Logic and Conversation: neglect-zero effects at the semantics-pragmatics interface

Maria Aloni

ILLC and Philosophy, University of Amsterdam
M.D.Aloni@uva.nl,
http://www.marialoni.org

In Free Choice (FC) inferences, conjunctive meanings are derived from disjunctive modal sentences contrary to the prescriptions of classical logic:

(1) Deontic FC (Kamp, 1973)
  a. You may go to the beach or to the cinema. $\rightsquigarrow$ You may go to the beach and you may go to the cinema.
  b. $\Diamond(\alpha \vee \beta) \rightsquigarrow \Diamond\alpha \wedge \Diamond\beta$

(2) Epistemic FC (Zimmermann, 2000)
  a. Mr. X might be in Victoria or in Brixton. $\rightsquigarrow$ Mr. X might be in Victoria and he might be in Brixton.
  b. $\Diamond(\alpha \vee \beta) \rightsquigarrow \Diamond\alpha \wedge \Diamond\beta$

Free choice inferences represent a much discussed case of a divergence between logic and language. Grice influentially argued that the assumption that such divergence does in fact exist is a mistake originating "from inadequate attention to the nature and importance of the conditions governing conversation" (Grice 1989: 24). I will first show that when applied to free choice phenomena, the standard implementation of Grice's view, modelling semantics and pragmatics as two separate components, is empirically inadequate. I will then propose a different account: a logic *of* conversation modelling next to literal meanings, also pragmatic factors and the additional enriched meanings that arise from their interaction (Aloni, 2021). The novel hypothesis at the core of this proposal is that FC and related inferences are neither the result of conversational reasoning (as in traditional gricean and neo-gricean approaches), nor the effect of spontaneous optional applications of grammatical operators (as in the grammatical view of scalar implicatures, Chierchia et al, 2011). Rather they are a straightforward consequence of something else speakers do in conversation, namely, when interpreting a sentence they create pictures of the world (Johnson-Laird, 1983) and in doing so they systematically neglect models which verify the sentence by virtue of some empty configuration (*zero-models*). This tendency, which I will call *neglect-zero*, follows from the expected difficulty of the cognitive operation of evaluating truths with respect to empty witness sets (Bott et al, 2019). Findings from number cognition confirm this difficulty, which also explains the special status of the zero among the natural numbers (Nieder, 2016) and why downward-monotonic quantifiers are more difficult to process than upward-monotonic ones (Bott et al, 2019). Encoding the absence of objects rather than their presence empty witnesses are more detached from sensory experience and, therefore, more difficult to conceive. The inference from the perception of absence to the truth of a sentence brings in additional costs, which results in a systematic dispreference for zero-models, a neglect-zero tendency.

In previous work (Aloni, 2021), I showed that the non-emptiness atom (NE) from team semantics (Yang and Väänänen, 2017) provides a perspicuous way to formally represent the neglect-zero tendency and to rigorously study its impact on interpretation. In a team semantics, a formula is interpreted with respect to a set of points of evaluation (a team) rather than a single point. The non-emptiness atom NE is satisfied in a team iff the team is *non-empty*. Aloni (2021) presented a bilateral version of a team-based modal logic (a system called Bilateral State-based Modal Logic (BSML), see appendix for definitions) where, in terms of NE, a pragmatic enrichment function was defined and showed that, in interaction with disjunction[1] occurring in positive contexts and only in these cases, pragmatic enrichment yields non-trivial effects including predicting FC inferences (also cases of Wide Scope FC) and their cancellation under negation as in (3).

(3) Dual Prohibition (Alonso-Ovalle, 2006)

a. You are not allowed to eat the cake or the ice cream.
$\rightsquigarrow$ You are not allowed to eat either one.

b. $\neg\Diamond(\alpha \vee \beta) \rightsquigarrow \neg\Diamond\alpha \wedge \neg\Diamond\beta$

The latter result relies on the adopted bilateralism, where each connective comes with an assertion and a rejection condition and negation is defined in terms of the latter notion.

In this paper, I will compare the characterisation of neglect-zero effects in terms of NE studied in Aloni (2021) (which I will call BSML$^+$) with an alternative model-theoretic characterisation, which globally rules out zero-models from the set of possible teams (which I will call BSML*). The two characterisations differ in their predictions with respect to the debated cases of Negative FC, which results valid in BSML* but not in BSML$^+$:

(4) Negative FC

a. It is not required that Mia buys apples and bananas. $\rightsquigarrow$ It is not required that Mia buys apples and that Mia buys bananas

b. $\neg\Box(\alpha \wedge \beta) \rightsquigarrow \neg\Box\alpha \wedge \neg\Box\beta$

