Logicality and Natural Language

Gil Sagi

University of Haifa

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An empirical phenomenon, the subject matter of current semantic theory

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An empirical phenomenon, the subject matter of current semantic theory

What is meant by Logic *in* Natural Language?

Is there a relation satisfying the criterion of invariance under isomorphisms that is modeled by current semantic theory?

Structure of Argument

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    1. Rebutting the arguments

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    1. Semantic constraints are an adequate representation of theories in formal semantics.

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    2. Invariance criteria for logicality can be defined in the framework. (*BSL* 2022)
3. Application to natural language (*Phil Studies* 2024):
    1. Semantic constraints are an adequate representation of theories in formal semantics.
    2. Using invariance under isomorphisms as a criterion for logicality and Glanzberg's theory of explanation and partiality in semantic theory (2014), the result is that theories of natural language semantics *are* theories of logical consequence in natural language.

Glanzberg

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Glanzberg: The logic in natural language thesis is *false* (assuming a restrictive notion of logic).

The Argument from Absolute Semantics

a. $[\![\mathit{Ann}]\!] = \mathit{Ann}$
b. $[\![\mathit{smokes}]\!] = \lambda x \in D_e : x \ \mathit{smokes}$

[Chierchia and McConnell-Ginet 2000; Heim and Kratzer 1998]

The Argument from Lexical Entailment

a. We loaded the truck with hay.
ENTAILS
We loaded hay on the truck.

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$$(\wedge)\text{: } I(\varphi \wedge \psi) = T \Leftrightarrow I(\varphi) = T \text{ and } I(\psi) = T$$

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allRed, *allGreen*

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$$I(allRed) \cap I(allGreen) = \emptyset$$

- $I(\text{Ann}) = \text{Ann}$
- $I(\text{smokes})$ = $\lambda x \in D.\ x$ smokes
- $I(\text{most}) = \{\langle A, B\rangle \in \mathcal{P}(D)^2 : |A \cap B| > |A \backslash B|\}$
- $I(even) \cap I(odd) = \emptyset$
- $I(bachelor) \subseteq I(unmarried)$
- $I(H_2O) = I(water)$
- $I(wasBought) = I(wasSold)$
- $I(\exists) = \{A \subseteq D : A \neq \emptyset\}$
- $I(\forall) \in \{\{B \subseteq D : A \subseteq B\} : A \subseteq D\}$
- $I(R)$ is a symmetric binary relation.
- $0 \in I(naturalNumber)$
- $I(prime) = \{2, 3, 5, ...\}$
- $|I(Red)| = 375$ (i.e., the size of the extension of *Red* is 375.)

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- $I(P) \subseteq D$
- $I(John) \in D$
- $I(abc) = T$ or $I(abc) = F$
- $I(d) \neq I(\wedge)$
- $I(or) \in \{f_\vee, f_{\underline{\vee}}\}$ where $f_\vee$ is the inclusive or function, and $f_{\underline{\vee}}$ is the xor function from pairs of truth values to truth values.

The Language and its Models

Language

- Primitive expressions (*terms*)
- Complex expressions (*phrases*)

Models

$M = \langle D, I \rangle$

- D (the domain) is a non-empty set.
- I (the interpretation function) assigns to phrases values from the set-theoretic hierarchy with the members of $D \cup \{T, F\}$ as ur-elements.

Semantic Constraints

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Let Δ be a set of semantic constraints. A *Δ-model* is an *admissible model* by Δ, i.e. a model abiding by the constraints in Δ.

Logical Consequence

Let Δ be a set of constraints.

An argument $\langle \Gamma, \varphi \rangle$ is *Δ-valid* ($\Gamma \models_\Delta \varphi$) if for every Δ-model M, if all the sentences in Γ are true in M, then φ is true in M.

Criteria for Logicality

Invariance under isomorphism

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$O_{\forall}(D) = \{D\}$

$O_{\exists_{\aleph_0}}(D) = \{A \subseteq D : \ |A| \geq \aleph_0\}$

Criteria for Logicality

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As a criterion for logical terms:

Let $M = \langle D, I \rangle$ and $M' = \langle D', I' \rangle$ be models, and let $f : D \to D'$ be a bijection.

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Definition (invariance under isomorphisms: terms)

A term t is *invariant under isomorphisms* if for any sets D and D' and a bijection $f : D \to D'$, $f^+(O_t(D)) = O_t(D')$.

Invariance under Isomorphisms and Semantic Theory

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Invariance under isomorphisms as a criterion for logicality: is this mathematical property representative of a linguistic distinction?

