, the speaker (S) "seems to be musing about the question. The addressee [(A)] can still answer the question if he wants to, but unlike the normal questions, there is no obligation to do so." Indeed, as the gloss in (1S) suggests, the interrogative utterance with *ne* has the sense that S does not expect A to know the answer to the question. This is also indicated by the fact that A can reply to S by saying (1A). Interestingly, if A replies to (1S) with (1A') instead of (1A), S can further say (1S'), expressing their surprise at the fact that A seems to know the answer to the question. Thus, we can conclude that (1S) indeed serves as a rhetorical question in the sense that S does not expect A to know the answer. The same applies to *wh* interrogatives. See (2).

(2) S Dare-ga zyuugatu-no biruboodo raibu oosaka-ni kur-u ka *ne*?
who-NOM October-GEN billboard live Osaka-to come-PRS Q *ne*
'I wonder who will be performing at Billboard Live Osaka in October.'
A Same as (1A).
A' Sam-to Jacob da *yo*. Sam-and Jacob COP *yo* 'Sam and Jacob.'

In this dialog too, S doesn't intend to get from A the answer to the question. Rather, S just verbalises their epistemological ignorance upon the answer to the question, with the assumption that A doesn't know the answer, either. Again, if A utters (2A') as a reply to (2S), S can felicitously say (1S'). The data thus show that with interrogatives with *ne*, S does not expect A to provide them with the answer. That is, upon the use of interrogatives with *ne*, S expects A to act upon their ignorance w.r.t. the answer to the question.[2] Even

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[1]One of the reviewers notes when A answers the *ne* interrogative, *yo* seems to be obligatory. Although in many cases the response sounds much more natural with *yo* than without it, the presence of the particle in an answer to the *ne* interrogative is not obligatory, as A can say *Soo da to omo-u* (so COP COMP think-PRS) 'I think so', in which the *yo* particle is not used.

[2]One of the reviewers raises an interesting issue. According to them, "*ne*-interrogatives do not always express the speaker's assumption that the addressee is ignorant." The reviewer reports that the intuition that they have is exemplified by the following example.

though the observation here is partly due to the work, Northrup 2014, 116–117 leaves the issue as a mystery (though the work makes some speculations on it). The crucial facts to be explained are: ① **with interrogatives with *ne*, S expresses their assumption that A does not know the answer to the question**, and ② **S further expects A to act in accord with their ignorance on the answer**. The aim of this paper is twofold: we seek to explain ① and ②, and in so doing we seek to provide a formally refined definition of the term *commitment*, the notion that has been widely used in the recent literature.

**Framework** Farkas and Roelofsen's (2017) commitment-based discourse update model within the framework of *Inquisitive Semantics* argues that an utterance $U$ with the informative content $\mathsf{Info(p)}$ (propositional content in the traditional sense) maps discourse agents to their commitment to the possibility that the actual world $w_a$ is contained in $\mathsf{Info(p)}$. In the case of an interrogative utterance, they claim that it maps them to the possibility that $w_a \in W$, where $W$ corresponds to the possibility that has been established in the current discourse, i.e., the context set (CS).[3] In this sense, the authors argue, commitment in the case of interrogatives is vacuous. However, their use of the notion "commitment" remains somewhat vague, leaving the precise (formal) definition of the term unexplained.

**Private Commitment** Geurts's (2019) notion of *private commitment* (pcom) and *social commitment* (scom) is useful here. He defines an agent's commitment as a tripartite relation: $x$ is committed to $y$ to act upon $w_a \in \mathsf{info(p)}$. The former type of commitment is where $x = y$, and according to Geurts, it corresponds to an agent's belief, which corresponds to Gungloson's (2003) notion of an agent's *Public Belief*, assuming that the publicity is an ancillary effect of utterance (in what follows, we are only concerned with publicised commitments, and $\mathrm{pc}_{S/A}$ denotes a set of worlds s.t. S/A is pcom'd to the possibility that $w_a$ is contained in it). Thus, CS $:= \mathrm{pc}_S \cap \mathrm{pc}_A$. Once we equate pc with belief (set), something intriguing emerges. Ciardelli et al. (2019) assume that for $x$, there is a map $\beta_x$ which assigns to each possible world $w$ a set of possible worlds that we call $\beta_x(w)$, a set of worlds compatible with what $x$ believes at $w$. Thus, we can say that $x$ doesn't

(i) Nee, asita-no densya tte nanzi dat-ta ka *ne*?
hey tomorrow-GEN train QUOTE what.time COP-PST Q *ne*
'Hey, do you remember when the train departs tomorrow?'

