NØthing is Logical

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Slides: https://www.marialoni.org/resources/Paris25A.pdf

LINGUAE Paris 2025: Lecture 1
10 December 2025

NØthing is logical (Nihil)

- Goal of the project: a formal account of a class of natural language inferences which deviate from classical logic
- Common assumption: these deviations are not logical mistakes, but consequence of pragmatic enrichments (Grice)
- Strategy: develop *logics of conversation* which model next to literal meanings also pragmatic factors and the additional inferences which arise from their interaction
- Novel hypothesis: **neglect-zero** tendency (a cognitive bias rather than a conversational principle) as crucial factor
- Main conclusion: deviations from classical logic consequence of enrichments albeit not (always) of the canonical Gricean kind

Non-classical inferences

Free choice (FC)

(1) FC: $\Diamond(\alpha \vee \beta) \rightsquigarrow \Diamond\alpha \wedge \Diamond\beta$ [von Wright 1968]

(2) Deontic FC inference [Kamp 1973]

a. You may go to the beach *or* to the cinema.
b. $\rightsquigarrow$ You may go to the beach *and* you may go to the cinema.

(3) Epistemic FC inference [Zimmermann 2000]

a. Mr. X might be in Victoria *or* in Brixton.
b. $\rightsquigarrow$ Mr. X might be in Victoria *and* he might be in Brixton.

Ignorance

(4) The prize is either in the garden *or* in the attic $\rightsquigarrow$ The prize might be in the garden *and* might be in the attic [Grice 1989, p.45]

(5) ? I have two *or* three children.

- In the standard approach, ignorance is a conversational implicature
- Less consensus on FC inferences analysed as conversational implicatures; grammatical (scalar) implicatures; semantic entailments; ...

The challenge of FC: adding FC to classical modal logic implies the equivalence of any two possibility claims

$$\Diamond a \Rightarrow_{\mathrm{CML}} \Diamond(a \vee b) \Rightarrow_{\mathrm{FC}} \Diamond b$$

Novel hypothesis: neglect-zero

- FC and ignorance inferences are [≠ semantic entailments]
  - Not the result of Gricean reasoning [≠ conversational implicatures]
  - Not the effect of applications of covert grammatical operators [≠ grammatical (scalar) implicatures]
- They are rather a consequence of something else speakers do in conversation, namely,

  NEGLECT-ZERO
  when interpreting a sentence speakers construct models depicting reality (some verifying the sentence, some falsifying it) ↦ common assumption
  and in this process tend to neglect models that verify the sentence by virtue of an empty configuration (*zero-models*) ↦ novel hypothesis
- Tendency to neglect zero-models follows from the cognitive difficulty of:
  1. conceiving emptiness, the absence of things rather than their presence
  2. evaluating truths with respect to empty witness sets

  [Nieder 2016; O. Bott *et al* 2019]

Novel hypothesis: neglect-zero

Illustration

(6) Less than three squares are black.

a. Verifier: [■, □, ■]
b. Falsifier: [■, ■, ■]
c. Zero-models: [□, □, □]; [■, ■, ■]; [△, △, △]; [▲, ▲, ▲]; . . .

Zero-models in (6-c) verify the sentence by virtue of an empty set of black squares

- Cognitive difficulty of zero-models confirmed by experimental findings and connected to / can be argued to explain:
  - the special status of 0 among the natural numbers [Nieder 2016]
  - why downward-monotonic quantifiers are more costly to process than upward-monotonic ones (*less* vs *more*) [Bott *et al* 2019]
- N-Z hypothesis: neglect-zero also at the origin of many common departures from classical reasoning
  - FC and ignorance [MA 2022]
  - Existential Import: every A is B ⇒ some A is B
  - Aristotle's Thesis: if not A then A ⇒ ⊥
  - Boethius' Thesis: if A then B & if A then not B ⇒ ⊥

[Ziegler, Knudstorp & MA 2025]

Novel hypothesis: neglect-zero effects on disjunction

Illustrations

(7) Maria ate an apple.