Experiments reported by Marty et al (2021) attest that negative FC inferences are real but far less robust than plain FC inferences. I will conjecture an explanation of these experimental findings in term of different impacts neglect-zero can have on linguistic interpretation: neglect-zero can lead to (i) global and cancellable pragmatic effects modeled by BSML*, which derive negative FC and ignorance inferences of plain disjunction, as in (5); but we can also have (ii) more robust effects resulting from local *lexicalisations* of the neglect-zero ten-

[1] In team semantics, a team s supports a disjunction $\phi \vee \psi$ iff s is the union of (can be split into) two substates, each supporting one of the disjuncts.

dency modeled by obligatory NE-enrichments triggered by specific lexical items, for example modal verbs. These lexicalisations would explain the robustness of the FC inference triggered by certain verbs, but also the obligatory ignorance effects we observe in epistemic indefinites (Alonso-Ovalle and Menéndez-Benito, 2015; Aloni and Port, 2015) and possibly other phenomena in the nominal domain (e.g., the existential imports operative in the logic of Aristoteles, i.e., the inference from *Every A is B* to *Some A is B*).

(5) Ignorance (plain disjunction)

a. John has two or three children. (Guess how many!)
$\rightsquigarrow$ Maybe two, maybe three

b. $\alpha \vee \beta \rightsquigarrow \Diamond\alpha \wedge \Diamond\beta$ [epistemic $\Diamond$]

(6) Ignorance (epistemic indefinites, German)

a. *Irgendein* Student hat angerufen. #Rat mal wer?
Irgend-one student has called guess prt who?

b. Conventional meaning: Some student called – the speaker doesn't know who

(7) Ignorance (epistemic indefinites, Italian)

a. Maria ha sposato *un qualche* professore. #Indovina chi?
Maria has married a qualche professor guess who?

b. Conventional meaning: Maria married some professor – the speaker doesn't know who

The discussion will lead us to the identification of at least three different systems which, I conjecture, correspond to different interpretation strategies or reasoning styles people may adopt in different circumstances (ordinary conversation vs the context of a mathematical proof):

- BSML^-: the NE-free fragment of BSML equivalent to classical modal logic, modelling logical-mathematical reasoning where neglect-zero effects are obviated;
- BSML^{lex}: modelling conventional meanings including lexicalisations of neglect-zero effects in modal and nominal domains;
- BSML^*: modelling global, purely pragmatic neglect-zero effects.

		BSML^-	BSML^{lex}	BSML^*
Positive FC	$\Diamond(\alpha \vee \beta) \models \Diamond\alpha \wedge \Diamond\beta$	-	+	+
Dual Prohibition	$\neg\Diamond(\alpha \vee \beta) \models \neg\Diamond\alpha \wedge \neg\Diamond\beta$	+	+	+
Negative FC	$\neg\Box(\alpha \wedge \beta) \models \neg\Box\alpha \wedge \neg\Box\beta$	-	-	+
Ignorance (disjunction)	$\alpha \vee \beta \models \Diamond\alpha \wedge \Diamond\beta$	-	-	+

Table 1. Comparison BSML^-, BSML^{lex} and BSML^*.

Appendix: Bilateral State-based Modal Logic (BSML)

Definition 1 (Language). *Let A be a set of propositional letters.*

$$\phi := p \mid \neg\phi \mid \phi \wedge \phi \mid \phi \vee \phi \mid \Diamond\phi \mid \text{NE}$$

where $p \in A$.

A Kripke model for L is a triple $M = \langle W, R, V \rangle$, where W is a set of worlds, R is an accessibility relation on W and V is a world-dependent valuation function for A.

Formulas in our language are interpreted in models M with respect to a state $s \subseteq W$ (in BSML*, we have the additional assumption that $s \neq \emptyset$).

Definition 2 (Semantic clauses).

$$\begin{aligned}
M, s \models p \quad & \textit{iff} \quad \forall w \in s : V(w, p) = 1 \\
M, s \mathrel{=\!\!|} p \quad & \textit{iff} \quad \forall w \in s : V(w, p) = 0 \\
M, s \models \neg\phi \quad & \textit{iff} \quad M, s \mathrel{=\!\!|} \phi \\
M, s \mathrel{=\!\!|} \neg\phi \quad & \textit{iff} \quad M, s \models \phi \\
M, s \models \phi \vee \psi \quad & \textit{iff} \quad \exists t, t' : t \cup t' = s \;\&\; M, t \models \phi \;\&\; M, t' \models \psi \\
M, s \mathrel{=\!\!|} \phi \vee \psi \quad & \textit{iff} \quad M, s \mathrel{=\!\!|} \phi \;\&\; M, s \mathrel{=\!\!|} \psi \\
M, s \models \phi \wedge \psi \quad & \textit{iff} \quad M, s \models \phi \;\&\; M, s \models \psi \\
M, s \mathrel{=\!\!|} \phi \wedge \psi \quad & \textit{iff} \quad \exists t, t' : t \cup t' = s \;\&\; M, t \mathrel{=\!\!|} \phi \;\&\; M, t' \mathrel{=\!\!|} \psi \\
M, s \models \Diamond\phi \quad & \textit{iff} \quad \forall w \in s : \exists t \subseteq R[w] : t \neq \emptyset \;\&\; M, t \models \phi \\
M, s \mathrel{=\!\!|} \Diamond\phi \quad & \textit{iff} \quad \forall w \in s : M, R[w] \mathrel{=\!\!|} \phi \\
M, s \models \text{NE} \quad & \textit{iff} \quad s \neq \emptyset \\
M, s \mathrel{=\!\!|} \text{NE} \quad & \textit{iff} \quad s = \emptyset
\end{aligned}$$

