Words in the mind: An introduction to the mental lexicon

Mei-Shin Wu

2016
Outline

Topics that we are going to cover today

The major questions
Are words floating around in human brain?
How the outer world connect with words?
   Fix-Fuzzy issue
   Prototype theory
Mental Model
   semantic networks
   Summary of semantic models
   Part of Speech
Semantic maps

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Summary
The major questions

The mental lexicon is the store of words in long-term memory from which the grammar constructs phrases and sentences.¹

The questions we would like to ask is as following:

▶ Are words floating around in human brain?
▶ How the outer world connect with words?
▶ How human brain retrieve words?
▶ The form of words in human brain.
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Summary
Are the words **floating** around in the brain?

- Human brain structurally organized linguistics information.
- The evidence
  - Straightforward point of view: The word association experiments.
  - Daily life observations: Slip of tongue phenomenon.
  - Medical point of view: fMRI evidence\(^3,^2\)
- semantic-network in human brain
  http://gallantlab.org/huth2016/
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Fix-Fuzzy issue I

Fix meaning assumption

► The original point of view.
► Each word has a basic meaning, which individuals should strive to attain.
► In favor of philosophers.

Fuzzy meaning assumption

► An alternative point of view.
► The natural language concepts have vague boundaries and fuzzy edges.
► In favor of psychologists.

Unfortunately, these two assumptions aren’t perfect.

This book assumes that people translate the real world into concepts. Second, this book treat the meaning of a word as overlapping with the concept to a large extent.
Fix-Fuzzy issue II

Issues about Fix meaning assumption
Let’s assume that human’s memories are like a series of snapshots. Example: Think about the word “cat”, what is the image in your mind?
Fix-Fuzzy issue II

what about this one?

The episodic memory theory: When a new image occurs, human brain will search all the image in mind. The recognition process fail when there is no image matched.

The truth: you can still recognize the images, even they don’t match the pictures in human’s brain.
Fix-Fuzzy issue III

Check list theory: Humans have an internal list of essential characteristics in mind for each words. And we label something if it possesses the criteria attributes.

Philosopher Aristotle: **Words must have a hard core of essential meaning which it is, in principle, possible to extract and specify.**
Fix-Fuzzy issue III

Essential meaning : It can be entered in linguistic dictionary.
additional meaning : It is encyclopaedic knowledge. It can be added and omit without alter the basic meaning of a word.

Problems of Checklist theory : \textbf{It is hard to determine a firm semantic core for some words}. 
Fix-Fuzzy issue IV

Fuzzy meaning assumption:
- fuzzy edge phenomenon.
- family resemblance.

Wittgenstein: *We are faced with a complicated network of similarities overlapping and criss-crossing.*
Prototype theories

Eleanor Rosch, 1975 [4]

- Questionnaire study on 200 psychology students.
- Seven-point scale with 1 meant excellent example for the category.
- The results were consistent. For example, students all agree that robin was the best example of a bird.
Prototype theory

The concept of **Prototype theories**: People categorize common objects, they do not expect them all to be on an equal footing.[5]

**Checklist Theory**
- red
- non-red
- non-red
- non-red

**Prototype Theory**
- red
- red
- red
- red
Prototype theories- example 1

**Degrees of lying**
A prototype lie occurs when a speaker:

- asserts something false
- which they know to be false
- with the intention of deceiving

**Case 1:**
After a boring party, guests said to the host:
I had a wonderful time.

**Case 2:**
Prototype theory explains how words can be used with slightly different meanings.

![Child with chocolate]
Prototype theories- example 2

Polysemy- multiple meanings

► go
  ▶ The janitor goes from top to bottom of the building.
  ▶ The staircase goes from top to bottom of the building.

► over
  ▶ The clouds floated over the city.
  ▶ Sam walked over the bridge.

