A Brief and Friendly Introduction to Computational Psycholinguistics

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COGS 1 guest lecture
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What is “computational psycholinguistics”?

- Inherently, linguistic communication involves the resolution of uncertainty over a potentially unbounded set of possible signals and meanings.
- How can a fixed set of knowledge and resources be deployed to manage this uncertainty?  
  *This is the study of language processing.*
- And how can such knowledge and resources be learned from finite input?  
  *This is the study of language acquisition.*

Computational psycholinguistics studies these problems by constructing explicit mathematical models and testing them with experiments.
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What is “language processing”?

- *Language processing* is the study of how humans comprehend and produce language (sentences, words within sentences, and sequences of sentences, etc.) in real time.

- We can divide this into *language comprehension* (understanding what is spoken and what is written) and *language production* (choosing what to say or write based on what you want to “mean”).
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What is “language acquisition”?

Language acquisition is the study of how humans acquire knowledge of their native language (as infants and as children).
In this talk I’ll focus on language comprehension, and then discuss a bit about language production.
Realistic models of human sentence comprehension must account for:

- Language has structure
- Robustness to arbitrary input
- Accurate disambiguation
- Inference on basis of incomplete input (Tanenhaus et al., 1995; Altmann and Kamide, 1999; Kaiser and Trueswell, 2004)
- Processing difficulty is *differential* and *localized*
Language has structure

The colored word sequences all have something in common:

- The girl gave the dog a big sloppy kiss.
- I gave the dog a big sloppy kiss.
- Every boy on the left side of the room gave the dog a big sloppy kiss.
- The teacher of this class gave the dog a big sloppy kiss.

In linguistics, this commonality is that the colored word sequences are all of the same **phrase type**. In this case, the phrase type is called a **noun phrase**. Languages have many different phrase types, and we can describe the grammar of a language in how its phrase types come together.
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- **The girl** gave the dog a big sloppy kiss.
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Languages have many different phrase types, and we can describe the grammar of a language in how its phrase types come together.
Robustness

Real linguistic input is not always totally well-formed. . .

*I think when she finally came to the realization that, you know, no, I can not, I can not take care of myself.*

. . .

*I mean, for somebody who is, you know, for most of their life has, has, uh, not just merely had a farm but had ten children had a farm, ran everything because her husband was away in the coal mines. And, you know, facing that situation, it’s, it’s quite a dilemma.*

. . .but usually we come to understand it pretty well anyway.
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*her husband was away in the coal mines.*  
*And, you know, facing that situation, it’s, it’s quite a*  
*dilemma.*  
*(The woman is facing being put in a resting home.)*

...*but usually we come to understand it pretty well anyway.*
Accurate disambiguation

Most sentences are ambiguous in ways we do not even notice:

Mary forgot the pitcher...
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Most sentences are ambiguous in ways we do not even notice:

*Mary forgot the pitcher of water sitting near the stove.*
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Accurate disambiguation

Most sentences are ambiguous in ways we do not even notice:

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That’s probably not what you were thinking of...
Inference on the basis of incomplete input

Comprehenders do not wait until the whole sentence has been heard to make inferences about what it means or will wind up meaning:

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“The boy will *eat/move* the cake...”

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“The boy will eat/move the cake...”

That is, comprehension is incremental

(Altmann and Kamide, 1999)
Processing difficulty is differential

Using multiple relative clauses in a sentence can make processing difficult:

This is the malt that the rat that the cat that the dog worried killed ate.

It’s not the meaning of the sentence, or the use of relative clauses, that makes it hard:

This is the malt that was eaten by the rat that was killed by the cat that was worried by the dog.
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It’s not the meaning of the sentence, or the use of relative clauses, that makes it hard:

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\text{This is the malt that was eaten by the rat that was killed by the cat that was worried by the dog.}
\]
Processing difficulty is differential

Did you believe that this sentence was English?

*This is the malt that the rat that the cat that the dog worried killed ate.*

- Consider this simple example:
  *This is the cat that the dog worried.*

- And this one:
  *This is the rat that the cat killed.*

- Which cat did the killing? Suppose it was the cat that the dog worried.
  *This is the rat that the cat that the dog worried killed.*
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► Which cat did the killing? Suppose it was \textit{the cat that the dog worried}.

\textit{This is the rat that \textit{the cat that the dog worried} killed.}
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Processing difficulty is localized

[self-paced reading demo, Example1]

(Grodner and Gibson, 2005)
Processing difficulty is localized

[Self-paced reading demo, Example1]

Word-by-word reading times for sentences with different types of relative clauses (RCs)

(Grodner and Gibson, 2005)
Try to guess the next word in the sentence

Empirically, it’s been shown that more highly predictable words are read more quickly (Ehrlich and Rayner, 1981)

Why would this be the case?
Try to guess the next word in the sentence

My brother came inside to...

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- Why would this be the case?
Try to guess the next word in the sentence

My brother came inside to... chat? get warm? talk? eat? rest?

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My brother came inside to... chat? get warm? talk? eat? rest?
The children went outside to...

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