

Communicative stability and the typology of logical connectives

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Outline

Introduction

Exhaustivity

Anti-exhaustivity

Stability

Summary

Introduction

- ▶ All 12 'meaningful' (non-trivial & non-redundant) binary logical connectives:

	AND	OR	NOR	NAND	XOR	IFF	NOTL	NOTR	ONLYL	ONLYR	→	←
$p \wedge q$	1	1	0	0	0	1	0	0	0	0	1	1
$p \wedge \neg q$	0	1	0	1	1	0	0	1	1	0	0	1
$q \wedge \neg p$	0	1	0	1	1	0	1	0	0	1	1	0
$\neg p \wedge \neg q$	0	0	1	1	0	1	1	1	0	0	1	1

Typological pattern

- ▶ Lexicalization of AND and OR is pervasive and seems to be morphologically simplex.
- ▶ No other connective is ever lexicalized as simplex.
- ▶ NOR sometimes appears to be lexicalized; however, when it does it's morphologically complex and arguably syntactically and semantically complex (Sauerland 2000; Penka 2011; Zeijlstra 2011). For the purposes of this talk we ignore apparent lexicalizations of NOR.

Positivity

- ▶ A major cross-linguistic puzzle:
 - (1) Why are AND and OR the only simple connectives attested in natural language?
- ▶ Most existing accounts of the typological pattern make the following assumption (Horn 1972; Katzir & Singh 2013; Uegaki 2022):
 - (2) **Positivity**: 'Positive' connectives (e.g., AND and OR) are more basic than 'negative' ones (e.g., NAND and NOR).
- ▶ Enguehard & Spector (2021); Incurvati & Sbardolini (2020) highlight the fact that Positivity is stipulative: It assumes what needs to be explained.

Previous accounts

- ▶ Enguehard & Spector aim to replace Positivity with assumptions about how prior probabilities affect communication.
- ▶ However, as pointed out by Züfle & Katzir (2021), in order to completely rule out languages with NAND they would have to assume Positivity after all (see also Kuhn & Pasalskaya 2022).
- ▶ Incurvati & Sbardolini also aim to account for the typological pattern without assuming Positivity, but they rely on specific assumptions about the dynamics of conversation which as far as we can see aren't independently motivated.
- ▶ More importantly, both accounts wrongly predict NOR to be lexicalizable as simplex.

Taking stock

- (3) Why are AND and OR the only simple connectives attested in natural language?
- ▶ All existing accounts are stipulative (specifically, they rely on Positivity) or empirically inadequate (predicting NOR to be lexicalizable as simplex).
 - ▶ **Our goal:** Derive Positivity by building on a property of AND and OR which falls out of an independently needed theory of exhaustivity and communication.

Plan

- ▶ **Exhaustivity:** We will identify a property which sets AND and OR apart from other meaningful connectives within a grammatical theory of scalar implicatures.
- ▶ **Anti-exhaustivity:** We will show that this property has implications within Iterated Rationality Models of communication (IRMs), building on the notion of Anti-exhaustivity from Cremers et al. (2022).
- ▶ **Stability:** We will argue that, as a result, only attested languages are communicatively stable, giving them an advantage over unattested ones.

Structure

	Exhaustivity		Anti-exhaustivity		Stability
AND and OR	succeeds	⇒	blocked	⇒	✓
Other CONs	fails	⇒	possible	⇒	✗

Outline

Introduction

Exhaustivity

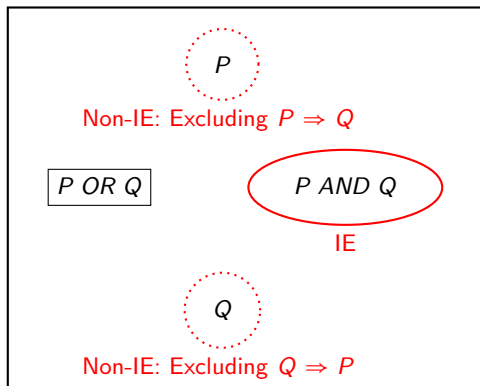
Anti-exhaustivity

Stability

Summary

Innocent Exclusion

- ▶ Following Fox (2007), we assume a covert exhaustivity operator $\mathcal{E}xh$ which negates alternatives that are innocently excludable (IE).
- ▶ Innocent Exclusion aims to avoid arbitrary choices of exclusion.
- ▶ Alternatives are IE (=Innocently Excludable) only if their exclusion does not entail other alternatives.