a. Verifier: [🍎]

b. Falsifiers: [🍌]; [🍐]; [ ]

c. Zero-models: none

(8) Maria ate a banana.

a. Verifier: [🍌]

b. Falsifiers: [🍎]; [🍐]; [ ]

c. Zero-models: none

(9) M ate an apple and a banana.

a. Verifier: [🍎 🍌]

b. Falsifiers: [🍐]; [ ]

c. Zero-models: none

(10) M ate an apple or a banana.

a. Verifier: ?

b. Falsifiers: [🍐]; [ ]

c. Zero-models: ?

Novel hypothesis: neglect-zero effects on disjunction

Illustrations

(11) Maria ate an apple.

a. Verifier: [🍎]

b. Falsifiers: [🍌]; [🍐]; [ ]

c. Zero-models: none

(12) Maria ate a banana.

a. Verifier: [🍌]

b. Falsifiers: [🍎]; [🍐]; [ ]

c. Zero-models: none

(13) M ate an apple and a banana.

a. Verifier: [🍎 🍌]

b. Falsifiers: [🍐]; [ ]

c. Zero-models: none

(14) M ate an apple or a banana.

a. Verifier: ?

b. Falsifiers: [🍐]; [ ]

c. **Zero-models**: [🍎]; [🍌]

- Two **zero-models** in (14-c): verify the sentence by virtue of an empty witness for one of the disjuncts

Novel hypothesis: neglect-zero effects on disjunction

Illustrations

(15) Maria ate an apple.

a. Verifier: [🍎]

b. Falsifiers: [🍌]; [🍐]; [ ]

c. Zero-models: none

(16) Maria ate a banana.

a. Verifier: [🍌]

b. Falsifiers: [🍎]; [🍐]; [ ]

c. Zero-models: none

(17) M ate an apple and a banana.

a. Verifier: [🍎 🍌]

b. Falsifiers: [🍐]; [ ]

c. Zero-models: none

(18) M ate an apple or a banana.

a. Verifier: [🍎 | 🍌] ⇐ 'split'

b. Falsifiers: [🍐]; [ ]

c. **Zero-models**: [🍎]; [🍌]

- Two **zero-models** in (18-c): sentence verified by virtue of an empty witness for one of the disjuncts
- **Split state** in (18-a): multiple (possibly conflicting) alternatives processed in a parallel fashion
- Neglect-zero hypothesis: ignorance and FC arise because zero-models, where only one of the disjuncts is depicted, are cognitively taxing and therefore kept out of consideration

A new conjecture: no-split

(19) Maria ate an apple or a banana.

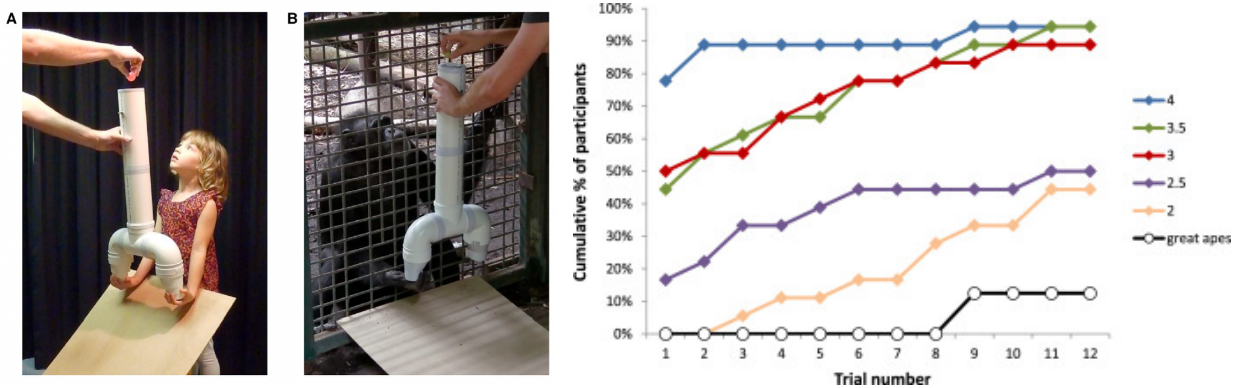
a. Verifier: [🍎 | 🍌] [⇐ **split state**]

b. Falsifiers: [🍐]; [ ]

c. **Zero-models**: [🍎]; [🍌]

