Pupil dilation as an index of processing load during pronoun resolution

Manizeh Khan & Jesse C. Snedeker
Harvard University

Pupillometry & Language Processing

•Measure of processing cost[1]

•Pupil size increases following grammatical or prosodic violations and semantic anomalies[2,3]

•Is pupillometry sensitive to processing cost of typical language comprehension?

•Pronoun resolution as a test case
- •Unambiguous vs. Ambiguous
- •First-mentioned vs. Second-mentioned

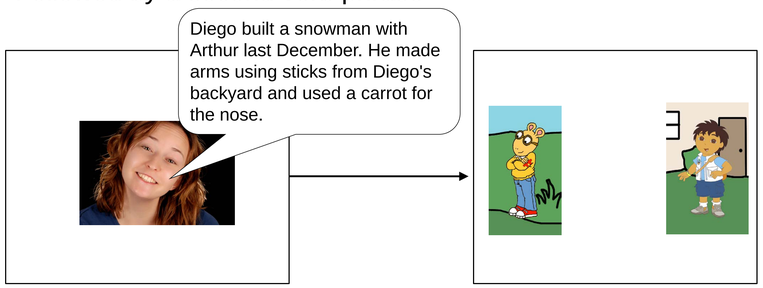
Experiment 1

•28 adults (native English speakers)

•13 items: Ambiguity & Order of Mention of Referent (First vs Second) varied within –subjects

•Pronoun disambiguated by possessive noun

•Followed by a second verb phrase



Analysis

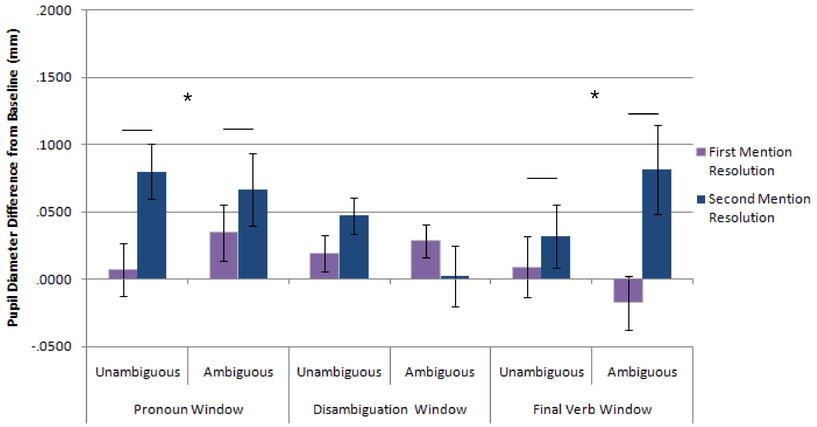
•Baseline: 500ms window before pronoun onset
- •Subtracted mean baseline diameter from pupil diameter during time regions of interest

•Three time windows of interest
- •Pronoun until disambiguation
- •Disambiguation until second verb phrase
- •Second verb phrase until end

•Time course analysis[5]
- •Locate clusters of time points with reliable effects
- •Bootstrapping technique to correct for multiple comparisons

Experiment 1 Results

Pupil Dilation by Time Regions of Interest

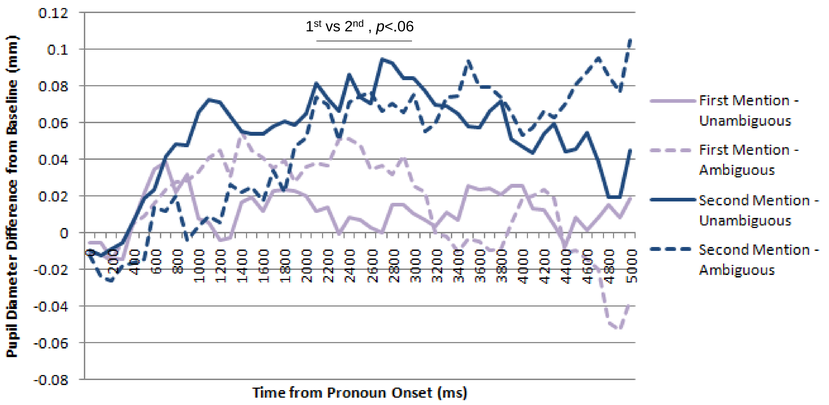


•Greater pupil response to pronoun resolution to second mentioned character, $p<.05$ in initial and final windows

