Computational Psycholinguistics

Lecture 2: Linguistic Modularity, Experimental Studies of Language

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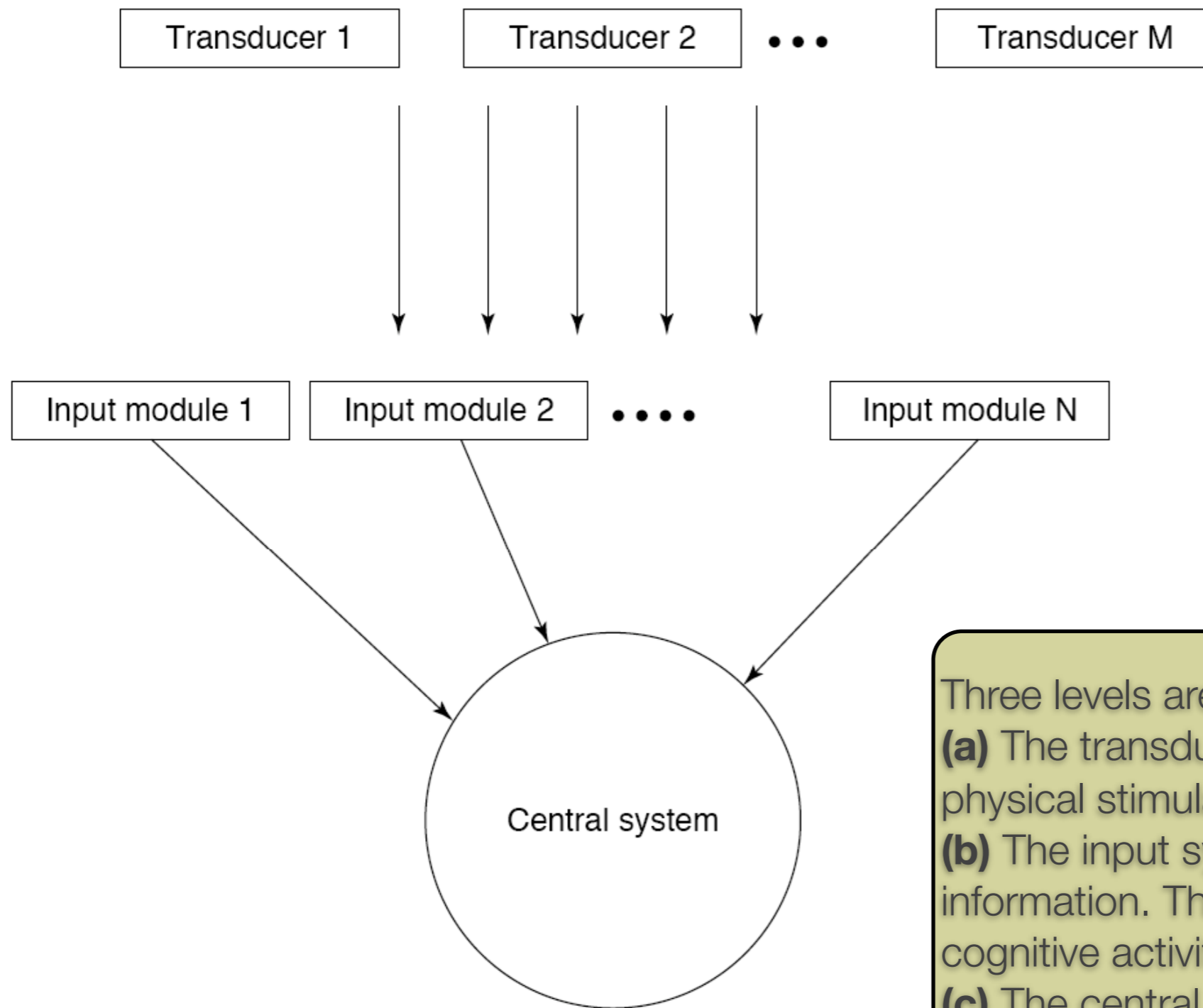
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Linguistic Modularity

- Is language distinct from other cognitive processes?

  - e.g. vision, smell, reasoning ...

- Do distinct modules exist within the language processor?

  - e.g. word segmentation, lexical access, syntax ...

- What is a module anyway!?

Architectures and Mechanisms

- What does "distinct" mean:

  - Representational autonomy: e.g. phonological versus syntax representations

    - possibly interactive processes

  - Procedural autonomy: e.g. lexical access versus syntax

    - possibly shared representations

- How is the language module organized/ connected to other systems?