- **Split states**: multiple (possibly conflicting) alternatives processed in a parallel fashion ↦ also a cognitively taxing operation

NO-SPLIT CONJECTURE [Klochowicz, Sbardolini & MA, SuB 2025]
the ability to split states (entertain multiple possibilities) is developed late



Children have trouble conceiving multiple possibilities [Redshaw & Suddendorf 2016]

- Proposal: Combination of neglect-zero + no-split can explain non-classical inferences observed in pre-school children

No-split: conjunctive children

- Pre-school children sometimes (but systematically) interpret disjunctions conjunctively [Evans 93; Singh *et al* 16 (cf. Skordos *et al* 20); Cochard25; Bleotu *et al* 25]

  (20) M ate an apple or a banana = M ate an apple and a banana
  $(\alpha \vee \beta) \equiv (\alpha \wedge \beta)$

  (21) M can eat an apple or a banana = M can eat an apple and a banana
  $\Diamond(\alpha \vee \beta) \equiv \Diamond(\alpha \wedge \beta) \not\equiv \Diamond\alpha \wedge \Diamond\beta$

  (22) M didn't eat an apple or a banana = M neither ate an apple nor a banana
  $\neg(\alpha \vee \beta) \equiv (\neg\alpha \wedge \neg\beta)$

- Proposal: children have conjunctive readings as they (similarly to adults) neglect zero and, unlike adults, do not have the ability to split

  1. Deriving ignorance:

     Apple OR banana $\Rightarrow_{\text{NZ}}$ 🍎 + 🍌 $\Rightarrow_{\text{SPLIT}}$ [🍎 | 🍌]

     $\rightsquigarrow$ It might be an apple and it might be a banana (adults)

  2. Deriving conjunctive reading:

     Apple OR banana $\Rightarrow_{\text{NZ}}$ 🍎 + 🍌 $\Rightarrow_{\text{NO-SPLIT}}$ [🍎 🍌]

     $\rightsquigarrow$ Both an apple and a banana (children)

  3. In case of incompatible alternatives: [Leahy & Carey 2020]

     Left OR right $\Rightarrow_{\text{NZ}}$ ↙ + ↘ $\Rightarrow_{\text{NO-SPLIT}}$ **contradiction** ($\bot$)

     $\rightsquigarrow$ Random singular guess (children)

No-split: homogeneity

- Ability to split a state not only required to interpret disjunction but also conjunction under negation [Sbardolini 2023]

  (23) M did *not* eat an apple *and* a banana $\rightsquigarrow$ M *neither* ate an apple *nor* a banana $\neg(\alpha \wedge \beta) \rightsquigarrow \neg\alpha \wedge \neg\beta$

- Proposal: also adults tend to avoid split-states in cognitively taxing environments, notably under negation

  1. Deriving homogeneity:

     NOT [apple AND banana] $\Rightarrow_{\text{NZ}}$ NO 🍎 + NO 🍌 $\Rightarrow_{\text{NO-SPLIT}}$ [NO 🍎 NO 🍌]

     $\rightsquigarrow$ Neither an apple nor a banana (children & no-splitting adults)

  2. Deriving ignorance:

     NOT [apple AND banana] $\Rightarrow_{\text{NZ}}$ NO 🍎 + NO 🍌 $\Rightarrow_{\text{SPLIT}}$ [NO 🍎 | NO 🍌]

     $\rightsquigarrow$ Possibly not an apple and possibly not a banana (splitting adults)

- Testable predictions:
  - increase of no-split interpretations under cognitive load in adults (dual-task)
  - correlation between failure in Redshaw & Suddendorf's task and conjunctive behaviour in children

Cognitive bias approach (NIHIL$^+$)

Common assumption: Reasoning and understanding of natural language involve the creation of mental models [Johnson-Laird 1983, a. o.]

