Psycholinguistics
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Lecture 5

Sentence Processing

- **Introduction:**
- Speech rates in everyday conversation typically average between 140 to 180 words per minute. Moreover, Individual words run together and often are not as clearly articulated as they might seem. However, listeners can with apparent ease segment the speech stream to isolate the words, decode the grammatical structure of the sentences, determine the semantic relations between the words, resolve semantic ambiguities, and draw logical inferences and implications that lie beyond the literal meanings of the sentences-all at the rapid rate of normal speech.
- Our goal in this lecture is to describe current theory and research on sentence processing and to explain how we can process sentences at such rapid rate.

Structural Properties of Sentences

- One reason why we can process speech so rapidly is our ability to systematically make use of structure in natural language.
- **What is *structure?***
- Sets of rules that tell us how words strung together can form a sentence and convey a meaning.
- For communication to occur, the speaker and the listener must share a common knowledge base, and each must have access to the same knowledge sets and rules. (see bottom of page 229 and top of page 230). Real world knowledge can supply constraints that operate as part of the structure of our language.

- Further, some words are more predictable than others, even out of context. **Why?** (see page 230, 2nd paragraph). When words are heard within a context, the effect is even further increased.
- Also, the speech we hear has an intonation pattern and rhythm to it that can give the listener hints about what is about to be heard, one of which can come from periodic appearance of pauses in spontaneous speech. Studies showed that these pauses occur before words of low probability in the context.
- **Sentence perception is thus an active process.**

- In order to discover how sentence processing takes place, we must understand how the listener accomplishes syntactic and semantic processing.
- Some theorists have claimed that we conduct syntactic structure and semantic analysis independently, and others have claimed that we process them at the same time in an interactive fashion.

Syntactic Processing

- Statistical properties of language say something about the consequences of the speaker's and listener's knowledge of language structure, but they do not explain this structure.
- Researchers in the 1960s used transformational grammar to fulfill this goal. These attempts made two important points relevant to our discussion:
- 1. the difference between surface structure and deep structure.
- 2. the difference between competence and performance.

- **1. Surface structure versus deep structure:**
- The surface structure is represented by the words you actually hear. The listener must “decode” this surface structure to discover the meaning that underlies the utterance- the “deep structure” of the sentence.
- Some sets of sentences have different surface structures, but the same deep structure, e.g. active and passive.
- By contrast, some sentences can have the same surface structure, but different deep structures, e.g. *flying planes can be dangerous.*
- This distinction between deep and surface structures tells us that sentence processing is conducted in two steps, and the second step conveys the meaning of the sentence which is the goal of the communicator.

- **2. Competence versus Performance:**
- The way people produce language is not equivalent to their knowledge of language.
- **Competence** is what the speaker knows about the structure of the language, while a theory of **performance** requires an explanation of how we can understand speech, however incomplete and fragmentary it may be.
- **A complete theory of sentence processing must take into account both competence and performance.**

Syntactic Structure of Sentences

- The assignment of words in a sentence to their relevant linguistic categories is called **parsing.**
- **Draw a tree diagram of the sentence *the boy threw the ball.***
- It shows the form class of each word, how they can be grouped into phrases, and how the phrase relationships form the structure of the sentence.
- The detection of such structures is an essential step for understanding the relationships between the objects and events within a sentence.
- In many sentences recognition of the correct constituent boundaries is less clear.
- **Draw tree diagrams of the possible structures of *they are eating apples.***

- Complete understanding of sentences must take into account “Trace” theory with its three elements:
- 1. linguistic constituents can move from one position to another.
- 2. this movement leaves a trace of the original constituent in the surface structure.
- Detection of this trace by the listener is necessary for correct thematic role assignment.
- *The doctor treated the patient from the new hospital who had become suddenly ill.*
- Another source of complication comes from the fact that most sentences we have to process have multiple clauses, e.g. *in order to achieve success, study and hard work are always necessary*.

