The History of Formal Semantics

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IITP RAS, Moscow, July 3, 2015

1. Introduction

- Formal semantics and formal pragmatics as they have developed over the last 50 years have been shaped by fruitful interdisciplinary collaboration among linguists, philosophers, and logicians, also interacting with cognitive science and computational linguistics.
- As part of a larger project on the history of formal semantics, in this talk I'll emphasize aspects of the pre-history and history of formal semantics that concern the relation between language and logic.
- There have been centuries of study of logic and of language. And until the late 19th century, the disciplines of logic, psychology and linguistics were not yet separated, and issues of logic, thought, and language were often discussed together and closely intertwined.
- Today I'll trace some of the history of these issues, including the history of claims that "natural language has no logic", and how joint work of linguists, logicians, and philosophers have taken that claim from a majority opinion to a minority opinion.
- Caveat: This talk has a "Western" bias.

"Semantics" can mean many different things

- "Semantics" traditionally meant quite different things to linguists, philosophers, and psychologists since different fields have different central concerns and different methodologies.
  - Philosophers have long been concerned with truth and reference, with logic, with compositionality, with how meaning is connected with thought, with the analysis of philosophically important terms.
  - Linguists influenced by Chomsky care about what's "in the head" of a speaker of a language, and how it's acquired.
  - Psychologists have experimentally studied concept discrimination, concept acquisition, emphasis on lexical level.
  - Syntax has influenced linguists' notions of "logical form"; 'structure' of meaning suggests 'tree diagrams' of some sort.
  - Logicians build formal systems, axioms, model theoretic interpretation. 'Structure' suggests inferential patterns or algebraic structures.

The principal sources of formal semantics

Formal semantics has roots in several disciplines, most importantly logic, philosophy, and linguistics.

The most important figure in its history was Richard Montague (1930-1971), whose seminal works date from the late 1960's and beginning of the 1970's.

There were of course many other important contributors; not all will get their fair treatment today, just because the story is too big and time is too short.

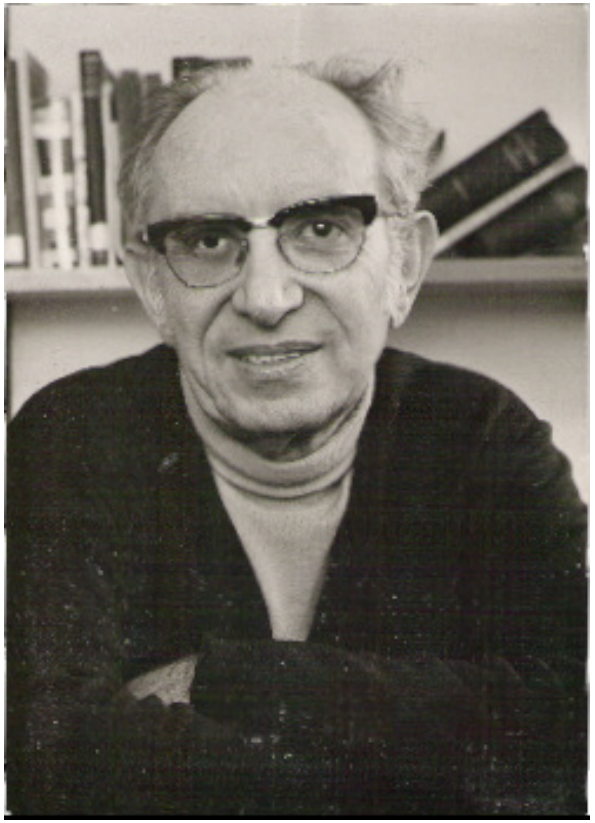
-- Now let me back up to some pre-history.

2. Semantics in linguistics

- **Before *Syntactic Structures (1957)* --**
- In the 19th century linguistics existed within philology in Europe and in large part within anthropology in the U.S.
- In the 20th century, like so many other fields, linguistics emerged as a science. Part of the Chomskyan revolution was to view linguistics as a branch of psychology (cognitive science).
- There were negative attitudes to semantics in American linguistics in the 20th century, partly influenced by logical positivism and by behaviorism in psychology. Neglect of semantics in early American linguistics also because of fieldwork tradition: start with phonetics, then phonology, then morphology, occasionally a little syntax …
- Semantics in logic and philosophy of language: much progress, but relatively unknown to most linguists.

Semantics in linguistics, *cont'd.*

- 1954: Yehoshua Bar-Hillel wrote an article in *Language* inviting cooperation between linguists and logicians, arguing that advances in both fields would seem to make the time ripe for an attempt to combine forces to work on syntax and semantics together.
- He was arguing against logicians who considered natural language too unruly to formalize, and appealing to linguists to make use of some of the logicians' methods.



Semantics in linguistics, *cont'd.*

- 1955: Chomsky, then a Ph.D. student, wrote a reply in *Language* arguing that the artificial languages invented by logicians were so unlike natural languages that the methods of logicians had no chance of being of any use for linguistic theory. (Chomsky and Bar-Hillel remained friends.)
- Bar-Hillel didn't give up, though. In 1967 he wrote to Montague, after receipt of one of Montague's papers: "It will doubtless be a considerable contribution to the field, though I remain perfectly convinced that without taking into account the recent achievements in theoretical linguistics, your contribution will remain one-sided."
- Also in 1967, during the 3rd Intl. Congress for Logic, Methodology and Philosophy of Science, Bar-Hillel organized a symposium in Amsterdam on 'The Role of Formal Logic in the Evaluation of Argumentation in Natural Languages', with Katz, Montague, Hintikka, Max Black, Staal, Stenius, Lyons, Dummett, others …
- But back to our history …

Chomsky's *Syntactic Structures* (1957)

- Chomsky concentrated on the native speaker's ability to produce and understand a potentially infinite class of sentences.
- His conclusion: linguistic competence must involve some finite description of an infinite class of sentences.
- His formulation of the goals of linguistic theory revolutionized the field.
- Chomsky has been ambivalent about semantics.
- He has been skeptical about the possibility of including semantics in a formal grammar, and has insisted on the "autonomy of syntax".
- But he has held that one test of a syntactic theory is that it should provide a basis for a good semantics (if only we had any idea how to study semantics).

