Logicality and Semantic Theory

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The Concept of Logical Consequence

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All Greeks are human
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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?

Logic as Model

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A formal language with its syntax and semantics can be used to *model* logical consequence in natural language. [Shapiro, 1998]

Outline

Glanzberg

[T]he logic in natural language thesis: A natural language, as a structure with a syntax and a semantics, thereby determines a logical consequence relation. (Glanzberg, 2015)

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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. $[\![Ann]\!] = Ann$
b. $[\![smokes]\!] = \lambda x \in D_e : x\ smokes$

[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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ENTAILS
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b. We loaded hay on the truck.
DOES NOT ENTAIL
We loaded the truck with hay.

The Argument from Lexical Entailment

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

The Argument from Logical Constants

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

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 $[\![most]\!]_M$

Glanzberg

[W]e only get to logic proper by a significant process of identification, abstraction, and idealization. We first have to identify what in a language we will count as logical constants. After we do, we still need to abstract away from the meanings of non-logical expressions, and idealize way from a great many features of languages to isolate a consequence relation. This process takes us well beyond what we find in a natural language and its semantics. We can study logic by thinking about natural language, but this sort of process shows that we will need some substantial extra-linguistic guidance to—some substantial idea of what we think logic is supposed to be—to do so. We do not get logic from natural language all by itself. (Glanzberg, 2015)

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?

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Logical terms in natural language

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

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allRed, *allGreen*

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$$I(allRed), \qquad I(allGreen)$$

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- $I(or) \in \{f_\vee, f_{\veebar}\}$ where $f_\vee$ is the inclusive or function, and $f_{\veebar}$ 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 such as those mentioned above.

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.

So, for instance we have:

$bachelor(John) \models_\Delta unmarried(John)$.

Criteria for Semantic Constraints

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Examples: $O_{\exists}(D) = \{A \subseteq D : A \neq \emptyset\}$

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

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

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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 $f : D \rightarrow D'$ be a bijection.

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

f can be naturally extended to f^+ over elements in the set-theoretic hierarchy over $D \cup \{T, F\}$ and $D' \cup \{T, F\}$.

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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 $f : D \to D'$, $f^+(O_t(D)) = O_t(D')$.

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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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- $I(John) \in I(Bachelor)$
- $I(s) = T$
- $I(\exists) = \{A \subseteq D : A \neq \emptyset\}$
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The following constraints are not invariant under isomorphisms:

- $0 \in I(naturalNumber)$
- $I(prime) = \{2, 3, 5, ...\}$
- $I(Even) \cap I(Prime) = \{2\}$
- $I(\text{Ann}) = \text{Ann}$
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$$C_= : \quad I(=) = \{\langle a, a\rangle : a \in D\}$$

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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)*

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- - $I(\text{most}) = \{\langle A, B\rangle \in \mathcal{P}(D)^2 :\ |A \cap B| > |A \setminus B|\}$

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

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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 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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