► old
  ▶ old woman
  ▶ old boyfriend

Judging by the above example, it seems that allowing rough matches to suffice is the way we understand a number of different words. Prototype theory cannot perfectly explain these examples.
Summery of prototype theory

- Words (or categories) have fuzzy boundaries
- Words are defined based on a best exemplar.
- Some members are better examples of a certain category than others.
- The meaning of words/categories is culture and context dependent.
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Mental Model-assumptions

There are assumptions:

- A prototype may be an unconscious attempt to reconcile natural variability with a *checklist* approach to meaning.
- The features of an object enhance human brain and thus forming category. And the object is the best exemplar.
- The prototypes represent internal theories. Each individual build their own mental models. And it is an inextricable mixture of acute observation, cultural brainwashing, fragments of memory and a dollop of imagination.
One of the central issues in developing a model of the mental lexicon is whether the form of a word in the lexicon (e.g., phonological, /kat/, or orthographic, cat) is represented with its meaning (e.g., the idea or concept of a cat) in the same lexical entry or if they occupy separate entries.
Lexicographer Samuel Johnson believed that words in mental lexicon are connected like a fishing net. **Every edge is equal length.** (18 century)

But is it true?

- Word association experiment.
- Tip of tongue phenomenon.
Semantic networks - Word association experiment.

Give me the first word you think of when I say *hammer*.

Give me the first word you think of when I say *wife*.

Give me the first word you think of when I say *car*.
Semantic networks- Word association experiment.

Give me the first word you think of when I say *hammer*. Out of 1000 people, 50% people will say *nail*. People select items from the same semantic field.

Give me the first word you think of when I say *wife*. People often reply with *husband*. If items is one of the pair, people go for it’s partner.

Give me the first word you think of when I say *car*. People often response with words in the same world class.

From the above observation, what have we found? Maybe the connections between words are not equal length?
Semantic network—Build a mental map

More examples about words association experiments.

<table>
<thead>
<tr>
<th>BUTTERFLY</th>
<th>HUNGRY</th>
<th>RED</th>
<th>SALT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. moth</td>
<td>food</td>
<td>white</td>
<td>pepper</td>
</tr>
<tr>
<td>2. insect</td>
<td>eat</td>
<td>blue</td>
<td>sugar</td>
</tr>
<tr>
<td>3. wings(s)</td>
<td>thirsty</td>
<td>black</td>
<td>water</td>
</tr>
<tr>
<td>4. bird</td>
<td>full</td>
<td>green</td>
<td>taste</td>
</tr>
<tr>
<td>5. fly</td>
<td>starved</td>
<td>colour</td>
<td>sea</td>
</tr>
<tr>
<td>6. yellow</td>
<td>stomach</td>
<td>blood</td>
<td>bitter</td>
</tr>
<tr>
<td>7. net</td>
<td>tired</td>
<td>communist</td>
<td>shaker</td>
</tr>
<tr>
<td>8. pretty</td>
<td>dog</td>
<td>yellow</td>
<td>food</td>
</tr>
<tr>
<td>9. flower(s)</td>
<td>pain</td>
<td>flag</td>
<td>ocean</td>
</tr>
<tr>
<td>10. bug</td>
<td>man</td>
<td>bright</td>
<td>lake</td>
</tr>
</tbody>
</table>

Can we build a brief semantic map from the above examples?
Semantic network—Listing the links

- Coordination
  - salt
  - pepper
  - mustard

- Collocation
  - salt
  - water

- Superordination
  - red
  - blue
  - green

- Synonym
  - hungry = starved
Semantic network—Listing the links II

- Coordinates: The words which cluster together on the same level of detail.
- Links between coordinates are strong.
- Topic areas are stored to some extent independently, and that some semantic fields can be damaged without affecting others.
- But it’s difficult to be precise about the detailed organization of coordinates within the mental lexicon.
Semantic network-Cluster of coordinates

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Semantic network—Collocation

The following material is extracted from Anna Vogel Sosa’s article. [6]

- They hypothesized units larger than the traditional word, such as two word collocations and phrases, may be stored in the mental lexicon and accessed holistically.

- The mechanism determining this constituency is the frequency with which items occur together in natural, connected speech: the collocational frequency.

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four levels of collocational frequency</td>
</tr>
<tr>
<td>Group 1</td>
</tr>
<tr>
<td>1 → 99</td>
</tr>
<tr>
<td>Mean = 24.33</td>
</tr>
<tr>
<td>sense of</td>
</tr>
<tr>
<td>piece of</td>
</tr>
<tr>
<td>sums of</td>
</tr>
<tr>
<td>each of</td>
</tr>
<tr>
<td>example of</td>
</tr>
<tr>
<td>colleague of</td>
</tr>
</tbody>
</table>
Semantic network-Collocation

The experiment results

- High collocational frequency (Group 4) has the lowest percentage of accurate responses at 37%.
- Low collocational frequency (Group 1 and Group 2) had a higher percentage of accurate responses at 47% and 60%.