Chomsky and semantics

- He argued early on that deep structure reveals semantically relevant structure that is obscured in surface structure.

(1) a. John is easy to please (surface structure)

b. (for someone) to please John is easy (deep structure)

- From *Syntactic Structures,* p.93: In proposing that syntactic structure can provide a certain insight into problems of meaning and understanding we have entered onto dangerous ground. There is no aspect of linguistic study more subject to confusion and more in need of clear and careful formulation than that which deals with the points of connection between syntax and semantics. The real question that should be asked is: "How are the syntactic devices available in a given language put to work in the actual use of this language?"

Semantics in early generative grammar: Katz & Fodor

- Katz and Fodor (early 60's) added a semantic component to generative grammar. They addressed the Projection Problem, i.e. compositionality: how to get the meaning of a sentence from meanings of its parts.
- At that time, "Negation" and "Question Formation" were transformations of declaratives: prime examples of meaning-changing transformations.
- So meaning depended on the entire transformational history. "P-markers" were extended to "T-markers", to which semantic Projection rules applied.
- Katz and Fodor's idea of computing the meaning on the basis of the whole T-marker can be seen as aiming in the same direction as Montague's derivation trees.

- (2a) [The airplanes [will [fly]]] (deep structure)

  $\Rightarrow_{\text{T-NEG}}$ (2b) [The airplanes [will not [fly]]]

- (3) T-marker for (2b) includes P-marker for its deep structure (2a) plus a graph showing what transformations have been applied in its derivation.

Katz & Fodor, *cont'd.*

- But their semantics was very primitive. Katz and Fodor worked with "semantic features", and their semantic representations were "bundles of features" – suitable at best for decompositions of one-place predicates.
- Quine (1970):"Logic chases truth up the tree of grammar"; Katz and Fodor's position might be characterized: "Semantic projection rules chase semantic features up the tree of grammar."
- What they were trying to capture had nothing to do with truth-conditions, but rather properties like ambiguity, synonymy, anomaly, analyticity, characterized in terms of 'how many readings' a sentence has, whether two sentences 'share a reading', etc.

Philosophers' reactions to linguists' "semantic representations"

David Lewis (1970, p.1):

- "But we can know the Markerese translation of an English sentence without knowing the first thing about the meaning of the English sentence: namely, the conditions under which it would be true. Semantics with no treatment of truth conditions is not semantics."
- "Translation into Markerese is at best a substitute for real semantics, relying either on our tacit competence (at some future date) as speakers of Markerese or on our ability to do real semantics at least for the one language Markerese."

Philosophers' reactions to linguists' "semantic representations", *cont'd*.

- But linguists *did* presuppose tacit competence in Markerese; they took it – or some kind of representation language -- to be universal and innate, and many still do (e.g. Jackendoff; also Jerry Fodor).
- To philosophers and logicians doing formal semantics, the language of Markerese looked empty, since it was uninterpreted.
- To linguists in 1970, concern with *truth* looked puzzling. Linguists were trying to figure out mental representations that would underlie linguistic competence. "Actual truth" was (correctly) considered irrelevant, and truth *conditions* were not really understood.
- When the linguistic relevance of truth conditions finally penetrated (later), the very nature of linguistic semantics changed – not just in terms of the tools used, but also in the questions asked and the criteria of adequacy for semantic analyses.

From *Syntactic Structures* to *Aspects*: Katz & Postal

- In a theoretically important move, separable from the "Markerese" issue, and related to the problem of compositionality, Katz and Postal (1964) made the innovation of putting such morphemes as Neg and a Question morpheme Q into the Deep Structure, as in (4), arguing that there was independent syntactic motivation for doing so, and then the meaning could be determined on the basis of Deep Structure alone.
- (4) a. [NEG [Mary [has [visited Moscow]]]] $\Rightarrow_{\text{T-NEG}}$
  [Mary [has not [visited Moscow]]]

  b. [Q [Mary [has [visited Moscow]]]] $\Rightarrow_{\text{T-Q}}$
  [Has [Mary [visited Moscow]]]

Katz and Postal

Paul Postal (b. 1936)