Modularity and Perception

- Cognitivist view of human perception
  - inferential and unencapsulated: cognitive penetration of perceptual processes

- Behaviorist view of human perception
  - non-inferential and encapsulated: perception reduces to conditioned reflexes

- Fodor (1983): inferential but encapsulated
  - perception performed by informationally encapsulated systems which may carry out complex computations

Transducer 1   Transducer 2   • • •   Transducer M

Input module 1   Input module 2   • • • •   Input module N

Central system

Modules are:
• domain specific
• innately specified
• informationally encapsulated
• fast
• hardwired (neurally specific)
• autonomous
• not assembled

Three levels are distinguished:
(a) The transducers, whose function is to convert physical stimulation into neural signals.
(b) The input systems, interpret transduced information. They are responsible for basic cognitive activities and are modular.
(c) The central system, is responsible for more complex cognitive activities such as analogical reasoning, and is not modular.

Reference
**a** Fodor, J.A. (1983) *The Modularity of Mind*, MIT Press/Bradford Books

Proving Modularity

- The best proof of Modularity would be evidence for a "Double Dissociation":

  - Dissociation #1: Damaged linguistic abilities, but intact cognition

  - Dissociation #2: Damaged cognitive abilities, but intact language

Proving Modularity

#1 Broca's aphasia
- normal IQ
- language comprehension is relatively unimpaired
- language production is non-fluent, few words, short sentences, few function words, no intonation
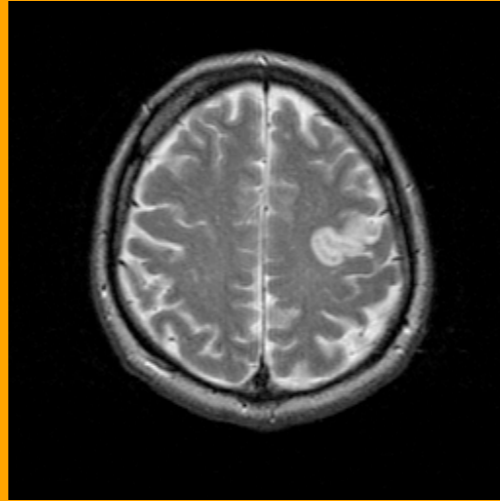
#2 Senile Dementia
- poor memory and diminished general cognitive function
- language production and comprehension remain intact

#1 Specific Language Impairment
- normal IQ and hearing
- language is meaningful, appropriate
- problem with grammatical morphemes

#2 Williams Syndrome
(Genetic defect in .001% births)
- low IQ, overly social, poor spatial reasoning
- good language ability, nearly age appropriate

Strong Competence & Modularity

- Fodor's proposals emphasis language as a module, distinct from other perceptual cognitive abilities

- Linguistic theories suggest that language itself may consist of sub-levels: phonology, morphology, syntax, semantics ...

  - each with different rules and representations

  - do these correspond to distinct processes?