Sentence Parsing and Syntactic ambiguity

- Researchers have found that the way listeners and readers handle ambiguity can offer valuable insights into general processing principles in language comprehension.
- **Local ambiguity versus Standing ambiguity:**
- *Local ambiguity* refers to cases where the syntactic function of a word, or how to pars a sentence, remains temporarily ambiguous until it is later clarified as we hear more of the sentence, e.g. *When Fred passes the ball, it always gets to its target.*
- *Standing ambiguity* refers to cases where sentences remain syntactically ambiguous even when all of the lexical information has been received, e.g. *the old books and magazines were on the bench*. Sentences such as these can only be disambiguated by the broader context in which they are encountered.

Models of Sentence Parsing

- To understand how theorists have used ambiguous sentences to understand syntactic parsing, consider the sentence *The old man the boats.*
- We initially hear only one meaning of the sentence. Therefore, when we reach the end of the sentence and discover we have done something wrong, we must go back and attempt to reparse the sentence in a different way.
- Alternatively, your intuition might tell you that as we listen to sentences that contain syntactic ambiguity we process both possible meanings, even though we are consciously aware of one of them. In this case when we get to the end of the sentence and discover our interpretation was wrong, we could solve the problem by switching our attention to the alternative interpretation that has been generated at the unconscious level.

- A theory similar to the first possibility is referred to in psycholinguistics as **garden path model.** Two important principles in the garden path model are the **late closure principle** (the way in which listeners or readers might determine when they have reached a major clause boundary; listeners and readers close a clause boundary by holding off until the latest point possible) and the **minimal attachment principle** (listeners and readers interpret sentences in the simplest syntactic structure, which is done by using the fewest phrase-structure nodes possible), e.g.
- *Because Jay always jogs a mile-----*
- *Because Jay always jugs a mile, this seems like a short distance to him.*
- *Because Jay always jogs, a mile seems like a short distance to him.*

- A theory similar to the second possibility is referred to as **constraint Satisfaction Model of Sentence Processing,** e.g. *the old man the boats.*
- Studies that measure eye movement during silent reading have provided support to the garden path model, i.e. reading time becomes significantly slower when the reader reaches an area of the sentence that is inconsistent with a n attempt to use these two parsing principles.

Meaning: The Goal of Sentence Processing

- The goal of sentence processing is to arrive at the meaning of the sentence. This means determining the semantic relationships between the rapidly arriving words.
- Studies of sentence processing suggest that under ordinary circumstances we strive to comprehend the meaning of a sentence as quickly as possible, and then discard the surface structure to retain only the meaning. See page 242-243.
- In some cases listeners remember the surface structure, e.g. jokes and insults.

Is syntax Processed Separately from Meaning?

- At the time when modern psycholinguistics was first developing, psychology as a whole was dominated by "serial" models of mental operations.
- **Explain and provide examples based on previous knowledge.**
- In its earliest form, it carried the implication that semantic analysis of a sentence could not begin until a major clause boundary or the end of the sentence had been reached.
- This view led to the attempts to demonstrate the importance of syntactic clauses at the earliest stages of sentence processing. See page 244 for the click experiment.
- **Result**: Perceptual isolation of the linguistic clause was the first step in sentence processing and formal syntactic structure alone was sufficient to tell the listener where the clause boundary had occurred.

On-Line Interactive Models of Sentence Processing

- Those who support an interactive model contend that knowledge-driven, top-down information and sensory-driven, bottom-up information interact continually, not only when the signal source is degraded. They assume that semantic processing co-occurs with syntactic processing as each word of the sentence is being heard, e.g. hearing the article *the*.
- Further evidence of these models come from **shadowing and Gating Studies.**
- Shadowing: Subjects listen to spoken passages and repeat what they are hearing as it was being heard.
- Gating: subjects are presented with recorded sentences that included only the first 50 milliseconds of the last word in the sentence. Subjects are asked to say what the last word was.