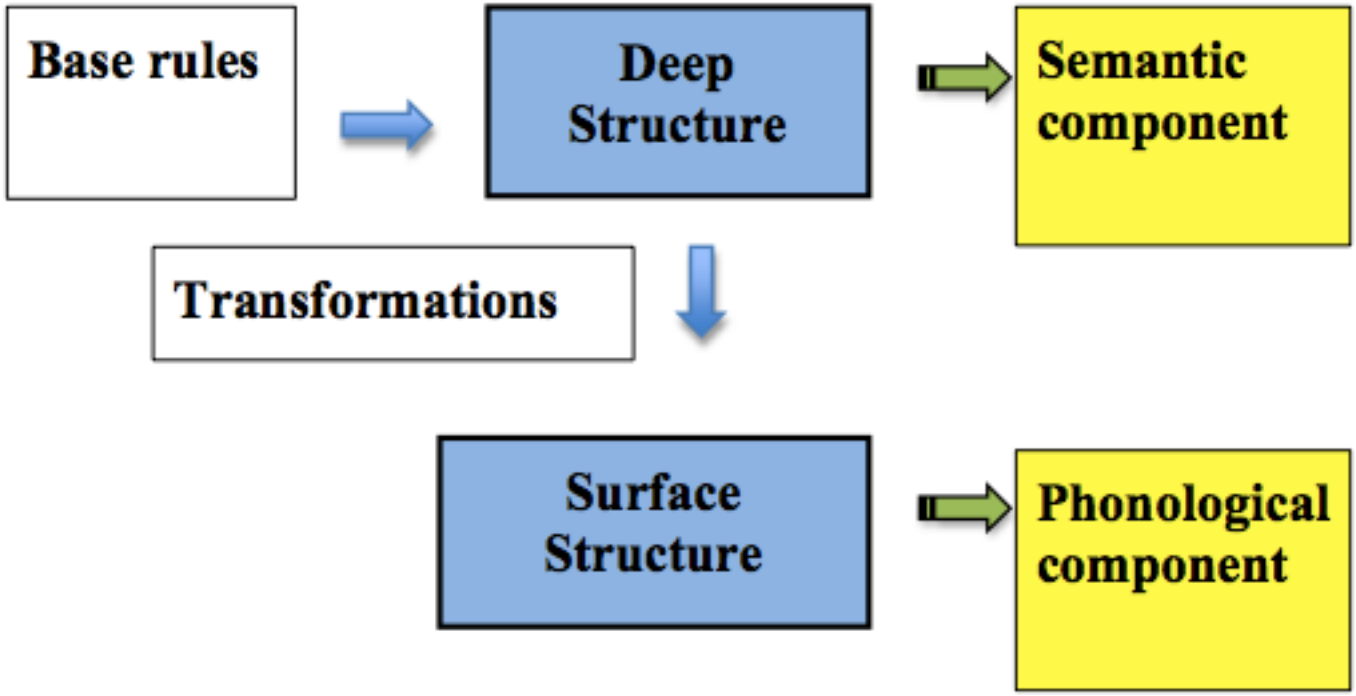
Jerrold Katz (1932 – 2002)

From *Syntactic Structures* to *Aspects*: Katz & Postal, *cont'd.*

- This led to a beautiful architecture, which Chomsky laid out in his *Aspects of the Theory of Syntax* (1965).
- Phrase structure rules generate Deep Structures.
- Deep Structure is the input to semantics.
- Transformations map Deep Structure to Surface Structure.
- Surface Structure is the input to phonology.

Chomsky 1965 – Aspects of the Theory of Syntax

Architecture of the theory:



Katz & Postal and *Aspects*: the Garden of Eden period

- This big change in architecture rested on Katz and Postal's claim that transformations should be meaning-preserving.
- It was an interesting and provocative claim, and even without any 'real semantics' at the foundation, it led to interesting debates.
- And the architecture of the theory, with syntax mediating between semantics and phonology, was elegant and attractive.
- Chomsky in *Aspects* (1965) had added to the elegance of the architecture by combining all the 'kernel' sentences underlying a sentence into a single Deep Structure.
- During the brief period when *Aspects* held sway, there was a rosy optimism that the form of syntactic theory was more or less understood and we could start trying to figure out the "substantive universals".

Garden of Eden period, *cont'd.*

- In that period, roughly the mid-60's, before the linguistic wars broke out in full force, I think generative grammarians generally believed the Katz and Postal hypothesis.
- The idea that meaning was determined at this "deep" level was undoubtedly part of the appeal of the notion of Deep Structure beyond linguistics (cf. Leonard Bernstein's Norton Lectures, *The Unanswered Question*) and probably contributed to the aura surrounding the notion of "language as a window on the mind."
- So around 1965, there was very widespread optimism about the Katz-Postal hypothesis that semantic interpretation is determined by deep structure, and the syntax-semantics interface was believed to be relatively straightforward (even without having any really good ideas about the nature of semantics.)

Expulsion from Garden of Eden and the roots of the linguistic wars

- What upset that lovely view? Linguists discovered quantifiers! Transformations that preserved meaning (more or less) when applied to names clearly did not when applied to some quantifiers.
- "Equi-NP Deletion"
  - With names: John wants John to win ⇒ John wants to win.
- But: Everyone wants everyone to win ⇒ Everyone wants to win ??
- This and similar problems led to the well-known Linguistic Wars between Generative Semantics and Interpretive Semantics. Slightly caricaturing, Generative Semanticists put "logical form" first, insisting on semantically interpretable deepest structures, whereas the Interpretive Semanticists put "linguistic form" first, insisting on an autonomous syntax.
- So with the battles of the late 60's and early 70's raging in linguistics, let's turn to philosophy and logic.

3. Semantics in Logic and Philosophy

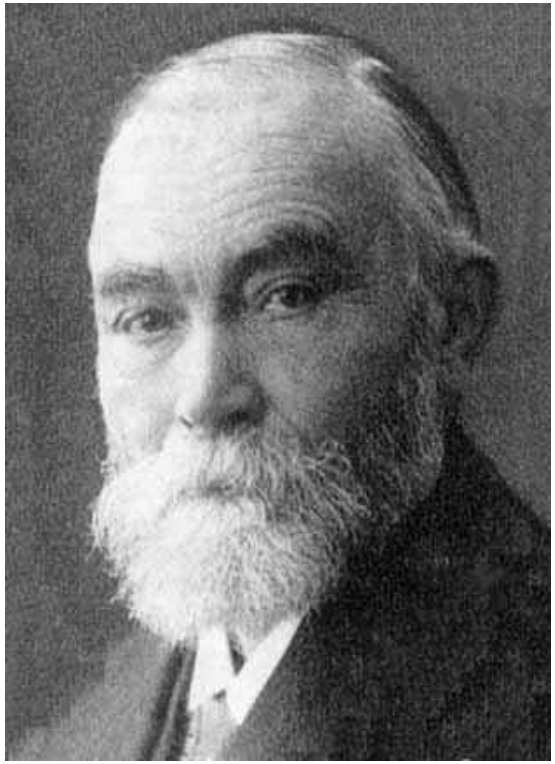
- The relevant history in philosophy goes back at least to Aristotle, but for today I'll start with just brief mentions of Descartes and Leibniz before turning to the central figures of the 19th and 20th centuries.
- The history of the formally oriented approach towards the philosophy of language goes back at least to Rene Descartes (1596-1650) and Gottfried Leibniz (1646-1716). [Cocchiarella 1997]
- Descartes, like the medieval speculative grammarians, believed that underlying all speech there exists a *lingua universalis*, but what it represented was the form of human reason and not the nature of things in the world.
- Leibniz agreed with Descartes that there exists a *lingua universalis* underlying all speech and that such a language represented the form of human reason.