Excludability of logically independent alternatives (LIAs)

- ▶ Suppose there are three salient propositions:

- (4)
- | | | |
|----|-----------------|----------|
| a. | Penny smiled. | (= P) |
| b. | Quentin smiled. | (= Q) |
| c. | Rachel smiled. | (= R) |

- ▶ Now suppose the following sentence is uttered, where CON is one of the meaningful connectives.

- (5) Penny smiled CON Quentin smiled $P CON Q$

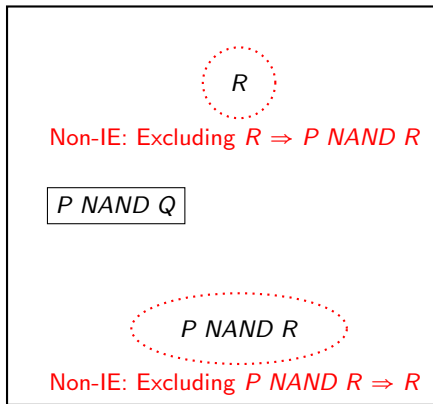
- ▶ Question: Is the logically independent alternative (LIA) R innocently excludable?

Singling out AND and OR

- Whether LIAs are excludable turns out to depend on the identity of the connective (assuming alternatives are derived as in Katzir 2007).

$$(6) \quad \mathcal{E}xh(P \text{ CON } Q) \Rightarrow \neg R \text{ iff } \text{CON} \in \{\text{AND}, \text{OR}\}$$

- For example, R is non-IE given the sentence $P \text{ NAND } Q$:



Singling out AND and OR

Excludability of LIAs

AND and OR are the only meaningful connectives which enable the exclusion of LIAs.

Structure

	Exhaustivity		Anti-exhaustivity		Stability
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Iterated Rationality Models (IRMs)

- ▶ Why should the excludability of LIAs matter?
- ▶ We claim that it matters once we consider the implications of non-excludability of LIAs within a theory of communication based on Iterated Rationality Models (IRMs; Franke 2009; Frank & Goodman 2012; Bergen et al. 2016), due to what Cremers et al. (2022) call **Anti-exhaustivity**.

Expectations and Anti-exhaustivity

- ▶ IRMs have often been used to derive scalar implicatures (SIs).
- ▶ Recent work argued that SIs are grammatically derived, and IRMs should serve as a disambiguation mechanism (see Champollion et al. 2019; Asherov et al. 2021; Fox & Katzir 2021; Cremers et al. 2022).
- ▶ Specifically, Cremers et al. show that, in the absence of grammatical strengthening, IRMs wrongly predict P to sometimes end up having anti-exhaustive meanings, depending on **expectations** (prior probabilities):

(7) Depending on expectations:

- $P \rightsquigarrow \neg Q$ (exhaustive meaning possible)
- $P \rightsquigarrow Q$ (anti-exhaustive meaning possible)

- ▶ This problem disappears once grammatical strengthening is assumed.

(8) Independently of expectations:

- $$\mathcal{E}xh(P) \Rightarrow \neg Q \quad (\text{only exhaustive meaning possible})$$

Anti-exhaustivity with connectives

- ▶ Note that we have shown that $\mathcal{E}xh$ does not always allow for exclusion of LIAs for sentences with connectives: It only does so if the connective at stake is AND or OR.