I confess that (i) sounds awkward to me as a genuine, answer-seeking question, despite the reviewer's intuition. 6 out of my 12 native Japanese consultants judged the sentence in the way I do, and the rest judged it in accord with the reviewer's intuition. Here the intuition appears to diverge. Also, to me the example sounds better as a regular question if the falling intonation is associated with the particle. It may thus be the case, as the reviewer notes, that the effect of intonation is key to the specific discourse function of *ne* in interrogatives (and beyond). Due to the lack of space, we have to leave the investigation of the effects that intonation patterns have on the use of *ne* for future research. See Oshima (2016) for an excellent descriptive survey of *ne* with specific intonation contours in declaratives.

[3] Since $W$ corresponds to what S and A have mutually agreed, it will not contain the possibilities that S and A disagree. For instance, assume that S thinks that the earth is round while A is a flat earth proponent. In this case, neither $p$ nor $\neg p$ is established in CS, where $p =$ the earth is round. And hence, the possibilities carved out by neither of the propositions are established in $W$. Therefore, we need not be concerned with such epistemological discrepancies between S and A in what follows. Thanks to one of the reviewers for raising this issue.

believe (nor know) that $p$ iff $\forall w \in s : \beta_x(w) \not\subseteq \mathsf{info(p)}$ (assuming that one's knowledge that $p$ at least presupposes their belief that $p$). Recall that in an interrogative utterance, $x$ is pcom'd to act on $W$. Since $W \not\subseteq \mathsf{info(q)}$ holds for any answer with the informative content $\mathsf{info(q)}$ to the question expressed by the interrogative sentence, the interrogative utterance indicates that $x$ doesn't believe nor know the answer.

**Social Commitment** An agent's scom is a commitment where $x \neq y$. What does this type of commitment amount to? According to Brandom (1994), scom is a particular agent's deontic status in the discourse. That is, if $x$ is scom'd to act on $w_a \in \mathsf{info(p)}$, $x$ is obligated to be consistent w.r.t. $p$'s truth when interacting with $y$. This indicates that an agent's social commitment can be modeled in terms of the agent's Modal Base (MB) (Kratzer 1991). In particular, assuming with Portner (2007, 2019); Oshima (2014) a.o. that modal bases are relativised to each conversation participant, $x$'s social commitment adds $\mathsf{info(p)}$ to their *deontic* MB.

**Proposal** Now we have equipped ourselves with the necessary tools for explaining the behaviour of *ne* in interrogatives. Based on Oshima's (2014) assumption and the Farkas and Roelofsen (2017) model, we propose that a discourse context C consists of a pair $\langle pc_S, pc_A, f_A, g_A \rangle$ (ignoring irrelevant details), where $f_A$ and $g_A$ are a MB and an ordering source relativised to A (cf. Portner 2007, 2019). We assume in particular that $f_A$ is A's deontic MB (not their priority MB as in Oshima's analysis of *yo* with the rising intonation), a set of propositions on the truth of which A is committed to act. Given all this, we claim based on Farkas and Roelofsen (2017) and Farkas and Bruce (2010) that an interrogative utterance with *ne* has the following discourse function (context change potential) (we refer the reader to Farkas and Roelofsen 2017 for the precise definition).

(3) *The discourse function of an interrogative with* ne *in the context C*
(superscripted C' marks the relevant element in the post-update context C': e.g., $\mathsf{Table}^{C'}$:=$\mathsf{Table}$ in C')
  a. The issue $\{p, \bar{p}\}$ is put on $\mathsf{Table}^{C'}$;
  b. A is pcom'd to act on $\mathsf{info(p)}$ in C', i.e., $\mathrm{pc}_A^{C'} = \mathrm{pc}_A^{C} \cap \mathsf{info(p)}$
  c. A is scom'd to act on $\mathsf{info(p)}$, i.e., $f_A^{C'} = f_A^{C} \cup \mathsf{info(p)}$

Compare (3) with the discourse function of a bare interrogative (an interrogative without the *ne* particle) below.

(4) *The discourse function of a bare interrogative in C*
  a. The issue $\{p, \bar{p}\}$ is put on $\mathsf{Table}^{C'}$;
  b. $\mathsf{info(p)}$ is added to $\mathrm{pc}_S$ in C', i.e., $\mathrm{pc}_S^{C'} = \mathrm{pc}_S^{C} \cap \mathsf{info(p)}$