On the intended interpretation $M, s \models \phi$ stands for 'formula ϕ is assertable in s' and $M, s \mathrel{=\!\!|} \phi$ stands for 'formula ϕ is rejectable in s', where s stands for the information state of the relevant speaker. $R[w]$ refers to the set $\{v \in W \mid wRv\}$.

We adopt the following abbreviation: $\Box\phi := \neg\Diamond\neg\phi$, and therefore derive the following interpretation for the necessity modal:

$$\begin{aligned}
M, s \models \Box\phi \;\; & \text{iff} \;\; \text{for all } w \in s : R[w] \models \phi \\
M, s \mathrel{=\!\!|} \Box\phi \;\; & \text{iff} \;\; \text{for all } w \in s : \text{there is a } t \subseteq R[w] : t \neq \emptyset \;\&\; t \mathrel{=\!\!|} \phi
\end{aligned}$$

Logical consequence is defined as preservation of support.

Definition 3 (Logical consequence).
$\phi \models \psi$ *iff for all* $M, s : M, s \models \phi \;\Rightarrow\; M, s \models \psi$

The pragmatic enrichment function is recursively defined for formulas in the NE-free fragment of the language (denoted by α and β) as follows:

Definition 4 (Pragmatic enrichment function).

$$\begin{aligned}
[p]^+ &= p \wedge \textsc{ne} \\
[\neg\alpha]^+ &= \neg[\alpha]^+ \wedge \textsc{ne} \\
[\alpha \vee \beta]^+ &= ([\alpha]^+ \vee [\beta]^+) \wedge \textsc{ne} \\
[\alpha \wedge \beta]^+ &= ([\alpha]^+ \wedge [\beta]^+) \wedge \textsc{ne} \\
[\Diamond\alpha]^+ &= \Diamond[\alpha]^+ \wedge \textsc{ne}
\end{aligned}$$

A conservative extension of BSML instead has been recently axiomatised by Anttila (2021).

Bibliography

Aloni M (2021) Logic and conversation: the case of free choice, manuscript, University of Amsterdam

Aloni M, Port A (2015) Epistemic indefinites and methods of identifications. In: Alonso-Ovalle L, Menéndez-Benito P (eds) Epistemic Indefinites, Oxford University Press

Alonso-Ovalle L (2006) Disjunction in alternative semantics. PhD thesis, University of Massachusetts, Amherst

Alonso-Ovalle L, Menéndez-Benito P (2015) Epistemic Indefinites. Oxford University Press

Anttila A (2021) The logic of free choice. axiomatizations of state-based modal logics. Master's thesis, ILLC, University of Amsterdam

Bott O, Schlotterbeck F, Klein U (2019) Empty-set effects in quantifier interpretation. Journal of Semantics 36:99–163

Chierchia G, Fox D, Spector B (2011) The grammatical view of scalar implicatures and the relationship between semantics and pragmatics. In: Maienborn C, von Heusinger K, Portner P (eds) Semantics. An International Handbook of Natural Language Meaning, de Gruyter

Grice HP (1989) Studies in the Way of Words. Harvard University Press

Johnson-Laird PN (1983) Mental Models. Cambridge University Press

Kamp H (1973) Free choice permission. Proceedings of the Aristotelian Society 74:57–74

Marty P, Romoli J, Sudo Y, Breheny R (2021) Negative free choice. Semantics & Pragmatics 14(13), URL https://semprag.org/index.php/sp/article/view/sp.14.13/pdf

Nieder A (2016) Representing something out of nothing: The dawning of zero. Trends in Cognitive Sciences 20:830–842

Yang F, Väänänen J (2017) Propositional team logics. Annals of Pure and Applied Logic 168:1406–1441

Zimmermann E (2000) Free choice disjunction and epistemic possibility. Natural Language Semantics 8:255–290