Formal and distributional semantics model different notions of meaning

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Our starting point

- Speakers somehow use linguistic expressions to convey their communicative intentions (speaker meaning).
- How? Part of the standard answer: linguistic expressions (as types) have meanings in their own right.
- This auxiliary notion of expression meaning should:
  1) provide an adequate starting point for explaining how a speaker in a context uses the expression;
  2) be derivative of the expression’s (past) usage in the relevant linguistic community.
Distributional semantics
(e.g., Harris 1954; Firth 1957; Turney and Pantel 2010, ...)

- Expressions are assigned numerical, high-D vectors,
- Obtained through abstraction over distributions in a dataset.

- Two views (e.g., Lenci ‘08):
  - ‘Weak’: What DS models correlates in certain ways with expression meaning.
  - ‘Strong’: What DS models is expression meaning.
Could DS model expression meaning?

- Recall:
  - DS immediately satisfies (2).
  - But it doesn’t seem *sufficient* for (1): (e.g., Boleda & Herbelot ‘16)
    - it cannot *really* do truth conditions,
    - entailment (e.g., Beltagy et al. 2013)
    - reference,
    - compositionality (cf. Baroni & Zamparelli 2010 a.o.)…
  - basically what *formal* semantics is good at…
Formal vs. distributional semantics

The red cat sees a mouse.

DS: [Diagram]

FS: \[ \forall x \left[ (x) \land (x) \right] \exists y \left( (y) \land (x,y) \right) \]

Apparent complementary strengths (e.g., Boleda & Herbelot ‘16):

- Distributional semantics: ‘conceptual’ aspects
- Formal semantics: ‘logical’ aspects

Which suggests a possible integration (e.g., Beltagy et al. ‘13, Erk ‘13, McNally ‘16)...
Our proposal

- FS and DS are *not* complementary models of the same notion of meaning.
- Plausibly, FS has inadvertently modeled *speaker meaning*.
  - And truth, reference, compositionality, etc. may belong with speaker meaning, not expression meaning.
- This takes a burden off DS, enabling the ‘strong’ view.

Proposal:

**Distributional semantics**: expression meaning

**Formal semantics**: speaker meaning
FS as a model of speaker meaning?!

Several reasons for assuming this:

• Centrality of ‘semantic intuitions’ as evidence:
  – These are about *stereotypical speaker meaning* (e.g., Strawson ‘50, Grice ‘75, Schwarz ‘96, Bach ‘02, increasingly in X-prag).

• Natural language is notoriously vague (Wittgenstein ‘53); *single* uses are more amenable to formal modeling.
  – E.g., failure of sense enumeration (Erk ‘10); vagueness of lexical/logical distinction (Abrusan et al. ‘18).

• Confusion about the semantics/pragmatics divide (Bach ‘97):
  – e.g., ‘sentence meaning is necessarily part of speaker meaning’. 
A closer look at DS

And after that:
• Integrating FS and DS.
A closer look at DS

Two main types of DS (for comparison see Baroni et al. ‘14):

- **Count-based:**
  - create a huge table of word-occurrence-per-context
  - obtain abstraction by dimensionality reduction.

- **Prediction-based:**
  - train a neural network to predict the use of each word;
  - it will learn abstract representations of words.
Prediction-based DS

- Two main possible tasks:
  - Given a word, predict its context (e.g., Collobert & Weston ‘08).
  - Given a context, predict a word (e.g., Mikolov, Yih, & Zweig ‘13).

- Contexts could be:
  - Sentences; neighboring words; syntax trees.
  - Image + caption (+ referents); movies + subtitles.
  - ...

- Extremely successful in NLP (“word embeddings”).
Concepts’? DS is often regarded as a model of concepts:

- DS performs well on intuitively ‘conceptual’ tasks;
- Concepts are plausibly abstractions over occurrences;
- Recall:  

\[ \forall x \left[ \left( x \right) \land \exists y \left( y \land \left( x, y \right) \right) \right] \]

But this isn’t quite right:

- The DS vector for “cat” wouldn’t model the concept Cat;
- But the concept of the word “cat”. (Uncontroversial.)

With this interpretation, the ‘strong’ view on DS is:

The meaning of an expression is its concept.
Let’s assess: the ‘strong’ view of DS

This auxiliary notion of **expression meaning** should:

1) provide an **adequate starting point** for explaining how a speaker in a context uses the expression;
2) be **derivative** of the expression’s (past) usage in the relevant linguistic community.

DS as a model of expression meaning (‘strong’ view):

- **Adequate starting point?**
  - Possibly, provided truth, reference etc. belong with speaker meaning.
  - Plausibly: where else to start if not the expression’s concept?
  - **YES!** according to NLP.

- **Derivative of use?**
  - Yes, through general-purpose abstraction/learning.
The final part:

towards Integrating DS and FS
The red cat sees a mouse.

DS: (expression meaning)  

FS: $\exists x [\text{RED}(x) \land \text{CAT}(x)] \land \exists y (\text{MOUSE}(y) \land \text{SEE}(x,y))$  

Two questions (of many):  
- How to get from $\text{RED}$ to $\text{CAT}$?  
- Where is compositionality?
How to get from \[\rightarrow\] to CAT?

A Gricean pragmatic perspective (Grice, ‘67):

- **Quality, Relevance, Quantity:**
  
  speaker meaning $\leftrightarrow$ speaker’s goals and beliefs.

- **Manner:** speaker meaning $\leftrightarrow$ expression meaning:

An attempt at Manner (cf. Relevance theory, Recanati ‘04):

- “Activate the word concepts; then, from each, keep ‘associating’ to the first concepts whose composition results in the content of a possibly cooperative speech act.”
Where does composition happen?

- The foregoing attempt at Manner:
  - ...when the right concepts have been found. (cf. Borge ‘09: speaker meaning)

- But the boundary may not be so clear:
  - Red cats are actually *orange*.
  - When does this *modulation* take place?
  (e.g. Erk & Padó ‘08, Aina ‘18, for DS approaches).
Not just a theory

(Example from Aina et al. 2018):

- Reference resolution on TV series Friends;
- Model (simplified):
  - Joey: See Ross, she’s in love with the cat!

**Two questions (again):**
- How to get from \( \uparrow \) to CAT?
- Where is compositionality?

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- How to get from \( \uparrow \) to CAT?
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Decisions

≈ reference

≈ FS model

Entity Library

≈ reference

Recurrent Neural Network

= DS

Word Embeddings

Joey: See Ross, she’s in love with the cat!
Conclusion

Proposal:

**Distributional semantics**: expression meaning
**Formal semantics**: speaker meaning

Gives a new outlook on their integration:

- *Not* ‘complementary’ models of a single notion;
- but two **very different explanatory roles** in a theory.
- Linked by ‘association and composition in context’ (Griceans: *Manner*; NLPers: *deep neural networks*).

We think this integration is vital to the field.
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