In both (3) and (4), an interrogative utterance adds the issue $\{p, \bar{p}\}$ to $\mathsf{Table}$. The first notable difference between the two is that while a bare interrogative utterance makes S pcom'd to $\mathsf{info(p)}$, an interrogative with *ne* pcoms A (not S) to $\mathsf{info(p)}$. Recall that S's and A's pcoms to $\mathsf{info(p)}$ in both (3b) and (4b) express that these agents do not know the answer to the question introduced to $\mathsf{Table}$, as $\mathsf{info(p)}$ in an interrogative utterance amounts to $W$. Thus, (4b) dictates that S does not know the answer to the question, which is the default discourse function of S's utterance of an interrogative sentence. In contrast, (3b) shows that if an interrogative with *ne* is uttered, the entire utterance aims to update the context in such a way that A does not know the answer to the question. In this way, the discourse functions of interrogatives with *ne* noted in ① above is explained: by uttering the *ne* interrogative S intends to update the context in such a way that A does not know the answer to the question added to Table. One more important point is that according to (3c), interrogatives with *ne* further scom A to act on $w_a$ being contained in $\mathsf{info(p)}$. That is to say, interrogatives with *ne* suggests the context update in such a way that $\mathsf{info(p)}$ is also added to A's deontic MB $f_A$ in C'. We claim that this is responsible for the discourse function of the *ne* interrogative in ②: by performing the speech act, S intends to make A committed to (not just A, but also S) to act on their ignorance w.r.t. the answer to the question. In this way, we successfully explain the behaviour of *ne* in interrogatives.

**Syntax** As for the syntax of *ne* in interrogatives, we propose the following syntactic structure (cf. Speas and Tenny 2003; Wiltschko and Heim 2016; Miyagawa 2022).

(5) $[_{CommitP}\ [_{Commit'}\ [_{ForceP}\ [_{TP}\ p]\ ka]\ \text{PCOM}]\ S]$

*Ka* is a Q-particle that is responsible for introducing $\{p, \bar{p}\}$ to the semantic representation (which is to be added to Table), and the PCOM-head is responsible for introducing an agent's pcom to act upon $\mathsf{info(p)}$. *S* is the Speaker-head that serves as the external argument to the CommitP, specifying that the pcom is made by the speaker. Based on this basic syntactic structure, we further claim that the *ne* interrogative has the following syntactic structure:

(6) $[_{CommitP}\ [_{Commit'}\ [_{Commit'}\ [_{ForceP}\ [_{TP}\ p]\ ka]\ \text{PCOM}]\ \text{SCOM}]\ ne_A]$

Here, in lieu of the *S*-head, the *A*-head feeds A as the agent whose commitment is relevant to the context update. The SCOM-head is a modifier for PCOM, and it semantically specifies that the agent should be both privately and socially committed to act on $\mathsf{info(p)}$. Thus, together with the *A*-head, SCOM is responsible for (3c), while PCOM is responsible for (3b). We further propose that *A* is realised as *ne* in the post-syntactic morphological process of Vocabulary Insertion when it embeds SCOM (cf. Halle and Marantz 1993 a.o.).

**Some Clarifications and Implications** First, a remark is in order regarding our notion of CS. As one of the reviewers points out, Geurts (2019) defines the notion of Common Ground (CG), which serves as the basis of CS, in terms of what we call Social Commitment. Even though it is possible to define CG (and accordingly, CS) on the basis of the interlocutor's Social Commitment, we follow Gungloson (2003) and others to assume that CG and CS are constructed based on the conversation participants' private commitments. But it should be noted that it's still possible to have two types of CS, one constructed via intersecting the interlocutors' private commitments, and the other constructed by intersecting their social commitments. The former serves as our CS, and the other would serve as another type of context set, which expresses the possibility that the conversation participants are obliged to obey. The latter is what Geurts calls CG, and this can be obtained by intersecting S and A's relevant deontic MBs.

Second, even though the present analysis focuses on *ne* in interrogatives, the empirical coverage of it can be extended to the same particle in different clause types. Let us discuss how it can provide us with an explanation for the behavior of the same particle in declaratives. Miyagawa 2022 claims that *ne* in (7) serves as a confirmational particle in that by using it S asks A to confirm that $p$ = 'Knower just released a new album' is true.

(7) Knower-ga sinpu-o dasi-ta *ne*.
Knower-NOM new.album-ACC release-PST *ne*
'Knower released a new album, right?'

In the present analysis, this reading of *ne* in (7) can be easily explained. In this example, info(p) should carve out the possible worlds in which $p$ is true, and info(p) should be a proper subset of $W$ (so long as the proposition is informative). The use of *ne* indicates that A is both pcom'd and scom'd to info(p). This means that the presence of *ne* expresses that S as the utterer suggests the CCP in such a way that A publicly believes that $p$ and further commits themselves to its truth. The latter, i.e. A's social commitment to act upon $p$'s truth, neatly captures the "confirmational" reading of the particle observed by Miyagawa (2022) (see also Saito and Haraguchi 2012).

Of note is that the present analysis explains some other readings of the same particle in declaratives. For instance, Oshima (2016) discusses that *ne* can be used as a request for permission, based on examples of the following sort.