Leibniz and Boole

- Leibniz called the general framework for such a universal language a *characteristica univeralis,* based on an *ars combinatoria*, a system of symbolization that would have simple forms for simple concepts, and unambiguous logical forms displaying the logical structure of all complex expressions, together providing a logical analysis of all the actual and possible concepts that might arise in science.
- And the framework should include a *calculus ratiocinator*, a complete system of deduction that would allow new knowledge to be derived from old. Leibniz aimed to encompass the three relationships between language and reality, language and thought, and language and knowledge.
- In the 19th century, George Boole (1815-64) had an algebraic conception for a system governing the "Laws of Thought", a *calculus ratiocinator* independent from the vagaries of natural language. (Boolean algebra turns out to have widespread application to natural language semantics, whether Boole would like that or not.)

Frege

- The greatest foundational figure for formal semantics is Gottlob Frege (1848-1925). His crucial ideas include the idea that *function-argument* structure is the key to semantic compositionality.
- Frege is also credited with **the Principle of Compositionality**: The meaning of a complex expression is a function of the meanings of its parts and of the way they are syntactically combined.
- And Frege introduced the distinction between *sense* and *reference* (*Sinn* and *Bedeutung*), which philosophers and semanticists have tried to formalize adequately ever since.



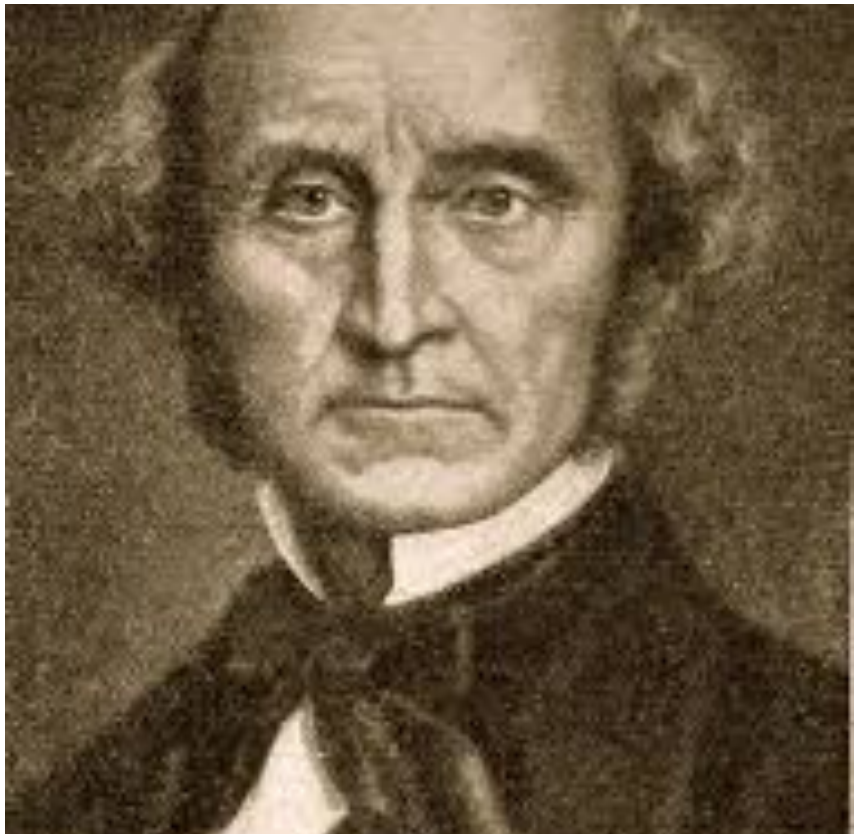
Frege, *cont'd.*

- One of Frege's great contributions was the logical structure of quantified sentences. That was part of the design of a "concept-script" (*Begriffschrift*), a "logically perfect language" to satisfy Leibniz's goals.
- He did not see himself as offering an analysis of natural language, but a tool to augment it, as the microscope augments the eye.
- Frege also figured out a systematic semantics for variable-binding, more compositionally than what Tarski did 50 years later.

- Frege rejected the psychologism of many of his predecessors, e.g. John Stuart Mill.

Psychologism and anti-psychologism in Logic

- Mill: Logic is a branch of psychology.
- So far as it is a science at all, [Logic] is a part, or branch, of Psychology; differing from it, on the one hand as the part differs from the whole, and on the other, as an Art differs from a Science. Its theoretical grounds are wholly borrowed from Psychology, and include as much of that science as is required to justify its rules of art (Mill, *Logic,* 1865, 359).



John Stuart Mill: 1806 - 1873

Frege's anti-psychologism in logic.