A Modular Architecture
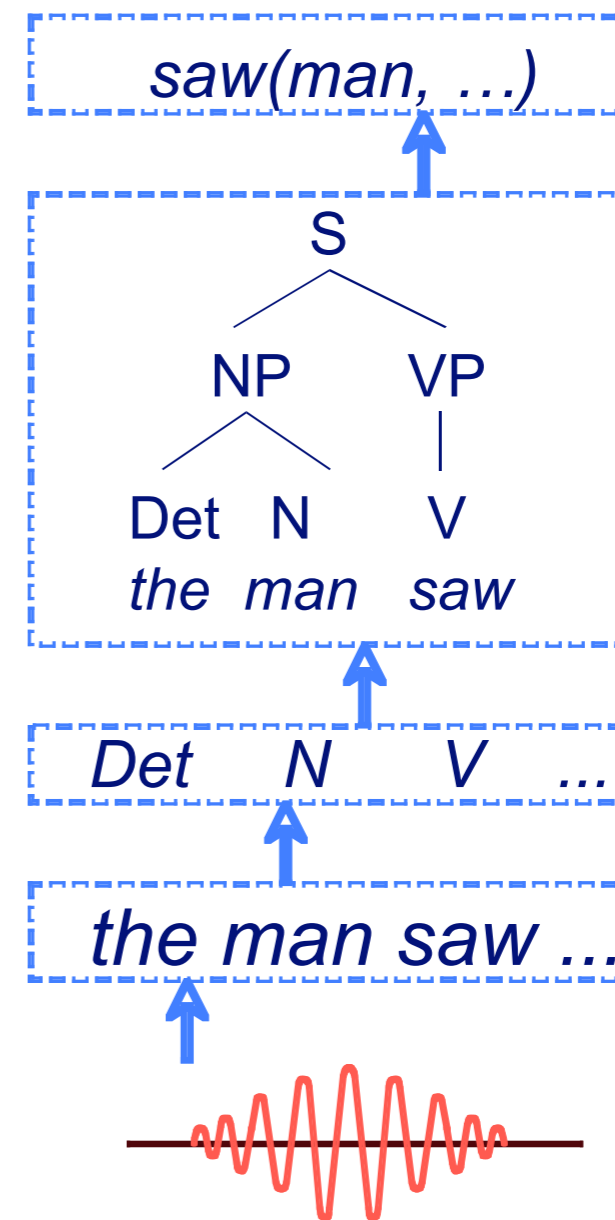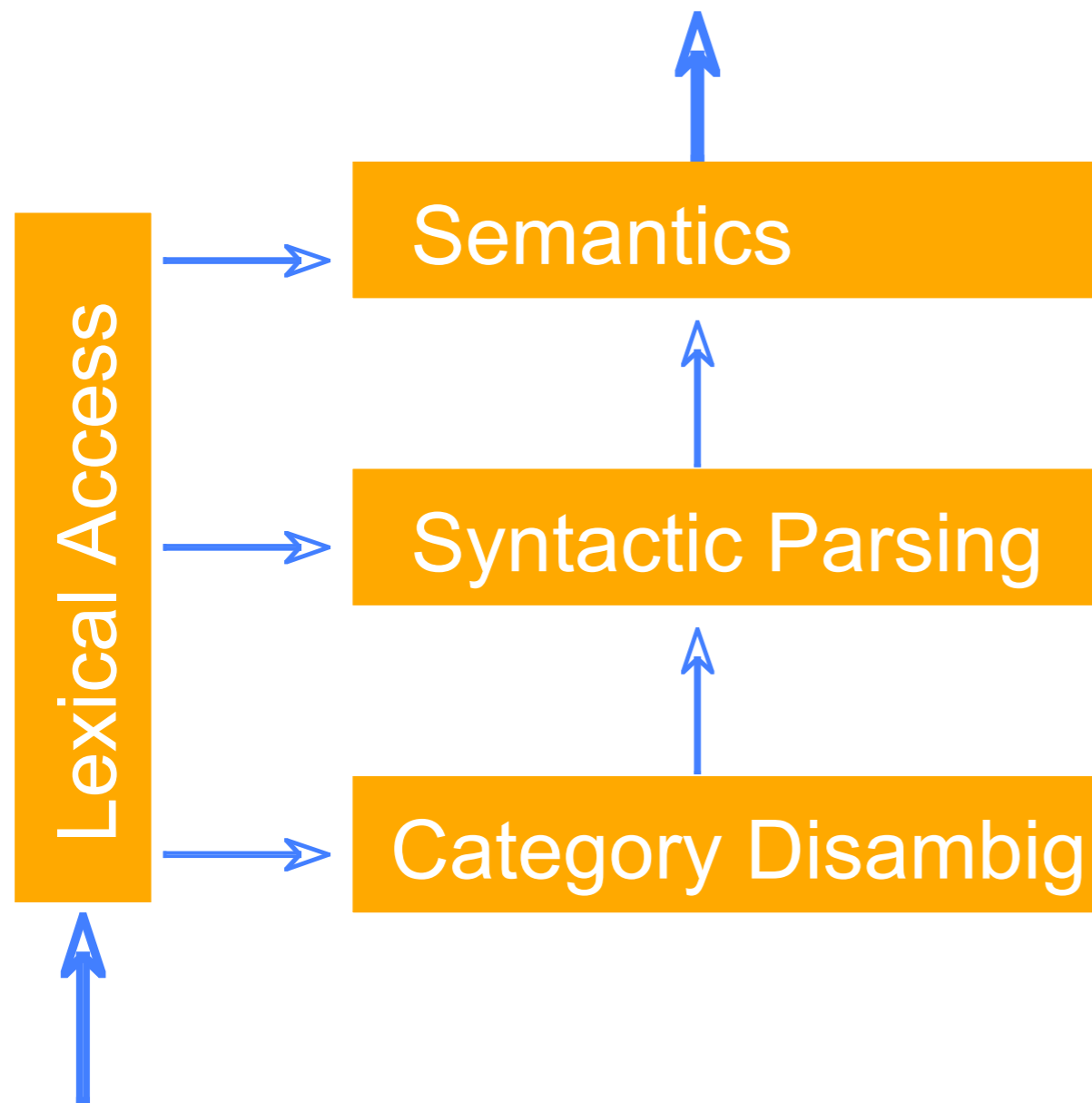
Support for Linguistic Modularity