- **Understanding** a sentence S means being able to mentally construct a model picturing the world which verifies S, and possibly also a model which falsifies it
- **Reasoning** depends on two main processes: first construct verifying models for the premises and then check the validity of the conclusion on these models

Novel hypothesis: biases can constrain the construction of these models and therefore impact both reasoning and interpretation:

- **Neglect-zero** prevents the constructions of zero-models;
- **No-split** expresses a dispreference for split-states.

Comparison with competing accounts

	Ignorance	**FC & DIST**	**ES-Quant**	**Scalar impl.**	**Conj *or* & homog.**
Neo-Gricean	reasoning	reasoning	reasoning	reasoning	—
Grammatical	debated	grammar	grammar	grammar	grammar
NIHIL$^+$	neglect-zero	neglect-zero	neglect-zero	—	negl-z + no-split

NEXT

- Logical modelling of biases in team semantics
- Experimental findings
  1. Degano *et al* (Nat Lang Sem, 2025): ignorance ⇐
  2. Nihil *et al* (SuB24, CogSci25, SuB25, XPRAG25): scalar, DIST & ES-Quant
  3. Bleotu *et al* (TbiLLC 2025, SuB25): on conjunctive *or*

Modelling biases in team semantics

General methodology

Natural language sentences translated into classical logic formulas interpreted in a team semantics which models both classical and enriched interpretations

NATURAL LANGUAGE $\mapsto$ LOGICAL LANGUAGE $\nearrow$ α **(classical)**

LOGICAL LANGUAGE $\searrow$ $[\alpha]^{+\cdots}$ **(enriched)**

Back to FC challenge

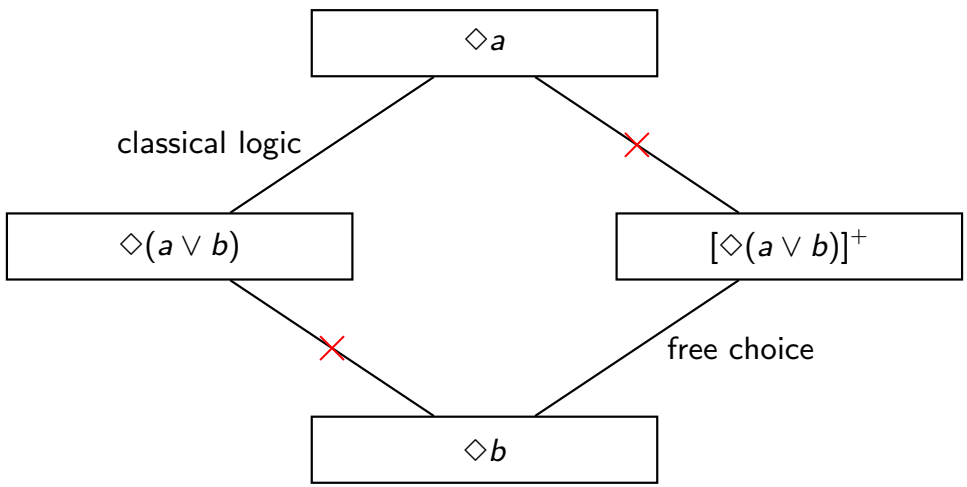


Figure: FC derived only for neglect-zero (NZ) enriched formulas

Modelling biases in team semantics

Team semantics

- Formulas interpreted wrt a set of points of evaluation (a team) rather than single ones [Hodges 1997; Väänänen 2007]
  - Classical modal logic: $[M = \langle W, R, V \rangle]$

$$M, w \models \phi, \text{ where } w \in W$$

  - Team-based modal logic:

$$M, t \models \phi, \text{ where } t \subseteq W$$

- Two crucial features
  - The empty set is among the possible teams ($\emptyset \subseteq W$) $\mapsto$ zero-models
  - Multi-membered teams can model parallel processing of alternatives $\mapsto$ split states