- One of Frege's main theses is that mathematics and logic are not part of psychology, and that the objects and laws of mathematics and philosophy are not defined, illuminated, proven true, or explained by psychological observations and results. One of Frege's central arguments for this thesis is the consideration that whereas mathematics is the most exact of all sciences, psychology is imprecise and vague (1884, 38). (Kusch 2011)
- Frege claims that in the realm of logic we find both descriptive and prescriptive laws, with the former being the foundation for the latter.
  - ...every law that states what is can be apprehended as prescribing that one ought to think in accordance with it ... This holds of geometrical and physical laws no less than logical laws (Frege 1893, XV).
- Frege's main criticism of psychological logic is that it conflates 'true' and 'being-taken-to-be-true'.

Some key 20th century developments in logic/ semantics

- Russell introduced *logical types* to avoid paradox, using them to impose restrictions on well-formed function-argument expressions.
- Early Carnap used the theory of types syntactically for the ‘logical construction of the world’ and ‘the logical construction of language’.
- Later Carnap developed a *semantic* approach, where meaning = truth conditions, an idea he got from Wittgenstein.
- Carnap introduced possible worlds as state-descriptions, and analyzed intensions as functions from possible worlds to extensions.
- Tarski developed *model theory* based in set theory and with it made major advances in providing a semantics for logical languages, including his semantical definition of truth.

Carnap and Tarski

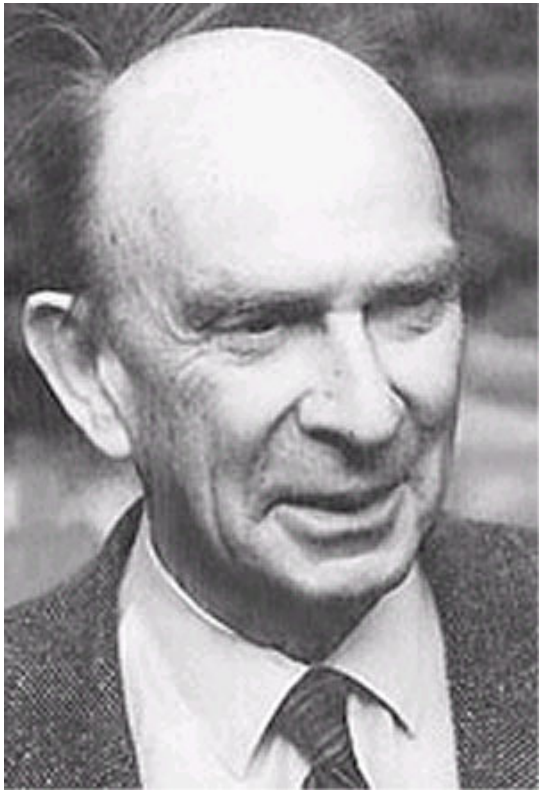
Carnap and Tarski both had major influence on Montague's work.

Rudolf Carnap: 1891 – 1970

Alfred Tarski: 1901 - 1983

The Ordinary Language – Formal Language war.

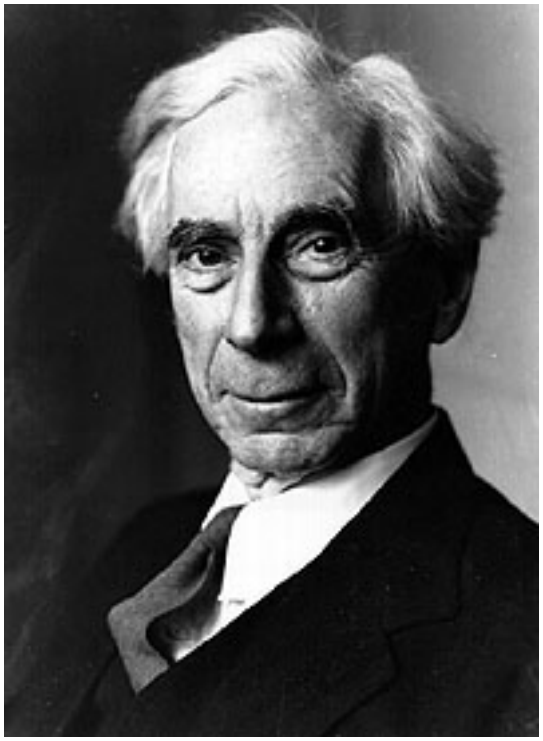
- In the 1950s a war began within philosophy of language, the "Ordinary Language" vs "Formal Language" war.
- Ordinary Language Philosophers rejected the formal approach, urged attention to ordinary language and its uses. Late Wittgenstein (1889-1951), Strawson (1919-2006), Austin, Ryle.
- Strawson 'On referring' (1950): "The actual unique reference made, if any, is a matter of the particular use in the particular context; …Neither Aristotelian nor Russellian rules give the exact logic of any expression of ordinary language; for ordinary language has no exact logic."



Peter F. Strawson
1919 - 2006

The Ordinary Language – Formal Language war.

- Russell 1957, 'Mr. Strawson on referring':
- "I may say, to begin with, that I am totally unable to see any validity whatever in any of Mr. Strawson's arguments." …
- "I agree, however, with Mr. Strawson's statement that ordinary language has no logic."
- So both sides in this 'war' (like Chomsky later) were in agreement that logical methods of formal language analysis do **not** apply to natural languages.



Bertrand Russell
1872 - 1970

On the claim that ordinary language has no logic

- Terry Parsons reports (p.c.) that when he started thinking about natural language in the late 60's, he was very much aware of the tradition from Russell that "the grammar of natural language is a bad guide to doing semantics".
- But in 'On denoting', he realized, Russell had produced an *algorithm* for going from this 'bad syntax' to a 'good semantics'.
- That would suggest that the grammar of natural language was not such a bad vehicle for expressing meaning, including the meaning of sentences with quantifiers, definite descriptions, etc.