Invariance under Isomorphisms and Semantic Theory

Logical terms in natural language

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There aren't: [Harman, 1984, Lycan, 1984]

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There are: [Fox, 2000, Gajewski, 2002, Fox and Hackl, 2006]

Generalizing the function/content distinction

Are function words limited to expressing permutation-invariant items? I'd say no. The clearest case is perhaps that of gender features (and more generally class agreement markers).

(37)

a. i. $||\text{fem}|| = \lambda x_e$: female($x_e$). x_e $||\text{male}|| = \lambda x_e$: male($x_e$). x_e.
   ii. $||\text{ragazz-a}|| = \lambda x_e$: fem($x_e$). young adult($x_e$)
   iii. $||\text{ragazz-o}|| = \lambda x_e$: male($x_e$). young adult($x_e$)

b. $\forall$x [female(x) $\rightarrow$ $\neg$male(x)]

Use of features of this sort induces disjointness constraints such as (37b), which are among the most common across languages. This seems to require an extension of what counts as 'logical' to constraints that define 'subcategories' of various content words. [Chierchia, 2021, p. 247]

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Definition (isomorphic models)

We say that $M = \langle D, I\rangle$ is *isomorphic* to $M' = \langle D', I'\rangle$ ($M \cong M'$) if there is a bijection $f : D \to D'$ such that $f^{+}(I(p)) = I'(p)$ for every phrase p in L.

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Definition (invariance under isomorphism: semantic constraints)

A semantic constraint C is *invariant under isomorphisms* if for any models M and M' such that $M \cong M'$, then if M is a $\{C\}$-model, then M' is a $\{C\}$-model.

(*cf.* [Zimmermann, 2011])

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- $I(John) \in I(Bachelor)$
- $I(s) = T$
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The following constraints are not invariant under isomorphisms:

- $0 \in I(naturalNumber)$
- $I(prime) = \{2, 3, 5, ...\}$
- $I(Even) \cap I(Prime) = \{2\}$
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Invariance under isomorphism: terms and constraints

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Example:

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Proposition. Let t be a term, O_t an associated operation and C_t an associated constraint. Then t is invariant under isomorphisms iff C_t is invariant under isomorphisms.

Can we apply the generalized criterion of invariance under isomorphisms to natural language semantics, and in this way demarcate the relation of logical consequence in natural language?

Partiality in Semantic Theory

[S]emantics, narrowly construed as part of our linguistic competence, is only a partial determinant of content. Likewise, semantic theories in linguistics function as partial theories of content. I shall go on to offer an account of where and how this partiality arises, which focuses on how lexical meaning combines elements of distinctively linguistic competence with elements from our broader cognitive resources. This account shows how we can accommodate some partiality in semantic theories without falling into skepticism about semantics or its place in linguistic theory.
(Glanzberg, 2014)

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> *[T]he use of disquotation in semantic theories precisely marks the places where they lose their explanatory force. Insofar as disquotation plays an ineliminable role in building theories of content, semantic theories can be at best partial theories of content... [D]isquotation is a guide to where linguistic meaning contains pointers to extra-linguistic elements of content. (Glanzberg, 2014)*

Separating the Explanatory from the Non-Explanatory

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Logical Consequence in Natural Language

The generalized criterion of invariance under isomorphisms: A semantic constraint is logical if it is invariant under isomorphisms.

Logical Consequence in Natural Language

The generalized criterion of invariance under isomorphisms: A semantic constraint is logical if it is invariant under isomorphisms.

Conjecture: The *logic of natural language* is precisely the explanatory part of semantic theory for natural language.

Refined Criterion for Logicality

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A connective is a logical connective if and only if it follows from the meaning of the connective that it is invariant under arbitrary bijections. [McGee, 1996, p. 578]

Refined Criterion for Logicality

A semantic constraint is a logical semantic constraint if and only if it follows from the meaning of the terms in the semantic constraint that it is invariant under arbitrary bijections. *Cf. [McGee 1996, p. 578]*

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A semantic constraint is a logical semantic constraint if and only if it follows from the semantic theory for the language and it is invariant under arbitrary bijections. *Cf. [McGee 1996, p. 578]*

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A semantic constraint is a logical semantic constraint if and only if it follows from the semantic theory for the language and it is invariant under arbitrary bijections. Cf. [McGee 1996, p. 578]

Thank you!

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The Argument from Lexical Entailment

John cut the bread.
ENTAILS
The bread was cut with an instrument.

The Argument from Logical Constants

$[\![most]\!](A, B) \Leftrightarrow |A \setminus B| < |A \cap B|$

The Argument from Logical Constants

a. Local: $[\![most]\!]_M = \{\langle A, B\rangle \in M^2 : |A \backslash B| < |A \cap B|\}$

b. Global: function from M to $[\![most]\!]_M$

Back to main