Neglect-zero & no-split

- Model-theoretic method: biases modelled by disallowing empty (neglect-zero) and multi-membered teams (no-split)
- Syntactic method: biases modelled via new logical atoms/operators
  - Neglect-zero: via **non-emptiness atom** NE which disallows empty teams as possible verifiers [Yang & Väänänen 2017]

$$M, t \models \mathrm{NE} \text{ iff } t \neq \emptyset$$

  - No-split: via **flattening operator** F which induces pointwise evaluations and therefore mimics ban on parallel processing of alternatives

$$M, t \models \mathrm{F}\phi \text{ iff for all } w \in t : M, \{w\} \models \phi$$

Modelling biases in team semantics

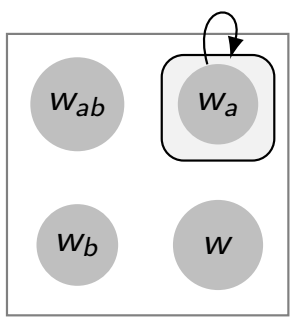
Classical and enriched interpretations

- $\alpha \Rightarrow$ empty team & split allowed $\mapsto$ **classical (literal) meaning**
- $[\alpha]^{+} \Rightarrow$ empty team not allowed $\mapsto$ **NZ-enriched**
- $[\alpha]^{++} \Rightarrow$ neither empty team nor split allowed $\mapsto$ **NZ+NS-enriched**

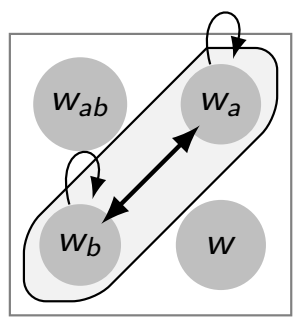
Split disjunction

- Team s supports a **disjunction** iff s is the union of two subteams, each supporting one of the disjuncts
  - $a \vee b$: empty team allowed $\mapsto$ subteams can be empty (**classical**)
  - $[a \vee b]^{+}$: empty team not allowed $\mapsto$ subteams cannot be empty (**NZ-enr**)
  - $[a \vee b]^{++}$: neither empty team nor split allowed $\mapsto$ no empty or distinct subteams allowed (**NZ+NS -enriched**)

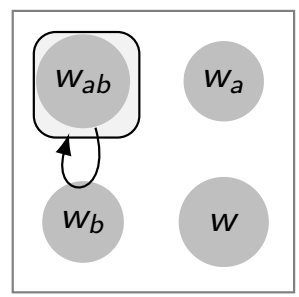
[**PROP**$= \{a, b\}; W = \{w_{ab}, w_a, w_b, w\}$]



$\models a \vee b$
$\not\models [a \vee b]^{+}$
$\not\models [a \vee b]^{++}$
$\mapsto$ **Zero-model**



$\models a \vee b$
$\models [a \vee b]^{+}$
$\not\models [a \vee b]^{++}$
$\mapsto$ **No-zero**, **split**



$\models a \vee b$
$\models [a \vee b]^{+}$
$\models [a \vee b]^{++}$
$\mapsto$ **No-zero**, **no-split**