- Modular lexical access versus syntax: Forster

  - all possible word meanings temporarily available

  - no immediate influence of syntactic context

- Modular syntax versus semantics: Frazier

  - initial attachment ambiguities resolved by purely structural preferences

  - no immediate effect of semantics or context

- Dissociation in language impairment at different levels

Against linguistic modularity

- Empirical evidence from on-line methods

  - later evidence for "immediate" (very early) interaction effects of animacy, frequency, plausibility, discourse context …

    - *The woman/patient sent the flowers was pleased*

- Appropriate computational frameworks:

  - symbolic constraint-satisfaction systems

  - connectionist systems & competitive activation models

Evaluation of Cognitive Models

- Cognitive models of language seek to model:

    - linguistic competence

    - human linguistic performance

- Evidence on how people learn and process language:

    - analysis of language production data

    - experimental studies of language comprehension

Language Production Data

- Spoken and written corpora
  - e.g., Wall Street Journal Corpus, Penn Treebank, British National Corpus (BNC)
  - not representative of human language production in daily, `normal' situations

- Conversational interactions
  - CHILDES: CHIld Language Data Exchange System
  - transcripts, audio and video of parent-child dialogs

Experimental Studies of Comprehension

- Experimental methods
  - Measuring reading difficulty
    - reading times, eye-tracking
  - Introducing visual stimuli
    - preferential looking, situated spoken comprehension
  - Neuroscientific methods
- Experiments must be designed to test a specific hypothesis about language processing, predicted by a particular theoretical proposal

Example: Local Ambiguity Resolution

"The man held at the station was innocent"

Crocker & Brants, *Journal of Psycholinguistic Research*, 2000.

Reading time studies

- We can use controlled experiments of reading times to investigate local ambiguity resolution

  (a) *The man held at the station was innocent.*

  (b) *The man who was held at the station was innocent.*

- Compare reading times of (a) with (b) to see if and when ambiguity causes reading difficulty.

  - need a *linking hypothesis* from theory to measures

  - manipulate other linguistic factors to determine their influence on RTs in a controlled manner

Reading Methods

- Whole sentence reading times:

  `The man held at the station was innocent`

- Self-paced reading, central presentation:

  `isntbeaheldont`

- Self-paced reading, moving window:

