Modeling Human Parsing, Syntactic Priming, Collaborative Action

Interdisciplinary Research with Psychology and Linguistics

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Prediction in Human Parsing

PI: Frank Keller; Funding: EPSRC

Aim: develop a fully implemented, broad coverage, crosslinguistic model of human parsing.

Approach: model processing difficulty in parsing in terms of syntactic prediction (entropy reduction, see Box 1). Tasks:

- formalize syntactic prediction as the **generation** of structural hypotheses and their subsequent **verification;**
- develop algorithms that compute predictions **incrementally** (i.e., word-by-word basis) as the sentence unfolds;
- evaluate the model using eyetracking data (Box 2);
- extend the model to French and German, test its **crosslinguistic** predictions.

Applications: parsing; language modeling; text simplification.

Box 1: Entropy Reduction

Assumption: processing difficulty corresponds to the **reduction in uncertainty** from one word to the next; can be formalized as Kullback-Leibler Divergence D between the distributions at words w_{n-1} and w_n:

$$D(P_n||P_{n-1}) = \sum_T P_n(T) \log \frac{P_n(T)}{P_{n-1}(T)} = \log \frac{1}{P(w_n|w_{1\cdots n-1})}$$

This can be computed using a language model, it is not structure dependent.

Syntactic Priming and Parallelism

PIs: Frank Keller, Johanna Moore, Martin Pickering (Psychology)

Funding: Leverhulme Trust, Stanford Link

Aim: explain persistence phenomena in human language processing (syntactic priming, structural parallelism).

Approach: use repetition probability of syntactic rules to investigate persistence in corpora (see Figure 1). Results:

- strong evidence for priming and parallelism effects in dialog;
- **priming decays** exponentially with time (see Figure 2);
- stronger priming effects in **task-oriented** dialog (see Figure 2).

Applications: natural language generation; dialogue systems.

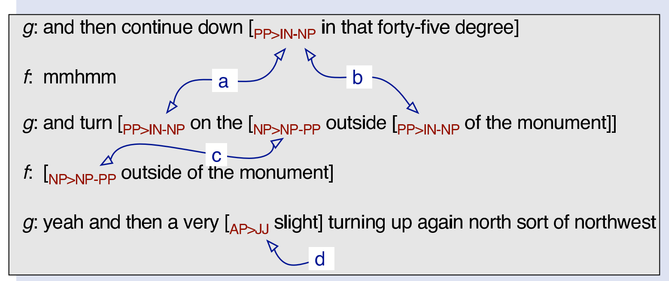

Figure 1: Repetition of syntactic rules in a dialog corpus.

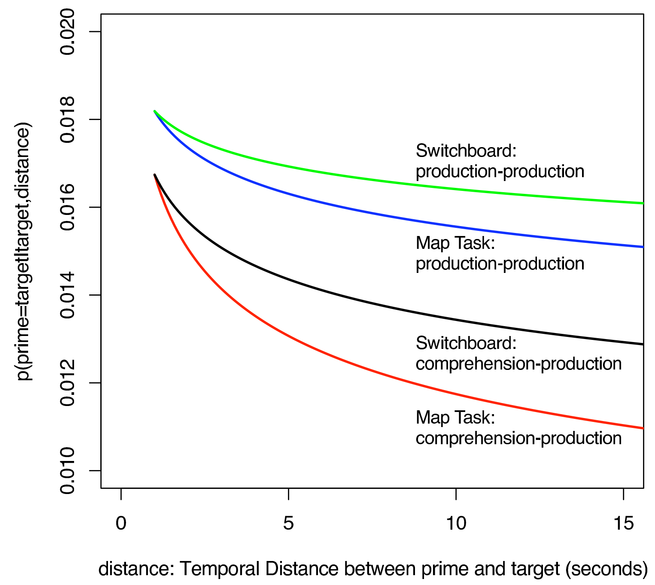

Figure 2: Decay over time of priming effects in two dialogue corpora.

JAST: Collaborative Action

PIs: Ellen Bard (Linguistics), Jean Carletta, Jon Oberlander

Funding: European Commission

Aim: investigate the perception and management of joint attention in a collaborative setting.