•Initial response driven by unambiguous trials, later by disambiguation of ambiguous pronouns

•Marginally significant Order of Mention x Ambiguity interaction in final window, $p<.09$

Pupil Dilation Time Course Analysis



•Marginally significant Order of Mention effect in window from 2100ms-3000ms after pronoun onset

•Future analyses will align to disambiguation and second VP
- •Time course of reconciling pronoun ambiguity

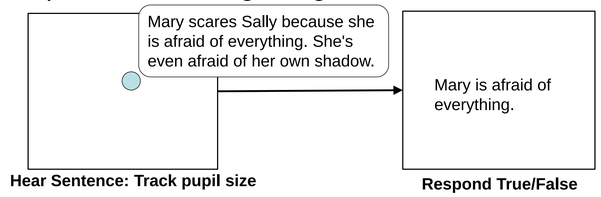
Experiment 2

•24 adults (native English speakers)

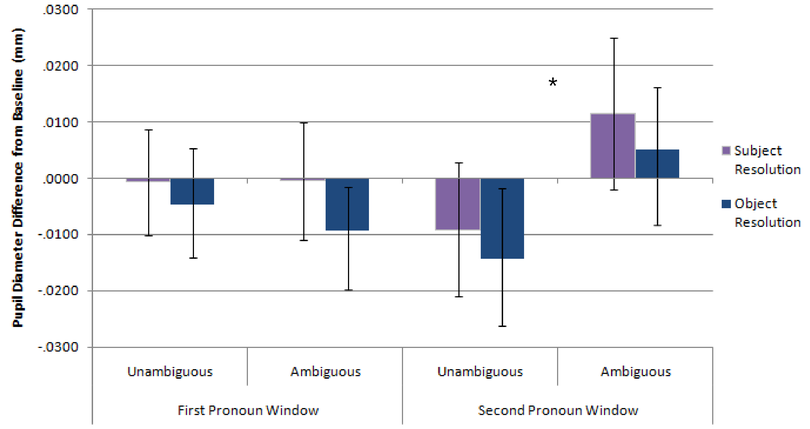
•32 Psych verbs followed by pronoun in a *because*-phrase
- •All verbs had a subject-resolution bias[4]

•Pronoun disambiguated by end of sentence

•Pronoun repeated at the beginning of the second sentence



Experiment 2 Results



Discussion

•Reliable pupil dilation following pronoun resolution
- •Sensitive to processing cost in typical comprehension

•Greatest pupillary response followed reactivation of the referent
- •Second verb phrase (Exp. 1), remention of pronoun (Exp. 2)
- •Consistent with initially shallow pronoun processing[6]

•Currently testing four year old participants
- •Tracks processing cost
- •No secondary task
- •Can be used in non-referential contexts (cf. Visual World)
- •Can be used with non-readers/non-fluent readers

References
1 For example, Beatty & Wagoner *(1978). Science, 199.*
2 Engelhart, Ferreira & Patsenko (2009). *Quarterly Journal of Experimental Psychology, 63.*
3 Gutierrez et al. (2011). *CUNY 2011: Conference on Human Sentence Processing.*
4 Hartshorne & Snedeker (*under review).*
5 Maris & Oostenveld (2007). *Journal of Neuroscience Methods, 164.*
6 Stewart, Holler & Kidd (2007). *Quarterly Journal of Experimental Psychology, 60.*