  `The man held at the station was innocent`

Eye-tracking

The man held at the station was innocent
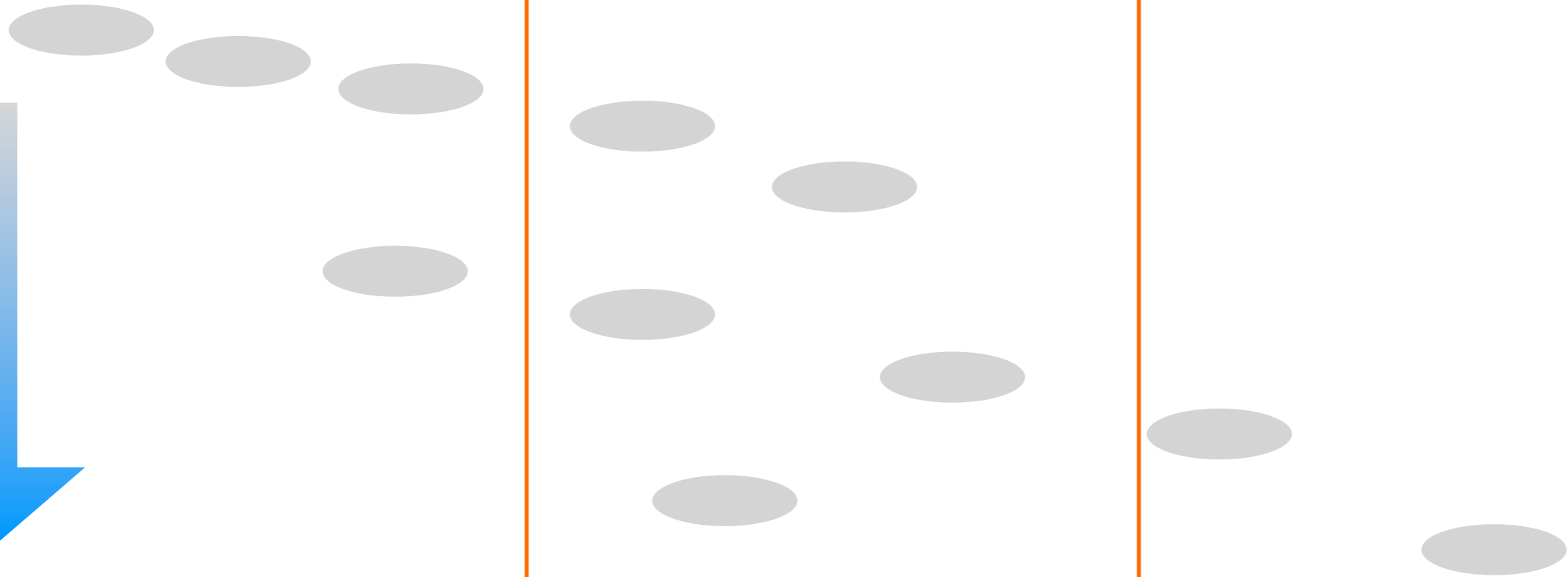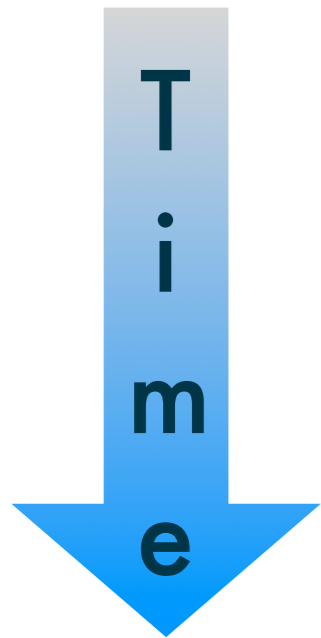