Excludability of LIAs (reminder)

AND and OR are the only meaningful connectives which enable the exclusion of LIAs.

- ▶ As a result, $\mathcal{E}xh$ can block anti-exhaustivity for AND and OR:

(9) If $CON \in \{AND, OR\}$, then, independently of expectations:
 $\mathcal{E}xh(P \text{ CON } Q) \Rightarrow \neg R$ (only exhaustive meaning possible)

- ▶ But $\mathcal{E}xh$ cannot block anti-exhaustivity for other connectives:

(10) If $CON \notin \{AND, OR\}$, then, depending on expectations:
 a. $\mathcal{E}xh(P \text{ CON } Q) \rightsquigarrow \neg R$ (exhaustive meaning possible)
 b. $\mathcal{E}xh(P \text{ CON } Q) \rightsquigarrow R$
 (anti-exhaustive meaning possible)

Anti-exhaustivity with connectives

- Under the assumption that IRMs affect interpretation, then, we can distinguish between AND/OR and all other meaningful connectives as follows:

Anti-exhaustivity with connectives

$\mathcal{E}xh(P \text{ CON } Q)$ can have both exhaustive and anti-exhaustive meanings (depending on expectations) iff $\text{CON} \notin \{\text{AND}, \text{OR}\}$.

Structure

	Exhaustivity		Anti-exhaustivity		Stability
AND and OR	succeeds	\Rightarrow	blocked	\Rightarrow	✓
Other CONs	fails	\Rightarrow	possible	\Rightarrow	✗

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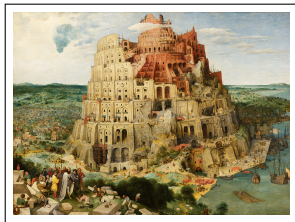
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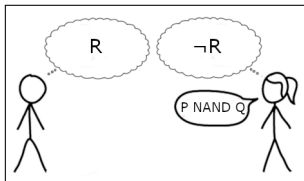
Stability and why it matters

- (11) **Stability:** A **stable** language is a language in which the interpretation of a message is not affected by (speaker's/hearer's) expectations (beliefs about prior probabilities).
- ▶ It is reasonable to think that a stable language would be better for communication than an unstable one because in a stable language there is much less room for miscommunication.
 - ▶ We hypothesize that this, in turn, can affect language change: unstable languages will be filtered out when languages evolve because they are not efficient for communication.



Anti-exhaustivity and instability

- ▶ Due to Anti-exhaustivity, languages with connectives other than AND and OR are **unstable**: Expectations determine whether the interpretation is exhaustive or anti-exhaustive.
 - ▶ Based on certain expectations, a speaker may utter $P \text{ NAND } Q$, expecting the hearer to infer $\neg R$ (exhaustive interpretation).
 - ▶ But a hearer with different expectations may infer R instead (anti-exhaustive interpretation).



Stable languages

- ▶ Languages with AND, OR, or both (but no other connective) are **stable** because in such languages exhaustification blocks anti-exhaustive readings: A hearer will never infer R from P AND/OR Q .

Stability

A language (an inventory of connectives) is stable *iff* it contains no meaningful connectives other than AND and OR.

Structure

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- ▶ We identified a property that distinguishes AND and OR from all other meaningful connectives in terms of **Exhaustivity**:

Excludability of LIAs

AND and OR are the only meaningful connectives which enable the exclusion of LIAs.

- ▶ This property has implications on **Anti-exhaustivity**:

Anti-exhaustivity with connectives

$\mathcal{Exh}(P \text{ CON } Q)$ can have both exhaustive and anti-exhaustive meanings (depending on expectations) *iff* $\text{CON} \notin \{\text{AND}, \text{OR}\}$.

- ▶ This in turn affects **Stability**, providing an account of the typology:

Stability

A language (an inventory of connectives) is stable *iff* it contains no meaningful connectives other than AND and OR.

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