Terry Parsons
b. 1939

The OL– FL war and responses to it

- In some quarters, that war continues. But the interesting response of some formally oriented philosophers was to try to analyze ordinary language better, including its context-dependent features.
- The generation that included Prior, Bar-Hillel, Reichenbach, Curry, and Montague gradually became more optimistic about being able to formalize the crucial aspects of natural language.
- Along with Bar-Hillel's calls for linguistics-philosophy cooperation, Frits Staal and several colleagues launched the journal *Foundations of Language* in 1965 calling for broader interdisciplinary cooperation. (Its successor is *Linguistics and Philosophy*.)
- Arthur Prior (1914-1969) made great progress on the analysis of tense, one central source of context-dependence in natural languages, which had been omitted from earlier logical languages.

4. Montague's work

- Montague, a student of Tarski's, was an important contributor to these developments. His Higher Order Typed Intensional Logic unified tense logic and modal logic (extending Prior's work) and more generally unified "formal pragmatics" with intensional logic.
- Montague treated both worlds and times as components of "indices", and intensions as functions from indices to extensions.
- Strategy of "add more indices" comes from Dana Scott's "Advice on modal logic".
- Montague also generalized the intensional notions of property, proposition, individual concept, etc., into a fully **typed intensional logic**, extending the work of Carnap (1956), Church (1951), and Kaplan (1964), putting together Frege's function-argument structure with the treatment of intensions as functions to extensions.

Montague's turn to "linguistic" work.

- A new clue about Montague's motivations: from an early talk version of "English as a Formal Language", July 31, 1968, UBC, Vancouver:

  (I think I'm deciphering RM's shorthand (for small words only) right.)
- "This talk is the result of 2 annoyances:
  - The distinction some philosophers, esp. in England, draw between "formal" and "informal" languages;
  - The great sound and fury that nowadays issues from MIT under the label of "mathematical linguistics" or "the new grammar" -- a clamor not, to the best of my knowledge, accompanied by any accomplishments.
- I therefore sat down one day and proceeded to do something that I previously regarded, and continue to regard, as both rather easy and not very important -- that is, to analyze ordinary language*. I shall, of course, present only a small fragment of English, but I think a rather revealing one."
- *Montague's inserted note: Other creditable work: Traditional grammar, Ajdukiewicz, Bohnert and Backer, JAW Kamp.
- Later notes (1970) suggest he eventually found it not entirely easy.

Montague's view of his "linguistic" work.

- From Staal's edited proceedings of Bar-Hillel's 1967 symposium:
- Montague: As far as the main points are concerned, let me say first that I deplore the distinction customarily drawn between formal and informal languages. The syntax and semantics of certain not insignificant fragments of English can be treated just as formally and precisely as those of the first-order predicate calculus, and in very much the same manner. No adequate treatment of this sort has yet been published; one has, however, been recently developed by my student J. A. W. Kamp and myself.
- I might add that our treatment [relies on] certain recent developments in intensional logic ... Thus the methods developed in connection with artificial languages can be employed to yield completely precise … notions of truth and logical consequence for significant fragments of natural language.
- Yet, although I have myself devoted some time to this goal, I somewhat question its importance. … Is it really so important … to be able to establish conclusively that a given argument in a natural language is invalid? I believe that as the scope of exact artificial languages is enlarged, people will begin to use them for argumentation; witness the gradual abandonment of ordinary language by mathematicians between 1875 and the present.

Montague's turn to "linguistic" work, *cont'd.*

- Montague's first work on natural language was the provocatively titled "English as a Formal Language" (Montague 1970b, "EFL"). He had taught the material at UCLA in spring 1965 (Kamp was there) and at UvA in Spring 1966.
- EFL famously begins "I reject the contention that an important theoretical difference exists between formal and natural languages."
- As noted by Bach (1989), the term "theoretical" here must be understood from a logician's perspective and not from a linguist's.
- What Montague was denying was the central presupposition of the formal language – ordinary language wars: a mismatch between linguistic form and 'logical form' for natural languages.
- What he was proposing, here and in his "Universal Grammar", was a framework for describing syntax and semantics and the relation between them that he considered compatible with existing practice for formal languages and an improvement on existing practice for the description of natural language.

Montague's work, *cont'd.*

- The Fregean principle of compositionality was central to Montague's theory and remains central in formal semantics.
- Montague's syntax-semantic interface: Syntax is an algebra, semantics is an algebra, and compositionality is the requirement that there be a homomorphism mapping the former into the latter.
- The nature of the elements of the syntactic and semantic algebras is left open; what is constrained is the relation between them.
- The differences between Montague's higher-order typed Intensional Logic and first-order predicate logic made a crucial difference for the possibility of giving a compositional semantics based on a relatively "conservative" syntax for English.
- Once Montague had shown what could be done with the use of model-theoretic techniques for compositional semantic interpretation, and with a higher-order intensional logic, both the linguistic wars and the philosophy of language wars could be peacefully resolved by removing their presuppositions.

Montague's work, *cont'd.*

- Details of Montague's own analyses of the semantics of English have in many cases been superseded, but in overall impact, PTQ was as profound for semantics as Chomsky's *Syntactic Structures* was for syntax.
- Emmon Bach (1989) summed up their cumulative innovations thus: Chomsky's Thesis was that English can be described as a formal system; Montague's Thesis was that English can be described as an *interpreted* formal system.
- **Truth-conditions** and **entailment relations** are basic.
- These are minimal data that have to be accounted for to reach "observational adequacy". That principle, inherited from the traditions of logic and model theory, is at the heart of Montague's semantics and is one of the defining principles of formal semantics.