Time

Eye-tracking: First Fixation

The man held at the station was innocent
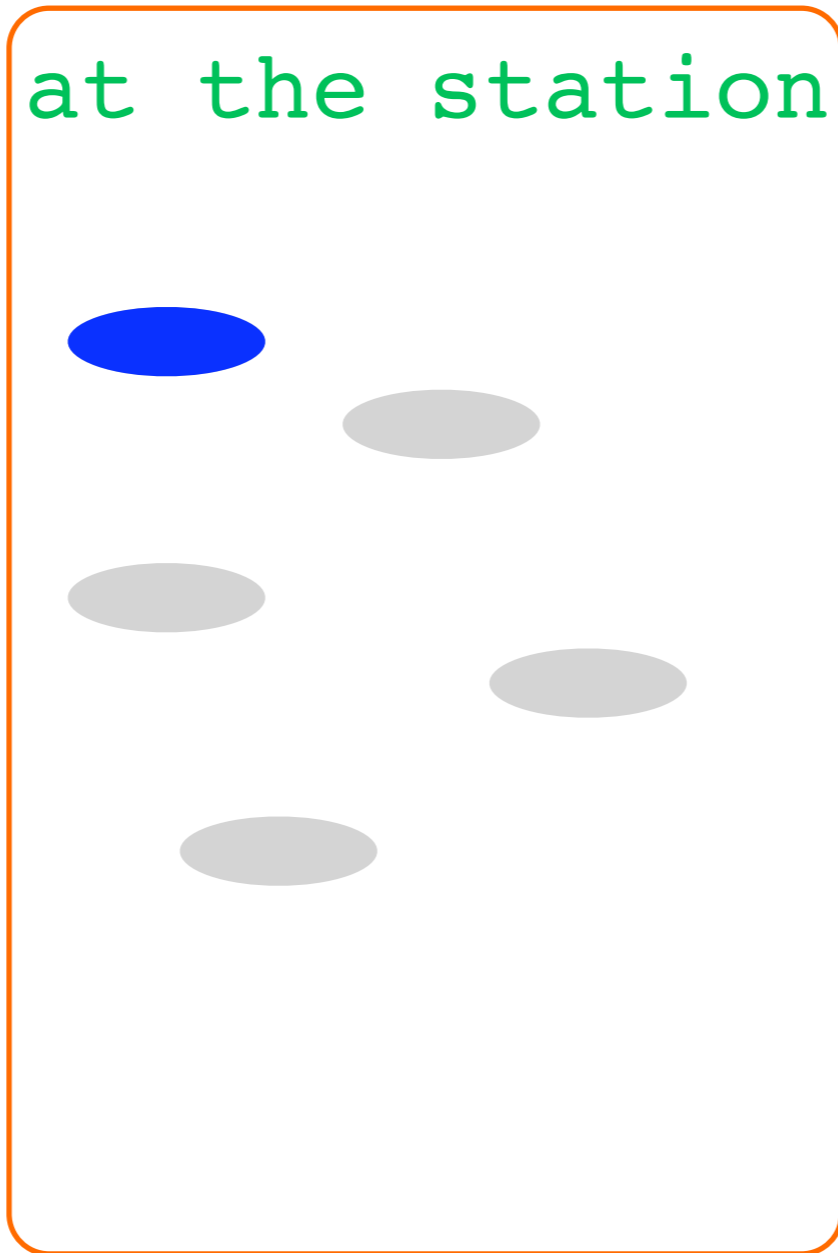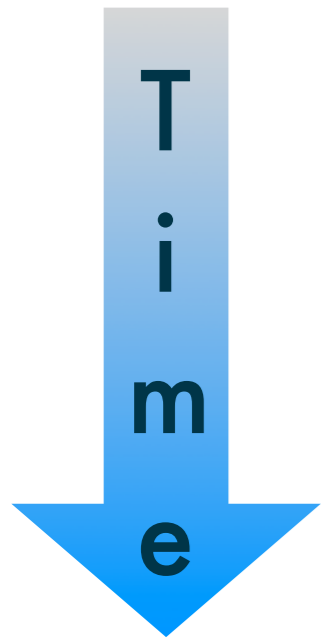
Time