Modelling biases in team semantics

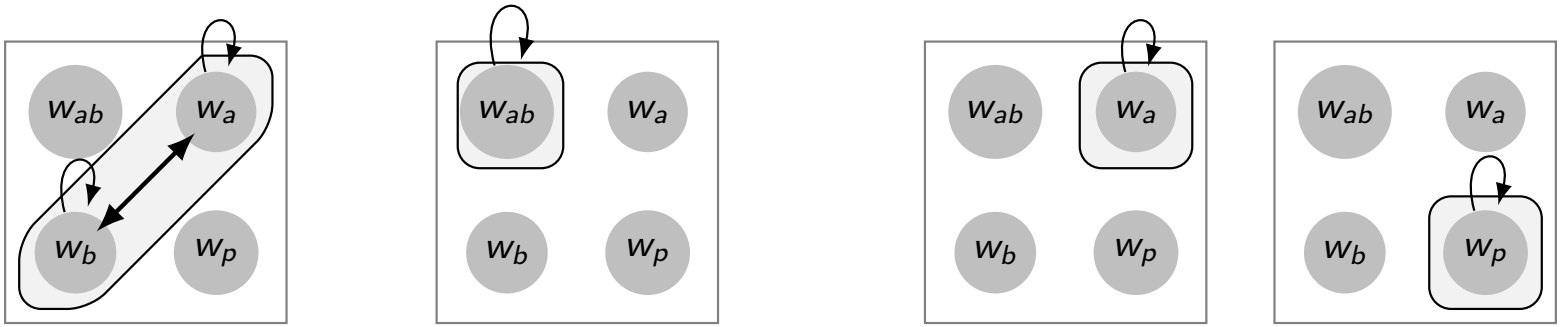
(24) Maria ate an apple or a banana. $[a \vee b]$

a. **No-zero**, **split** verifier: [🍎 | 🍌] $\rightsquigarrow$ it might be apple, it might be banana

b. **No-zero**, **no-split** verifier: [🍎 🍌] $\rightsquigarrow$ both apple and banana

c. **Zero-models**: [🍎] ; [🍌]

d. Falsifier: [🍐]



No-zero, **split** verifier | **No-zero**, **no-split** verifier | **Zero-model** | Falsifier

Predictions

We derive ignorance & conjunctive interpretations for nz- and ns-enriched formulas with no undesirable effects under negation

(25) M ate an apple or a banana $\rightsquigarrow_{nz}$ It might be an apple and it might be a banana

$[\alpha \vee \beta]^{+} \models \Diamond_e \alpha \wedge \Diamond_e \beta$ (where R is state-based)

(26) M ate an apple or a banana $\rightsquigarrow_{ns}$ M ate both apple and banana

$[\alpha \vee \beta]^{++} \models \alpha \wedge \beta$

(27) M didn't eat an apple or a banana $\rightsquigarrow_{(nz/ns)}$ M ate neither apple nor banana

$[\neg(\alpha \vee \beta)]^{(++)} \models \neg\alpha \wedge \neg\beta$

and more predictions including FC, homogeneity, ...

A closer look at these predictions

Many enrichments triggered by disjunction

(28) Maria ate an apple or a banana $(\alpha \vee \beta) \rightsquigarrow$

a. Ignorance: speaker doesn't know which $\Diamond_e\alpha \wedge \Diamond_e\beta$

b. Conjunctive interpretation: both $\alpha \wedge \beta$

c. Scalar implicature: not both $\neg(\alpha \wedge \beta)$

Two components of full ignorance: possibility vs uncertainty

(29) Maria ate an apple or a banana $\rightsquigarrow$ speaker doesn't know which

[Degano *et al* 2025][1]

a. Possibility: It is possible that M ate an apple and it is possible that M ate a banana $\Diamond_e\alpha \wedge \Diamond_e\beta$