- Results:
- Subjects were able to speak almost simultaneously with what they were hearing, correct errors in pronunciation or grammar even before the incorrect word on the tape was fully completed.
- Subjects could recognize words within 175 to 200 milliseconds of their onset, while for words out of context 333milliseconds of their onset.
- The effect of context would presumably be to reduce the initial cohort of possible words heard on word-onset sounds, to those that could reasonably “fit” within the sentence frame heard.
- However, the idea that context alone reduces cohort size is now thought unlikely. Real word survival demands a bottom-up priority to some degree in the processing system.

Where does Context Operate?

- Modularity theorists are those who believe that input process such as lexical activation are cognitively impenetrable. That is, these operations are performed rapidly, automatically, and uninfluenced by prior or collateral information.
- Forster (1979) defined what he believed to be three separate processing systems devoted to language processing:

1. Lexical processor
2. Syntactic processor
3. Message processor

In contrast with interactive models, in Forster's conceptualization no processor would have any information from operations conducted by any of the higher-level processors.

- How can we peek into automatic unconscious processing activity to see whether or not semantic context is operating on a word the instant it is being heard rather than later?
- An early experiment by Swinney (1979) illustrates one interesting approach to this question (bottom of page 254 and top of page 255)
- Swinney found that for subjects who saw the probe words presented at position [1], the lexical decision for both *ant* and *spy* were significantly faster than for lexical decision to a semantically unrelated control word such as *sew*. By the time several hundred milliseconds had passed (position [2]), however, only the word related to the contextually appropriate meaning of the word (for example, the word *ant*) was facilitated.
- These results appear to support modularity at the lexical level.

- To Swinney and colleagues, these data seemed to indicate a sentence comprehension system composed of autonomous subsystems, called modules, that act automatically and are uninfluenced by higher-level processes. When an ambiguous word is heard, all of its meanings are activated. If a context is present, it operates only at a later point in time to select among possible meanings and to allow only the contextually appropriate one to come into conscious awareness.

Comprehension of Nonliteral Meaning

- A distinction important to a discussion of sentence processing is the distinction between the **literal** meaning of an utterance and cases where sentences also have **non-literal** meanings, e.g. sarcasm, idioms, metaphors, and indirect requests.
- In general, we have two accounts of hoe nonliteral meaning is processed.
- One theory assumes a three-stage process:
- 1. the individual determines the literal meaning of the sentence.
- 2. the individual determines whether the literal meaning seems appropriate to the context and circumstances surrounding the utterance.
- 3. the individual rejects the literal truth value of the utterance and seeks a nonliteral interpretation.

- This kind of model implies that figurative language comprehension is secondary to, and qualitatively different from, literal language comprehension.
- Recent work has cast doubt on the implications of this account.
- Listeners need not process the literal meaning of the phrase before understanding its figurative meaning. Second, the process involved in understanding nonliteral language may be qualitatively no different from the processes involved in understanding literal language. Often the literal meaning helps us understand the figurative meaning.

- **How specialized is the memory system used for sentence processing?**
- The necessity of some sort of short-term or working memory for effective sentence processing seems persuasive.
- How then can we account for reports of brain-damaged patients with severe short-term memory deficits who nevertheless show good ability for at least some aspects of sentence processing?
- Martin (1987) examined sentence comprehension for a group of brain-injured patients whose memory span for materials such as word lists had been tested and was known to be limited. The sentences she used varied in complexity from one-clause active sentences, to one-clause passive sentences, to sets of center-embedded relative clause constructions (see the table on page 260).

- **The Results:**
- Short-term memory span was not the defining predictor of adequate comprehension and thematic role assignment. For example, two subjects had a memory span of only 2.2 items, versus the 7 or so items most adults can recall. One patient scored only 57% correct on a comprehension test of role relations in the simple active and passive sentences, and 45% correct on the relative-clause sentences. However, the other patient with exactly the same memory span scored 88% on the active and passive sentences and 93% correct on the relative-clause sentences.
- **It would appear that the kind of memory representation required for language comprehension is not easily6 measured by our standard tests of ordinary memory capacity.**