Montague's work, *cont'd.*

- Cresswell (1978) put this in the form of his "Most Certain Principle": We may not know what meanings are, but we know that if two sentences are such that we can imagine a situation in which one of them is true and the other false, then they do not have the same meaning.
- And many decisions about semantic analysis, both in general architecture and in particular instances, can be seen to follow from that principle, as Cresswell (and others) showed.
- The advent of truth conditions and the tools of model theory made semantics an incomparably more powerful discipline than it had been before. It may be hard to realize how surprising and controversial an idea it was to linguists in the early 1970's that we should think about truth conditions rather than just ambiguity, semantic anomaly, and synonymy.

Montague and generalized quantifiers

- According to Peters and Westerståhl, the logical notion of quantifiers as second-order relations is "discernible" in Aristotle, full-fledged in Frege, then forgotten until rediscovered by model theorists.
- Mostowski 1957: unary generalized quantifiers, sets of sets: 'everything', 'something', 'most things'.
- Lindström 1966: binary generalized quantifiers, like 'every', 'most', which take two arguments. Our 'generalized quantifiers', e.g. the denotation of 'most cats', represents the application of a Lindström quantifier to its first argument, giving a unary generalized quantifier.)
- Montague 1973 (and David Lewis 1970): English NPs like *every man, most cats* can be treated categorematically, uniformly, and compositionally if they are interpreted as generalized quantifiers.
- This was a big part of the refutation of the point Russell and Strawson were agreed on, that there is no logic of natural language.
- For details, see online lecture notes from my Moscow courses.

5. Joint work by linguists and philosophers: Montague Grammar and the development of formal semantics

- Montague was doing his work on natural language at the height of the "linguistic wars" between generative and interpretive semantics, though Montague and the semanticists in linguistics had no awareness of one another.
- The earliest introduction of Montague's work to linguists came via Partee (papers on “Montague Grammar” starting in 1973) and Thomason (who published Montague’s collected works with a long introductory chapter in 1974).
- Partee and Thomason argued that Montague's work might allow the syntactic structures generated to be relatively conservative ("syntactically motivated") and with relatively minimal departure from direct generation of surface structure, while offering a principled way to address many of the semantic concerns that motivated some of the best work in generative semantics.

Joint work by linguists and philosophers, cont'd.

- Let me review an obstacle I faced when I started trying to put MG and TG together, whose solution is related to a leading idea that came into linguistics from philosophy and logic in this period, namely the (Fregean) idea that recursion must be done on *open* sentences.
- Obstacle: what to do about deletion rules? In classical TG, (5a) was derived from something like (5b) by "Equi-NP Deletion".

(5) a. Mary was eager to win.

b. $[_S$ Mary was eager for $[_S$ Mary to win]]

- But given the principle of compositionality, and given the way MG works by building up the meanings of constituents from the meanings of their subconstituents, there is nothing that could correspond to "deleting" a piece of a meaning of an already composed subpart.

Joint work by linguists and philosophers, cont'd.

- Recall the consequences of the analysis in (5b) for a sentence like (6a). The presumed deep structure (6b) would clearly give the wrong meaning.

(6) a. Everyone was eager to win.

b. [$_S$ everyone was eager for [$_S$ everyone Tns win]]

- MG-TG resolution suggested in (Partee 1973, 1975): what we want as "underlying" subject in the embedded sentence is a bindable variable; I followed Montague's line and bound it by lambda abstraction to make a VP type. (Some kept an S type for the infinitive, with the variable bound by the higher quantifier.)

(7) a. [[to win]] = ^λx [win (x)]

b. alternatively: everyone' (λx[x was eager for [x to win]])

- That solution is one illustration of the importance of the Fregean principle that wherever quantifiers may be involved, recursion must be allowed to work on *open* sentences.

Joint work by linguists and philosophers, cont'd.

- As Fred Landman (p.c.) notes, it was Montague's innovative use of lambda abstraction as the active variable-binding operator in PTQ that enabled a unified treatment of variable binding in connection with quantification, relative clauses, and interrogatives.
- In retrospect, we can see that it was trying to do all recursion on closed sentences was what made transformational rules cast in terms of "identical NPs" break down when quantifiers were discovered, which led to the expulsion from the Garden …
- In Chomskyan syntax, a corresponding change was eventually made, replacing the "identical NP" by the special null element PRO, interpreted as a bound variable. Other syntactic theories, including modern versions of Categorial Grammar, were developed after the quantifier issues had become well known, so they were designed from the start not to run into those problems.

Joint work by linguists and philosophers, cont'd.

- **Function-argument structure** as semantic glue was largely unknown to linguists before Montague's work.
- Before Montague, linguists knew nothing about lambdas or semantic types, and had no clear idea about how to combine meanings above the lexical level. That's why the usual attempts involved "semantic representations" in a hypothesized "language of thought", which looked very much like natural language. No one had entertained the idea that the things *denoted* by expressions could have a natural way of combining.
- The appreciation of the importance of function-argument structure also helped linguists understand much more of the original motivation of categorial grammar, invented and developed by Polish logicians (Lesniewski 1929, Ajdukiewicz 1935; then also Curry and Lambek) but dismissed by linguists as soon as it was proven to be equivalent in generative power to context-free phrase-structure grammar. Revival in linguistics after Montague: Bach and others.

Formal semantics and the end of the linguistic wars

- One of the methodological principles implicit in transformational grammar, and explicit in some (not all) versions that included the Katz-Postal hypothesis, and carried to extremes in Generative Semantics, was the principle that **sameness of meaning should be reflected in sameness of deep structure.**
- But with a real semantics, we don't need sameness at any syntactic level, including "LF", to capture sameness of meaning (cf. Thomason 1976).
- Oversimplifying hugely, but at least part of the story: this ended the linguistic wars. Eventually formal semantics became mainstream semantics in linguistics.

Chomsky's skepticism about all this.

