The crook arrested by the detective was guilty of taking bribes.

1. Combines constraints as they become available in the input
2. Input determines the probabilistic activation of each constraint
3. Constraints are weighted according to their strength
4. Alternative interpretations compete to a criterion
5. Cycles of competition mapped to reading times
Interpretation of *by*-phrases

**Agent context:** The artist decided to go to the gallery. Once he got there he wanted to know who had hung his prize painting. *He was pleased to discover that his painting had been hung by the director* earlier in the week.

**Location context:** The artist decided to go to the gallery. Once he got there he wanted to know where his prize painting had been hung. *He was pleased to discover that his painting had been hung by the entrance* earlier in the week.

- **Relevant constraints:** preference due to the verb, general interpretation of *by*-phrases in passives, and the discourse context

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**Results**
Modeling discourse constraints

1 Referent: An actress and the producer’s niece were auditioning for a play. The director selected the actress but not the niece. The actress selected by the director believed that her performance was perfect.

2 Referents: Two actresses were auditioning for a play. The director selected one actress but not the other. The actress selected by the director believed that her performance was perfect.

Thematic fit of actress makes active implausible, and discourse context can facilitate settling on the reduced relative clause, i.e.:

- Two referent context increases the likelihood of a relative clause

Revised model
Summary of McRae et al 1998

• An **interactive model** of constraint-based ambiguity resolution

• **Quantitative linking hypothesis** relating constraint-integration and reading times

• An **empirical evaluation** which includes:
  
  • setting constraint biases (using corpus estimates, and human judgements)
  
  • setting model weights (to fit completion data)
  
  • evaluating the predictions (against human reading times)
  
  • comparing constraint-based and modular predictions

The Interactive Activation Model

• Rich lexical entries; frequency determines ‘activations’

• Consider: “John examined the evidence”

• “examined” is either a simple past or past participle

  ➔ thematic fit, tense frequency, structural bias ...

(MacDonald et al, 1994)
Interactive Activation

• The Interactive-Activation Model: In sum
  • Multiple access is possible at all levels of representation, simultaneously, constrained by frequency/context
  • Richly structured lexical entries enriched with frequency information
  • Language processing is “constraint satisfaction”, between lexical entries, and across levels; No distinct parser
• Questions: Complex interaction behaviours are difficult to predict
  • Conflicting constraints should cause difficulty. Do they?
  • Difficult to actually implement, and estimate frequencies/parameters

Constraint-based vs. Probabilistic

• Similarities between constraint-based and probabilistic models:
  • Weighting of different constraints
  • Simultaneous integration of constraints (e.g. lexical and syntactic)
• Differences between constraint-based and probabilistic models:
  • Probabilistic models scale more easily, typically not “handcrafted”
  • How probabilities are linked to reading times.
  • Constraint-based models directly predict difficulty (competition among constraints), probabilistic models do not
  • Free choice of constraints
• Focus on isolated, circumscribed phenomena.

• Binary question: framing theoretical predictions as binary outcomes

• Cumulativity: Reconciling new results with old ones.

• Need to understand methods subjects use to perform task
  • And not average over methods when analysing data
  • Require an explicit control structure of how task is performed

• Cognition must be viewed as information processing

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YOU CAN'T PLAY 20 QUESTIONS WITH NATURE AND WIN: PROJECTIVE COMMENTS ON THE PAPERS OF THIS SYMPOSIUM

Allen Newell
May, 1973
Newell continued

1. Build complete processing models, with detailed control structures

2. Analyse complex tasks, not just “disaggregated” tasks


• Maybe we’re reaching the day of theorists in psychology!

• Models of cognition, not dependent measures

• Do we want a theory of ERPs, or for ERPs to inform theories of comprehension?

• Skeet shooting: trying to shoot down, rather than improve theories

Human Language Processing

• We understand language **incrementally**, word-by-word

  • *How do people construct interpretations?*

• We must resolve **local** and **global ambiguity**

  • *How do people decide upon a particular interpretation?*

• Decisions are sometimes wrong!

  • *What information is used to identify we made a mistake?*

  • *How do we find an alternative interpretation?*

• Answers can reveal important details about the underlying mechanisms
Theories of Sentence Processing

- Explanatory and descriptive goals

- Theories of parsing typically determine …
  - what architecture is assumed: modular? symbolic? …
  - what mechanism is used to construct interpretations?
  - which information sources are used by the mechanism?
  - which representation is preferred/constructed when ambiguity arises?

- Linking Hypothesis: Relate theory/model to observed measures
  - What cognitive processes does the measure reflect, how can this be related with aspects of the model’s processing or memory

Topics

- Human language processing: Reading times, eye-tracking, EEG/ERP

- General and Philosophical Issues
  - Modularity versus Interaction
  - Marr’s levels, Rational theories
  - Experience-based versus innate mechanisms

- Syntactic Processing
  - Psychologically plausible parsers: Incrementality, Memory Load and Ambiguity
  - Theories of Syntactic Ambiguity Resolution (Frazier, Pritchett)
  - Reanalysis & Monotonic Parsing (Pritchett; Sturt & Crocker)
Topics

• Probabilistic Models
  • Lexical category disambiguation (Corley & Crocker)
  • Syntactic parsing (Jurafsky)
  • Wide coverage sentence processing (Crocker & Brants)
  • Other rational approaches: Informativity (Chater, Crocker & Pickering)
• Interactive Models (McRae et al)
  • Multiple competing constraints, non-modular
  • Setting model parameters from corpora and off-line experiments

Topics

• Linking Hypotheses: There are two kinds of theories/models involved when we model human language behaviour:
  • The model of the cognitive system itself (at any of Marr's levels)
  • A theory that links some aspect of that system to a particular empirical measure (reading time, ERPs, visual attention, etc.)
• Most common linking theories in computational psycholinguistics:
  • Reanalysis (in serial processing models)
  • Pruning of unlikely parses, parse re-ranking (in bounded parallel models)
  • Surprisal – a computational theory, but with a mechanistic interpretation
  • Cycles for analysis to exceed threshold, reflects time need to reconcile constraints.
Course Assessment & Materials

- Course assessment:
  - Satisfactory participation in all tutorials
  - Exam at end of course = 100% of grade
    - Responsible for all material discussed in the lectures & tutorials
    - Reading: Lecture material, tutorials, key papers
- Materials
  - Lecture overheads and recommended readings
    - available from the course web page
  - All tutorial material
Key Readings …


Why spend time on old theories?

- Important to see different motivations, these are still relevant!
  - Emphasis on linguistic representations, comprehension, action
  - Focus on cognitive limitations or strengths
  - Rationality? If so, rational in what sense?
  - Surprisal and the causal bottleneck … can psycholinguistics ever really tell us about linguistics? Is that important?
  - So far, assumed symbolic representations, computation & algorithmic theories … will implementation level theories (neural) change things?
Structure of the exam

- **Exam structure:**
  - Part 1: Short questions (8 or 9), all obligatory (approx 50%)
  - Part 2: Do 2 out of 3 long questions (approx 50%)

- **Materials for the exam:** 1 side (not both) of A4 paper, hand-written, with anything you want on it. A simple calculator is allowed. No smartphones.

- **Duration:** 100 minutes

- **Place:** Meeting Room & Aquarium

- **Time:** Monday **03.02.2020 @ 14:00 *sharp***