

Mechanisms of Meaning

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Plan for Today

Today's lecture will be dedicated to dialogue phenomena that call for incremental models of interpretation:

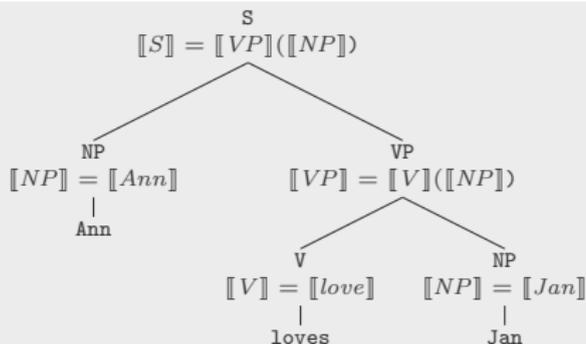
- Motivation for incrementality
- Dialogue phenomena that require incrementality

Common View of Interpretation

Most linguistic theories take the utterance/sentence as the unit of interpretation. It is commonly assumed that:

- *linguistic modules* (lexicon, syntax, semantics, pragmatics) operate on complete units and do so in a *sequential fashion*;
- semantic composition takes place once a syntactic parse of a complete sentence is available:

$[[Ann]] = a$
 $[[Jan]] = j$
 $[[love]] = \lambda xy. Love(x, y)$



Incremental Interpretation

There is wide psycholinguistic evidence, however, that language interpretation does not operate in this manner.

- Linguistic theories do not necessarily aim at being psychologically realistic: they are often concerned with *competence* not *performance*.

A large amount of psycholinguistic results show that language comprehension is not sequential but *incremental*:

- it's a *continuous process*, carried out in small, gradual steps as an utterance unfolds in time
- with *modules operating synchronously*.

A classic and a more recent reference for overviews of incremental processing:

Marslen-Wilson (1975) Sentence perception as an interactive parallel process. *Science*, 189:226-228.

Moore (ed.) (2009) *The Perception of Speech: From Sound to Meaning*, Oxford University Press.

Evidence for Incremental Interpretation

- We have seen that *lexical* and *compositional semantics* interact in parallel in the disambiguation of word senses:

(1) The chair broke the bad news to the committee.

* the sense of ambiguous words such as 'chair' and 'break' is refined as the linguistic context brings in more information

- Steedman and colleagues showed that the *syntactic parser* interacts with the *referential context* to resolve ambiguities:

(2) The horse raced past the barn fell.

(3) The burglar blew open the safe with the ... dynamite/new lock.

Crain & Steedman (1985) On not being led up the garden path: The use of context by the psychological syntax processor, In *Natural language parsing: Psychological, computational, and theoretical perspectives*, CUP.

Altmann & Steedman (1988) Interaction with context during human sentence processing. *Cognition*, 30:191–238.

Syntax-Semantics Integration

Steedman et al. propose the following two principles:

- *Principle of parsimony* (Crain & Steedman, 1985): A reading which carries fewer unsupported presuppositions will be favoured over one that carries more.
 - * without previous context, there is a preference for considering 'raced' as the main verb instead of part of a reduced relative clause.
- *Principle of referential support* (Altmann & Steedman, 1988): An NP analysis which is referentially supported will be favoured over one that is not.
 - * in a context with two 'safes', the PP is interpreted as NP modifier (longer reading times with 'dynamite');
 - * in a context with one referent, the VP attachment is more parsimonious (longer reading times with 'new lock')

⇒ Context can rapidly constrain syntactic structure building.

Eye-tracking: more on syntactic disambiguation

Eye-tracking methodologies provide more precise information about the step-by-step interpretation process than reading times.

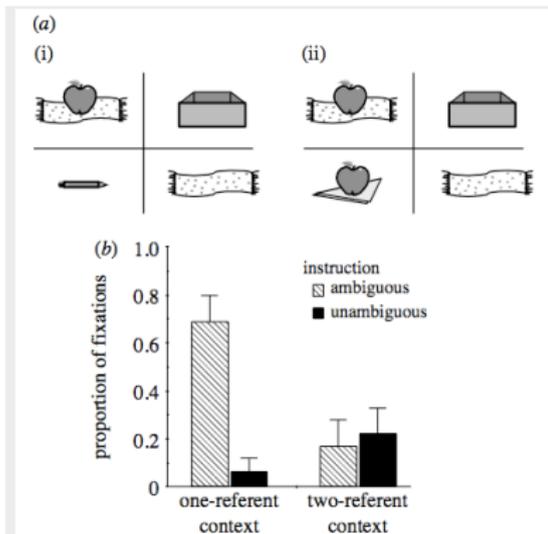


Figure 4. (a) Sample stimuli for (i) one-referent (pencil) and (ii) two-referent (apple on napkin) conditions. (b) The proportion of looks to the competitor goal (the towel) for instructions with locally ambiguous and unambiguous prepositional phrases in one-referent and two-referent contexts.