Approach: human-robot construction task, with and without dialogue. Robot has ability to track head, eyes, hands of human partner (see Figure 3).

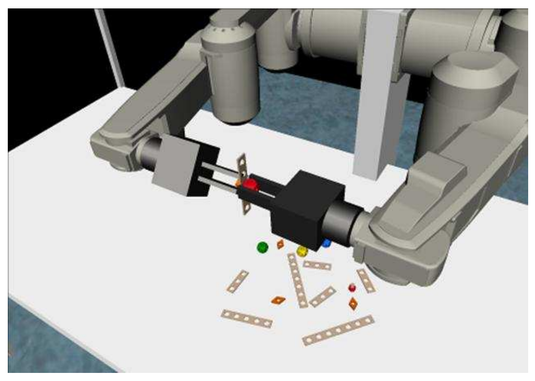

Figure 3: Schematic view of the JAST robot.

Complemented by human-human experiments (see Figure 4):

- use eyetracking (see Box 2) and the instrumented meeting room (see AMI poster) to determine who looks where and when;
- investigate how **attention** is guided by action, talk, knowledge of other's focus of attention; also test influence of available **cognitive resources;**
- key question: do people attend to partner's model of the task?

Applications: dialog systems; human-computer interaction; ergonomics.

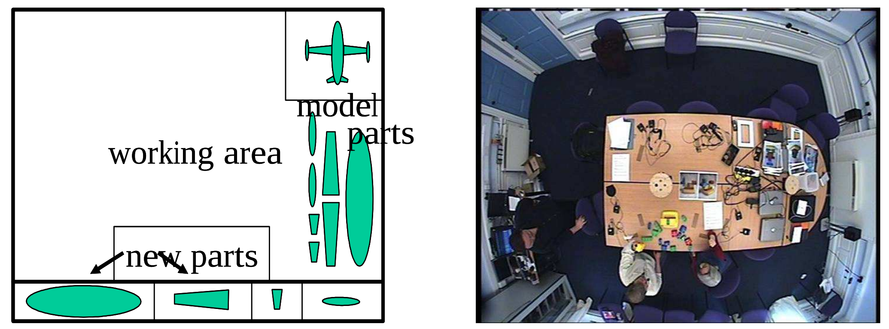

Figure 4: Interaction capture during the JAST collaborative construction task.

Box 2: Eyetracking

An **eyetracker** records the eyemovements of subjects while their are performing a cognitive task (see Figure 5).

Figure 5: A head-mounted, video-based eyetracker.

Eyetracking can be recorded while participants **read text:**

- very high spatial (1 character) and temporal (1 ms) resolution;
- eyemovements in reading are saccadic: a series of relatively stationary periods **(fixations)** between very fast movements **(saccades);**
- average fixation time is about 250 ms; can be longer or shorter, depending on ease or difficulty of processing;
- **eyetracking corpora** are large collection of eyetracked text that can be used for cognitive modeling.

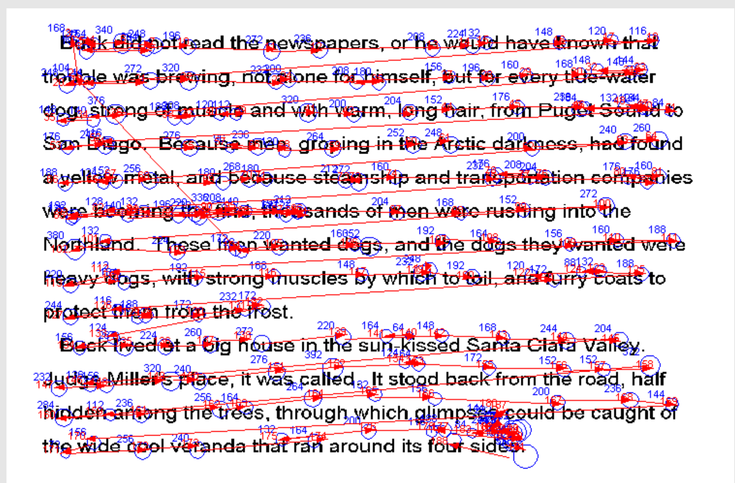

Figure 6: Fixations (blue) and saccades (red) recorded when reading.