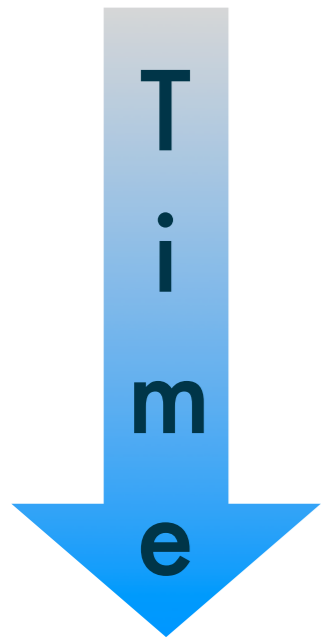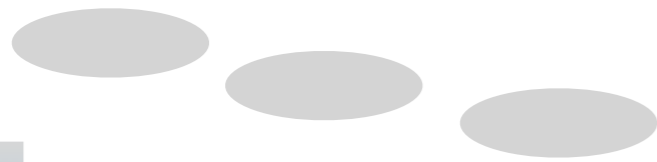# Eye-tracking: First Pass

The man held at the station was innocent
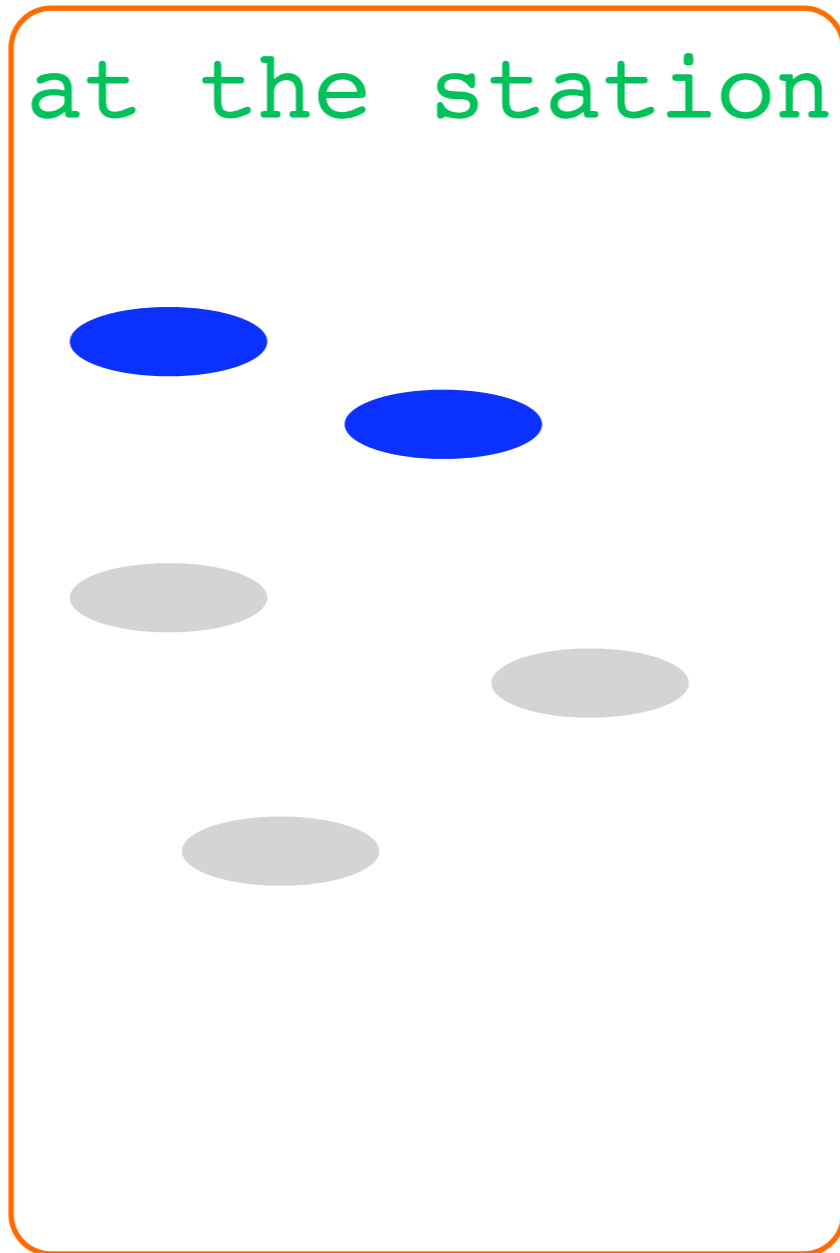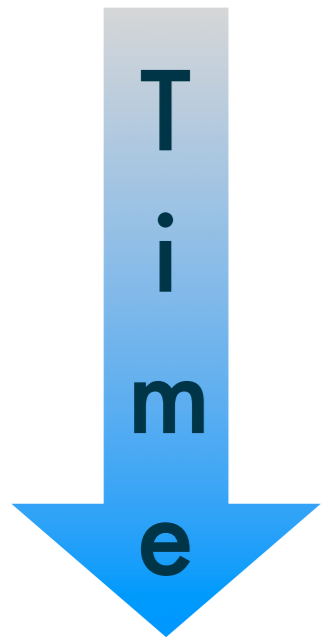
Time