- *'Put the apple on the towel into the box'* temporarily ambiguous instruction
- *'Put the apple that's on the towel in the box'* - unambiguous instruction
- In (i) subjects initially misinterpret *'on the towel'* as the object of the verb *'put'*
- In (ii) there is no misinterpretation: *'on the towel'* uniquely identifies a referent

Spivey, Tanenhaus, Eberhard & Sedivy (2002) Eye movements and Spoken language comprehension: effects of visual context on syntactic ambiguity resolution. *Cognitive Psychology* 45:447-481.

Incremental Interpretation

- In summary, there is ample evidence that partial interpretations are constructed incrementally in parallel to syntactic parsing.
- There is interaction between linguistic “modules” at the sub-utterance level.
- Is this something limited to the processing mechanisms of individual speakers? How does it affect interactive dialogue processes?

Incrementality and Dialogue

In dialogue interaction we find several phenomena that required incremental processing:

- *Turn-taking*: turn-taking is *predictive* not *reactive*.
- *Grounding*: continuous feedback.
- *Split utterances*: continuations by the interlocutor.

Turn Taking

- Turn-taking is one of the fundamental organisational principles of conversation:
 - * participants in dialogue contribute utterances in turns, mostly talking one at a time, and using various mechanisms to yield and take the turn;
 - * turn-taking is universal, although there are some individual and cultural differences.
- Turn-taking happens very smoothly:
 - * Overlaps are rare: on average, less than 5% of speech.
 - * Inter-turn pauses are very short: $\sim 200\text{m}$.
 - ▶ even shorter than some intra-turn pauses
 - ▶ shorter than the motor-planning needed to produce the next utterance
- Turn-taking is not reactive but *predictive*.

Conversation Analysis Model

The seminal model of turn-taking was put forward by sociologists within the framework of Conversation Analysis (Sacks et al. 1974)

- According to this model, turns consist of *turn constructional unites* (TCUs) with *projectable* points that can be predicted beforehand.
- Such projectable points act as *transition relevance places* (TRPs) where turn transitions are relevant.
- Three rules govern the expected behaviour at TRPs:
 1. if devices to select a next speaker (e.g. questions) are used, the selected speaker takes the turn; else
 2. any other party may take the turn, or
 3. if no other participant takes the turn, then the current speaker may continue.

Sacks, Schegloff, & Jefferson (1974) A simplest systematics for the organization of turn-taking in conversation. *Language*, 50:735–99.

Turn-Taking Models

Subsequent research has focused on how to make more precise the notions of TCU and TRP.

- *How can TRPs be predicted?* Experiments show that speakers are able to predict whether an utterance will continue and if so for how many words.
 - * syntactic closure plus acoustic information (rising/falling intonation; faster speaking rate);
 - * prosody contributes to holding the turn: certain prosodic patterns signal that the speaker plans to hold the turn beyond syntactic completion;
 - * syntactic completion is context-dependent - *pragmatic completion*;
 - * lexical cues: word fragments and filled pauses are indicative of turn-hold.

Grounding Utterances and Turn-Taking

Backchannels ('*uhu*', '*mhm*') are a class of utterances that do not follow the CA model:

- frequently produced in overlap;
- not meant and not perceived as attempts to take the floor;
- they signal attention and give evidence of grounding.

According to Clark (1996), the CA turn-taking rules do not apply to utterances at the *meta-linguistic level* of interaction:

- backchannels do not indicate floor competition
- their placement determines which part of the speaker's utterance they react to.
- what is the right place for a backchannel?