- It turned out that Chomsky was deeply skeptical of formal semantics and of the idea of compositionality in any form.
- I have never been able to satisfactorily explain his skepticism; it has seemed to me that it was partly a reaction to a perceived attack on the autonomy of syntax, even though syntax is descriptively autonomous in Montague grammar.
- But syntax is not "explanatorily autonomous" in Montague grammar, or in any formal semantics, and I do not see any rational basis for believing that it should be.
- Maybe also because of puzzles about the nature of our knowledge of semantics (raised in my 1979 "Semantics: mathematics or psychology?").
- Chomsky 1986: mental representations – fine; but embedding them into models that include the actual world, dubious.
- In any case, formal semantics spread and became "mainstream semantics" in the US and Europe in spite of Chomsky's skepticism, and MIT hired its first formal semanticist, Irene Heim, in 1989, and its second, Kai von Fintel, in 1994, and quickly became one of the leading programs in formal semantics as well as syntax.

Formal semantics as a subdiscipline of linguistics.

- The height of initial interaction on semantics between linguists and philosophers had passed by 1980, followed by the rise of cognitive science, including semantics as an interdisciplinary concern, and then by a greater specialization of semantics inside of linguistics proper, though always with many individual scholars maintaining links of various kinds within and across the disciplines.
- I'm omitting the important developments in the 80's – too many to list here – also beginnings of semantic typology, formal pragmatics, computational semantics …
- By the middle of the 1980's the recognition of formal semantics as part of the core curriculum in linguistics was seen in the publication of textbooks and the growing number of departments with more than one semanticist.

Formal semantics within linguistics and philosophy.

- By the beginning of the 1990's, formal semantics (no longer "Montague grammar", though that's about the time that the term "Montague grammar" made it into the Oxford English Dictionary) was a fully established field within linguistics, and students were not conscious that the core fields hadn't always been 'phonology, syntax, semantics'.
- In the 1980's, there was less interaction between linguists and philosophers in the U.S., in part because interest in the philosophy of language had declined as interest in philosophy of mind increased.
- But by the late 90's, it was on the increase again, at least in some places, and more sophisticated than ever, thanks in part to Stalnaker's students at MIT of the Stanley-Szabo generation.
- With the work of Heim, Kratzer, Chierchia and others, also greater integration of formal semantics with Chomskyan syntax. Now much important work is at the 'syntax-semantics interface.'

Recent history: building bridges to Russian semantics.

- Starting in 1996, I spent half of (almost) every year in Moscow, teaching formal semantics at RGGU, MGU, and last year at HSE.
- With the help of two NSF grants, several Russian colleagues and I did joint research on the integration of lexical semantics and formal semantics in two domains: Possessives, and Genitive of Negation.
- My main collaborators here were Vladimir Borschev, Elena Paducheva, Ekaterina Rakhilina, Yakov Testelets, and Igor Yanovich.
- One recent paper (2012) was “The Role of verb semantics in genitive alternations: Genitive of Negation and Genitive of Intensionality” by Partee, Borschev, Paducheva, Testelets, and Yanovich. We argued there that genitive NPs have property type (<e,t>), and that the semantics of the verbs they combine with under negation also must shift to accommodate the change in type of that argument of the verb.

Recent history: building bridges to Russian semantics, *cont'd.*

- Earlier, In joint papers and talks, Borschev and Partee proposed integrating Apresjan-school lexical semantics with formal semantics by recasting lexical descriptions in terms of "meaning postulates", an approach first proposed by Carnap and then used by Montague.
- Montague treated all except some 'logical' words as unanalyzed "logical constants", leaving empirical lexical work to others.
- But he added meaning postulates representing partial descriptions of lexical meanings.
- Example (simplified):
  - ***seek*** **(*x*, ^*P*)** $\Leftrightarrow$ ***try*** **(x, ^[** ***find*** **(x, P)])**
  - where **x** is of the type of *John*, and **P** is of the type of *a unicorn*
- That let him treat the intensional verb *seek* as a transitive verb while giving provably the same semantic results as the decompositional treatment of Quine, for whom intensional verbs all took propositional complements.

Recent history: building bridges to Russian semantics, *cont'd.*

- We have noted in our work that the use of meaning postulates can allow one to remain agnostic about the reducibility of all lexical meanings to combinations of lexical atoms or "quarks".
- If that hypothesis is correct, then all the predicates used in meaning postulates can be atoms or definable from atoms.
- If the hypothesis is incorrect, meaning postulates are still useful for describing semantic relations that hold among different lexical items.
- Early formal semantics paid little attention to lexical semantics, concentrating then (and now) on the "semantics of syntax".
- Happily, formal semantics have paid increasing attention to lexical semantics in recent years in a number of domains where lexical semantics interacts in crucial ways with compositionality – verbal aspect, gradable adjectives, diathesis alternations, number and mereology in nouns, and more.
- As the world grows smaller, integration becomes easier. We still have much to learn from one another. Vivant iuventes!

Selected references

More material and fuller references can be found in several papers, versions of which are downloadable from my site, http://people.umass.edu/partee/ .

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Acknowledgements

- My thanks to many people who have helped me learn more about the history of my field, including Nino Cocchiarella, Hans Kamp, Richmond Thomason, Dana Scott, F.J. Pelletier, David Kaplan, Joseph Almog, Dagfinn Føllesdal, Ede Zimmermann, Solomon and Anita Feferman, Edward Keenan, Theo Janssen, Tyler Burge, Patrick Suppes, John Perry, Dag Westerståhl, Stanley Peters, Arnim von Stechow, Robert Stalnaker, Hilary Putnam, Irene Heim, Ivano Caponigro and others whose interviews and correspondence I am still digesting. And to the Special Collections archivists at UCLA for valued help in accessing the archived collection of Richard Montague's papers.