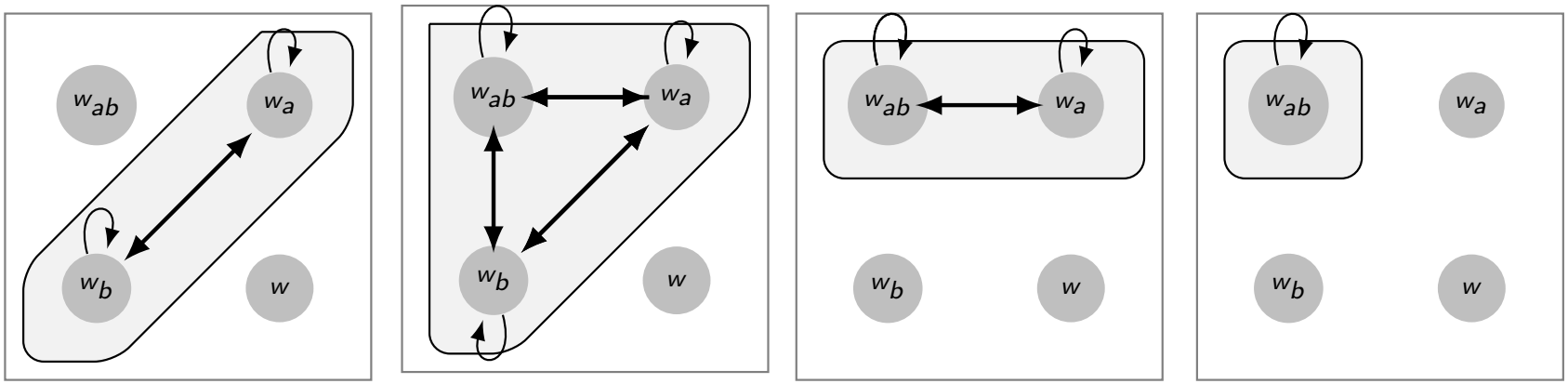
b. Uncertainty: It is uncertain that M ate an apple and it is uncertain that M ate a banana $\neg\Box_e\alpha \wedge \neg\Box_e\beta$

Can we capture all these inferences as nz- or ns-effects?

[1] Degano, Marty, Ramotowska, MA, Breheny, Romoli, Sudo. "The ups and downs of ignorance." *Natural Language Semantics*, 2025.

Neglect-zero effects on disjunction: predictions of $[\ ]^{+\cdots}$-enrichment

Many no-zero verifiers for nz-enriched disjunction



(a) no-zero & scalar $\models \neg(a \wedge b)$ (b) no-z & non-scalar $\not\models \neg(a \wedge b)$ (c) no-z & no-uncertain $\not\models \neg\Box_e a$ (d) no-zero & no-split $\models (a \wedge b)$

Figure: Models for enriched $[a \vee b]^+$.

1. Neglect-zero enrichment derives **possibility**: $[\alpha \vee \beta]^+ \models \Diamond_e\alpha \wedge \Diamond_e\beta$
2. Neglect-zero + no-split derives conjunctive *or*: $[\alpha \vee \beta]^{++} \models \alpha \wedge \beta$
3. Neglect-zero enrichment does not derive scalar implicatures;
4. Neglect-zero enrichment does not derives uncertain inferences $\mapsto$ in contrast to standard neo-Gricean approach to ignorance $\Leftarrow$

Two derivations of full ignorance

1. **Standard neo-Gricean derivation** [Sauerland 2004]

   (i) Uncertainty derived through quantity reasoning

   (30) $\alpha \vee \beta$ ASSERTION

   (31) $\neg\Box_e\alpha \wedge \neg\Box_e\beta$ UNCERTAINTY (from QUANTITY)

   (ii) Possibility derived from uncertainty and quality about assertion

   (32) $\Box_e(\alpha \vee \beta)$ QUALITY ABOUT ASSERTION

   (33) $\Rightarrow \Diamond_e\alpha \wedge \Diamond_e\beta$ POSSIBILITY

2. **Neglect-zero derivation**

   (i) Possibility derived as neglect-zero effect

   (34) $\alpha \vee \beta$ ASSERTION

   (35) $\Diamond_e\alpha \wedge \Diamond_e\beta$ POSSIBILITY (from NEGLECT-ZERO)

   (ii) Uncertainty derived from possibility and scalar reasoning

   (36) $\neg(\alpha \wedge \beta)$ SCALAR IMPLICATURE

   (37) $\Rightarrow \neg\Box_e\alpha \wedge \neg\Box_e\beta$ UNCERTAINTY

The ups and downs of ignorance [Degano et al 2025]