The experiment conclusion:

- Through frequent use, collocations and phrases may become chunked and stored as single processing units.
- Accessing *of* as a constituent of *kind of* might entail a process of morphological decomposition or require the use of explicit language knowledge.
Semantic network - Synonymy

- pursue ⇔ chase.
  You can pursue knowledge but you can’t chase it.
- wide ↔ broad.
  A wide choice (broad choice) of sites can be made available.
- wide ⇔ broad.
  The table is textcolormyredwide.

Summary:
Speakers need to be permanently “tuned in” to the usages of their language.
Mental lexicon might be organized in hierarchical structures.

Links between hyponyms and their superordinates are overall somewhat weaker.

Some links are firmly than others. So human use these firm connections in conjunction with their reasoning ability to make other as they are needed.
Summary of semantic models

According to previous slides, we have introduced
- The Hierarchical Network Model (slides 32)
- The Semantic Feature Model (slides 14)
- The Spreading Activation Model (slides 38)
- The ACT and WordNet Models (slides 31)
Part of Speech

**Strong Lexicalist View**
- Conceptual Features
- Lexical Codes
- Phonological/Orthographic Codes

**Combinatorial View**
- Conceptual Features
- Lexical Codes
- Phonological/Orthographic Codes
- Communicative Intentions

**Emergentist View**
- Conceptual Features
- Lexical Codes
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Strong Lexicalist View

- founded in 1970s
- Based on Lexical functional grammar theory (LFG)
- LFG views language as being made up of multiple dimensions of structures.
- Among all of the structures, syntax is the base.
- The words in minds are listed as a dictionary, grammar class, semantic, phonology and etc.
- Electroencephalography (EEG) studies indicates that in sentence comprehension, the grammatical class of a word is accessed very early.
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Combinatorial View.

- Based on 1950s, Chomsky’s theory.
- A set of rules that generates an endless variety of sentences that considered grammatically correct.
- Generativist approaches aim at finding universally applicable definitions of grammatical categories, including of nouns and verbs.
- **Grammatical class** (e.g. morpho-syntactic information) is part of combinatorial processes that apply to words during the processing of sentences.
Emergentist View

- Elman, 2014 “An alternative view of the mental lexicon”
- Simple Recurrent Network to predict next word.
- Grammatical class is a property emerging from a combination of constraints, semantic constraints is the most important.

![Diagram of Simple Recurrent Network]

*Figure 1. Simple Recurrent Network. Each layer is composed of one or more units. Information flows from input to hidden to output layers. In addition, at every time step t, the hidden-unit layer receives input from the context layer, which stores the hidden-unit activations from time t−1.*
Part of Speech-neural models

Fig. 2. Schematic overview of different neural models concerning the processing of nouns and verbs.
Part of Speech-neural models summary

Neural systems: The processing of words from different grammatical classes will engage partial separable networks.

- Neural separability between the processing of object and action words.
- Emergentist view: to specific word into one or the other class, pragmatic/semantic cues play the most important role.
- Object knowledge: inferotemporal networks.
- Reliability of distributional information: Left prefrontal.
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Semantic maps

Summary
In this section, we are going to visualize human brain responses to complex natural stimuli. We are going to visit a website to show you the semantic maps.

http://gallantlab.org/huth2016/
Summary

- Words are not randomly floating in human brain.
- Words have fuzzy boundaries.
- There are various Mental models have been proposed.
- Neuroscience provided us a semantic maps to visualize the semantic system in human brain.


References II

- **Eleanor Rosch et al.** “Basic objects in natural categories”. In: *Cognitive psychology* 8.3 (1976), pp. 382–439.

- **Anna Vogel Sosa and James MacFarlane.** “Evidence for frequency-based constituents in the mental lexicon: Collocations involving the word of”. In: *Brain and language* 83.2 (2002), pp. 227–236.