Grounding Utterances and Turn-Taking

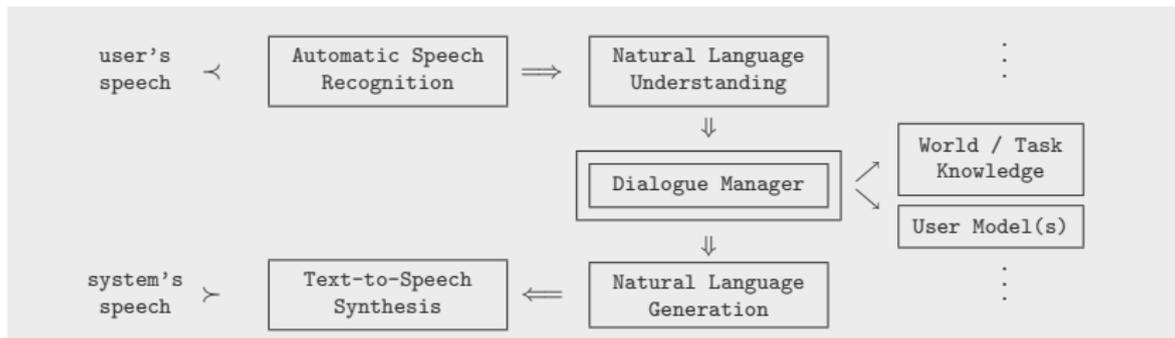
What about negative feedback utterances that request for repair?

- *Clarification requests* have slightly different constraints:
 - * they involve turn switching
 - * but the preceding turn can be resumed smoothly

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(4) A: They X-rayed me, and took a urine sample, took a blood sample.  
      Er, the doctor...  
      B: Chorlton?  
      A: Chorlton, mhm, he examined me...
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Turn-taking: Demo

Traditional architecture of a dialogue system:



Incremental architectures are currently being developed where modules receive input from other modules as available, and information flows in both directions, with “later” modules informing “previous” ones

- Demonstration video of the ‘*Numbers System*’, which implements incremental dialogue processing for smooth turn-taking:

www.sigdial.org/content/discourse-processing-and-dialogue-systems

Skantze & Schlagen (2009) Incremental Dialogue Processing in a Micro-Domain, in *Proc. of SIGdial*.

Aist et al. (2006) Software architectures for incremental understanding of human speech, *Proc. Interspeech/ICSLP*.

Schlagen and Skantze (2009) A general, abstract model of incremental dialogue processing, in *Proc. of EACL*.

Split Utterances

Split utterances are utterances constructed collaboratively by more than one speaker: canonical example of coordination in dialogue

completions:

(5) A: Before that then if they were ill
B: They get nothing.

(6) A: . . . and then we looked along one deck, we were high up, and down there were rows od, rows of lifeboats in case, you see,
B: There was an accident.
A: of an accident.

opportunistic cases:

(7) A: Well I do know last week that =uh A1 was certainly very
< pause 0.5 >
B: pissed off

expansions:

(8) A: Profit for the group is a hundred and ninety thousand pounds.
B: Which is superb.

Purver, Howes, Gregoromichelaki & Healey (2009) Split Utterances in Dialogue: a Corpus Study, *Proc. of SIGDial*.

Split Utterances

- Corpus studies show that splits can occur everywhere in a string.
- At the very least, split utterances required incremental interpretation and prediction:
 - * the initial speaker must be able to switch to the role of hearer;
 - * the initial hearer must monitor the speaker closely to be able to take over;
 - * this is in line with e.g. the interactive alignment model, according to which it should be as easy to complete someone else's utterance as one's own.
- Two references related to grammatical frameworks that take up the incremental challenge and provide accounts of split utterances:

Poesio & Rieser (2010) Completions, Coordination, and Alignment in Dialogue, *Dialogue & Discourse*,1:1–89.

Purver, Gregoromichelaki, Meyer-Viol & Cann (2010) Splitting the 'I's and Crossing the 'Yous': Context, Speech Acts and Grammar, in *Proc. of SemDial 2010*.

Split Utterances

- Demonstration video of a virtual human character capable of collaborative utterance completion developed at the Institute for Creative Technologies (ICT) <http://ict.usc.edu/>
 - * <http://people.ict.usc.edu/~devault/incremental.html>

DeVault, Sagae & Traum (2009) Can I finish? Learning when to respond to incremental interpretation results in interactive dialogue, in *Proc. SIGdial*.

Next Week

- Presentation of your plans for your final paper
- Room: C3.108