Marco Degano


Paul Marty


Sonia Ramotowska


Yasu Sudo


Jacopo Romoli


Richard Breheny

Degano, M., Marty, P., Ramotowska, S., MA, Sudo, Y., Romoli, J., Breheny, R. The ups and downs of ignorance. *Nat Lang Semantics* 33, 1–41 (2025)

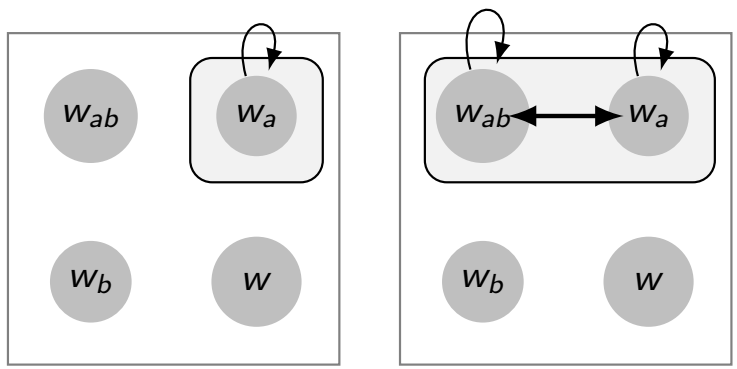
The ups and downs of ignorance [Degano et al 2025]

Contrasting predictions of competing accounts of ignorance

- Neo-Gricean: No possibility without uncertainty
- Neglect-zero: Possibility derived independently from uncertainty

Experimental findings

- Using adapted mystery box paradigm, compared conditions in which
  - both uncertainty and possibility are false [**zero-model**]
  - uncertainty false but possibility true [no-zero, no-uncertain model]
- Less acceptance when possibility is false (95% vs **44%**)
  $\Rightarrow$ Evidence that possibility can arise without uncertainty
- A challenge for the traditional neo-Gricean approach



(a) **zero-model** (b) no-uncertain

Figure: Models for $(a \vee b)$

Conclusions

- FC, ignorance: a mismatch between logic and language
- Grice's insight:
  - stronger meanings can be derived paying more "attention to the nature and importance to the conditions governing conversation"
- Nihil hypothesis: some strengthenings due to cognitive tendencies rather than Gricean reasoning
  - FC, possibility and related inferences as neglect-zero effects

    Literal meanings (classical fragment) + cognitive factor (NZ) $\Rightarrow$ FC, possibility, etc
  - Conjunctive *or*, homogeneity as no-zero + no-split effect

    Literal meanings (classical fragment) + cognitive factors (NZ, NS) $\Rightarrow$ conjunctive *or*, homogeneity
- Implementation in team-based modal logics
- Ignorance experiment: a challenge for Grice and in agreement with Nihil hypothesis
- Tomorrow: More on modelling and experimenting with zero-models

Collaborators & related (future) research


Anttila


Degano


Klochowicz


Knudstorp


Ramotowska


Zhou

& many more . . .

Logic

Proof theory (Anttila, Yang); expressive completeness (Anttila, Knudstorp); bimodal perspective (Knudstorp, Baltag, van Benthem, Bezhanishvili); qBSML (van Ormondt); dynamics (MA); typed BSML (Muskens); connexive logic (Knudstorp, Ziegler & MA); belief revision (Klochowicz)

Language

FC cancellations (Pinton, Hui); modified numerals (vOrmondt); attitude verbs (Yan); conditionals (Flachs, Ziegler); questions (Klochowicz); quantifiers (Klochowicz, Bott, Schlotterbeck); indefinites (Degano); homogeneity (Sbardolini); acquisition (Klochowicz, Sbardolini); experiments (Degano, Klochowicz, Ramotowska, Bott, Schlotterbeck, Marty, Breheny, Romoli, Sudo, Spychalska, Szymanik, Visser); . . .

Thank You![2]

[2]This work is supported by NWO OC project *Nothing is Logical* (grant no 406.21.CTW.023).

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