(8) Arigatoo, omiyage kat-te-kur-u *ne*.
thank.you souvenior buy-IMPFV-come-PRS *ne*
'Thank you, I'll buy you a gift."

Imagine that A drove S to the airport and S utters (8) to A. Here, it is weird to interpret the utterance as S's attempt to make A confirm that $p$ = 'S will buy A a gift' true. Rather, by uttering (8) in this context, S seeks to get permission from A to buy them a gift to express their gratitude towards them.

This reading can be captured by our analysis as follows. By uttering (8), S suggests the CCP that A becomes pcom'd and scom'd to the truth of $p$. Here, A's commitment is telic in the sense of Geurts 2019, because their commitment is "fulfilled" once the proposition is made true. To be precise, the commitment is accomplished once S buys a gift to A. According to Geurts, this type of telic private commitment corresponds to an agent's intention, and the same agent's telic social commitment obliges them to see to it that $p$ will be the case. Based on this idea, we can say that S utters (8) so as to suggest that A come to hold the intention of making $p$ true and further see to its truth. It seems natural to conclude that from this semantics, the "request for permission" reading of *ne* surfaces.

**Conclusion** The present account provides us with a straightforward explanation for the discourse function of interrogatives with *ne* in Japanese. In so doing, it also presents a refined notion of commitment, which decomposes the notion widely used in the literature into an agent's (publicised) private and social commitments. We have seen that the former corresponds to the agent's belief/intention, whereas the latter corresponds to their deontic status. The former serves as a partial basis for CS, which is defined to be the intersection of $\mathrm{pc}_S$ and $\mathrm{pc}_A$, and the latter makes the informative content an element of the agent's *f*.

# References


Brandom, Robert. 1994. *Making it Explicit.*Cambridge, MA. Harvard University Press.

Ciardelli, Ivano, Jeroen Groenendijk, and Floris Roelofsen. 2019. *Inquisitive Semantics.*Oxford. Oxford University Press.

Farkas, Donka F. and Kim B. Bruce. 2010. On reacting assertions and polar questions. *Journal of Semantics.* 27: 81–118.

Farkas, Donka F. and Floris Roelofsen. 2017. Division of labor in the interpretation of declaratives and interrogatives. *Journal of Semantics.* 34: 237–289.

Geurts, Bart. 2019. Communication as commitment sharing: Speech acts, implicatures, Common Ground. *Theoretical Linguistics.* 45: 1–30.

Gungloson, Christine. 2003. *True to form: Rising and Falling Declaratives as Questions in English.*New York. Routledge.

Halle, Morris and Alec Marantz. 1993. Distributed morphology and pieces of inflection. In Hale, Ken and Samuel Jay Keyser (eds.), *The View from Building 20: Essays in Linguistics in Honor of Sylvan Bromberger.* 111–176.Cambridge, MA. MIT Press.

Kratzer, Angelika. 1991. Modality. In *Semantics: An International Handbook of Contemporary Research.* 639–650.Berlin. Mouton de Gruyter.

Miyagawa, Shigeru. 2022. *Syntax in the Treetops.*Cambridge, MA. MIT Press.

Northrup, Oliver. 2014. Grounds for Commitment. Ph.D. dissertation. University of California, Santa Cruz.

Oshima, David Y. 2014. On the functions of the Japanese discourse particle *yo* in declaratives. In McCready, Elin, Katsuhiko Yabushita, and Kei Yoshimoto (eds.), *Formal Approaches to Semantics and Pragmatics: Japanese and Beyond..* 251–271.Heidelberg. Springer.

Oshima, David Y. 2016. On the polysemy of the Japanese discourse particle *ne*: A study with special reference to intonation. *Forum of International Development Studies.* 4:3 1–17.

Portner, Paul. 2007. Imperatives and modals. *Natural Language Semantics.* 15: 351–383.

Portner, Paul. 2019. Commitment to Priorities. In Fogal, Daniel, Daniel Harris, and Matt Moss (eds.), *New Work in Speech Acts.* 296–316. Oxford University Press.

Saito, Mamoru and Tomoko Haraguchi. 2012. Deriving the cartography of the Japanese right periphery: The case of sentence-final discourse particles. *Iberia: An International Journal of Theoretical Linguistics.* 4:2 104–123.

Speas, Margaret and Carole Tenny. 2003. Configurational Properties of Point of View Roles. In Sciullo, Anna Maria Di (ed.), *Assymetry in Grammar: Syntax and Semantics.* 315–344.Amsterdam. John Benjamins.

Wiltschko, Martina and Johannes Heim. 2016. The syntax of confirmationals. A neo performative analysis. In Kaltenböck, Gunther, Evelien Keizer, and Arne Lohmann (eds.), *Outside the clause: Form and function of extra-clausal constituents.* 305–340.Amsterdam. John Benjamins.