

# Sentence Comprehension as a Cognitive Process: A computational modeling approach Day 3: Modeling reading processes

Shravan Vasishth and Felix Engelmann

Universität Potsdam, Germany

University of Manchester, UK

vasishth@uni-potsdam.de, felix.engelmann@manchester.ac.uk

<http://bit.ly/sentcomp>

August 17, 2016

## Eyetracking: The eye-mind assumption

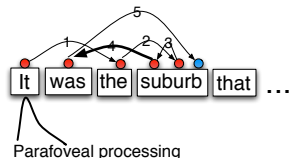
Just and Carpenter 1992:

**“there is no appreciable lag between what is being fixated and what is being processed.”**



## Eye movements

- During reading, the eyes make little jumps or **saccades**, followed by moments of **fixations** at words (about 200-400ms).
- 3-4 saccades per second, each saccade can last about 20-40 ms.
- The eyes can **skip** a word, or fixate multiple times (**refixate**) on a word.
- The eyes can revisit previously read (or skipped) word: **regressive eye movements**.



- 4: Regressive saccade during first pass
- 5: Progressive saccade to already read word
- Re-reading time

- The eyes can revisit previously read (or skipped) word: **regressive eye movements**.
- Some information can be picked up from the parafovea.

## “Early” and “late” measures in reading studies

Several eye-tracking measures are used in sentence processing to measure comprehension difficulty.

- First-fixation duration
- First-pass reading time
- Regression path duration
- Regression probability
- Re-reading time
- Total reading time

## Linking fixation durations to cognitive processes

- There is an informal assumption that longer fixation durations/higher regression probability indexes increased processing difficulty.
- An effect found in pretty much any dependent measure is taken as evidence; the link to the underlying cognitive process is rather informal.
- It is only in cognitive psychology that computational models of eye-movements in reading have been developed (e.g., E-Z Reader and SWIFT).
- Engelmann et al 2013 was the first formal attempt to connect parsing difficulty with eye-movement control models.

## Example eyetracking data

time	xleft	yleft	pupil	xright	yright	pupil
689473	112.7	138.0	703.0	78.9	121.9	632.0.....
689475	113.0	137.8	703.0	78.9	122.2	632.0.....
689477	113.2	137.6	702.0	79.1	122.4	633.0.....
689479	113.2	137.5	702.0	79.3	122.4	633.0.....
689481	113.0	137.5	702.0	79.2	122.5	633.0.....
689483	112.7	137.6	703.0	78.9	122.5	634.0.....
689485	112.5	137.7	705.0	78.7	122.6	634.0....

## Example eyetracking data

trial	rid	word	fix_start	fix_end	x	y
E6I25D0	9	Schauspieler	12789353	12789531	577	200
E6I25D0	9	Schauspieler	12789563	12789679	557	197
E6I25D0	NA	NA	12789861	12789873	80	528
E6I25D0	NA	NA	12789879	12789983	74	527
E6I25D0	10	den	12790031	12790321	47	537
...						

## Example eyetracking data

subj	trial	res	ans	cond	item	roi	FFD	FFP	SFD
30	E6I25D0	6	6	E6	25	17	190	1	0
30	E6I25D0	6	6	E6	25	18	234	1	0
30	E6I25D0	6	6	E6	25	19	0	0	108
30	E6I25D0	6	6	E6	25	20	180	1	180
30	E6I25D0	6	6	E6	25	21	182	1	0



## The goal today

- Our goal today is to demonstrate one way to specify the underlying cognitive process of sentence comprehension that leads to fixations and saccades in reading.
- We do this by building on previous work on eye-movement control in reading (in psychology).