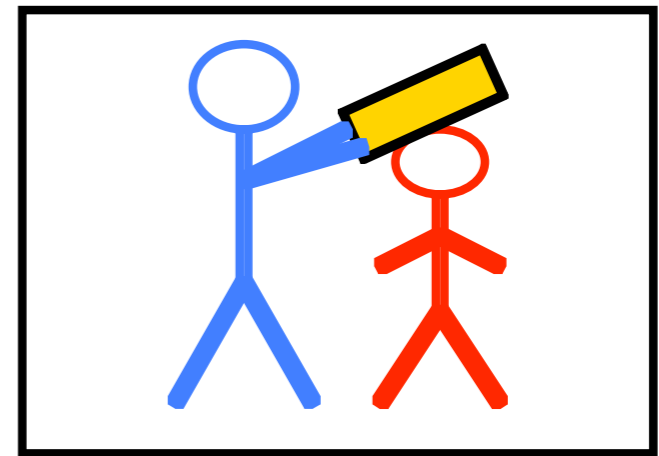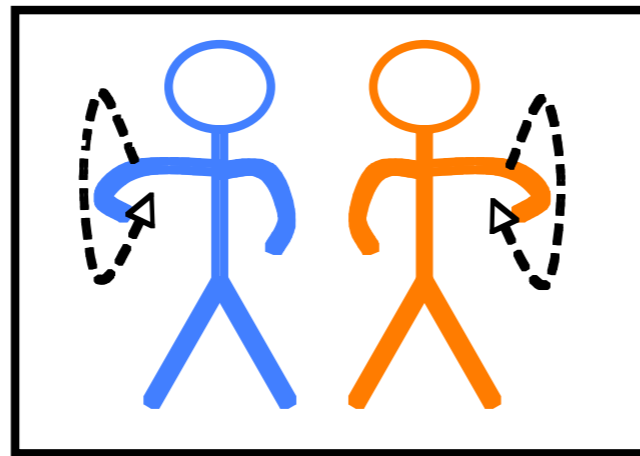# Eye-tracking: Total Time
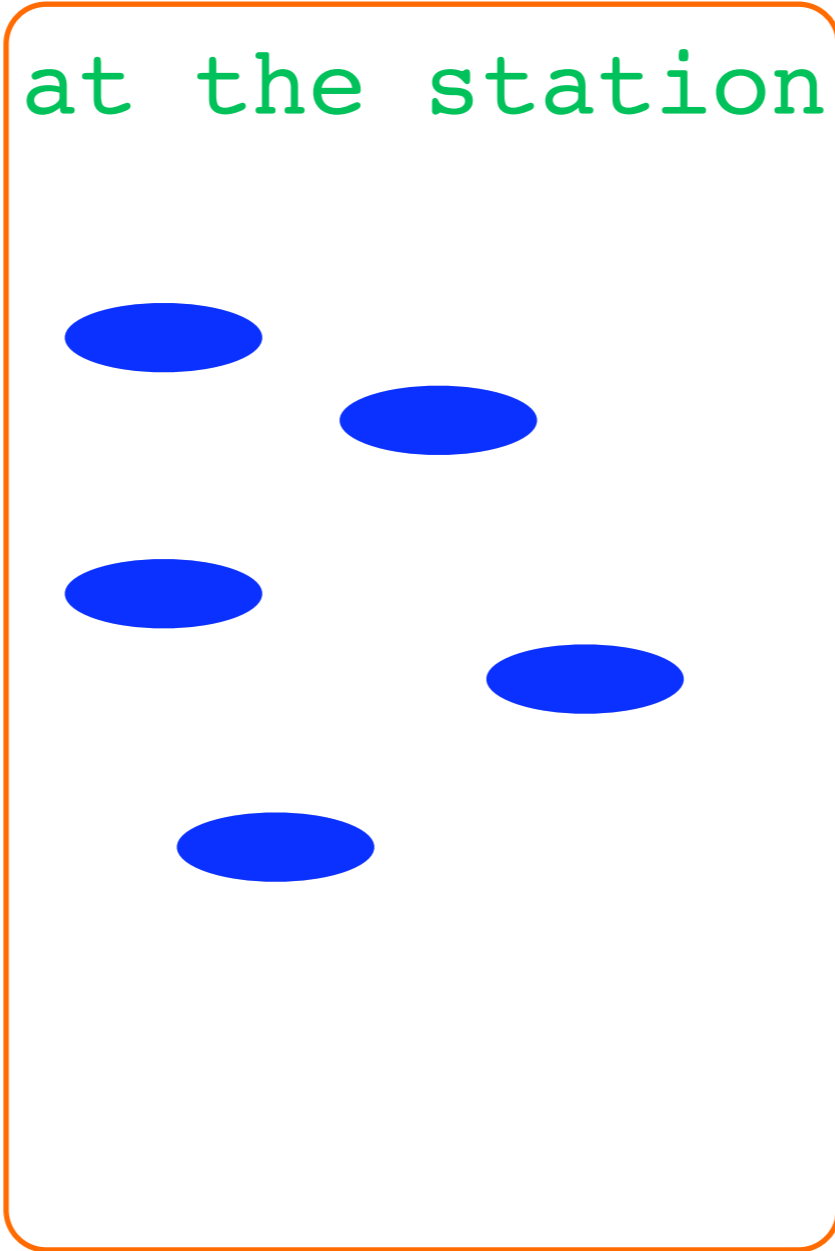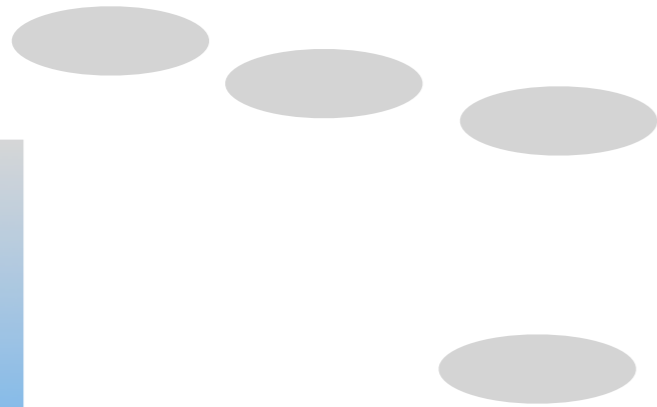
Eye-tracking: Regression Path

The man held at the station was innocent
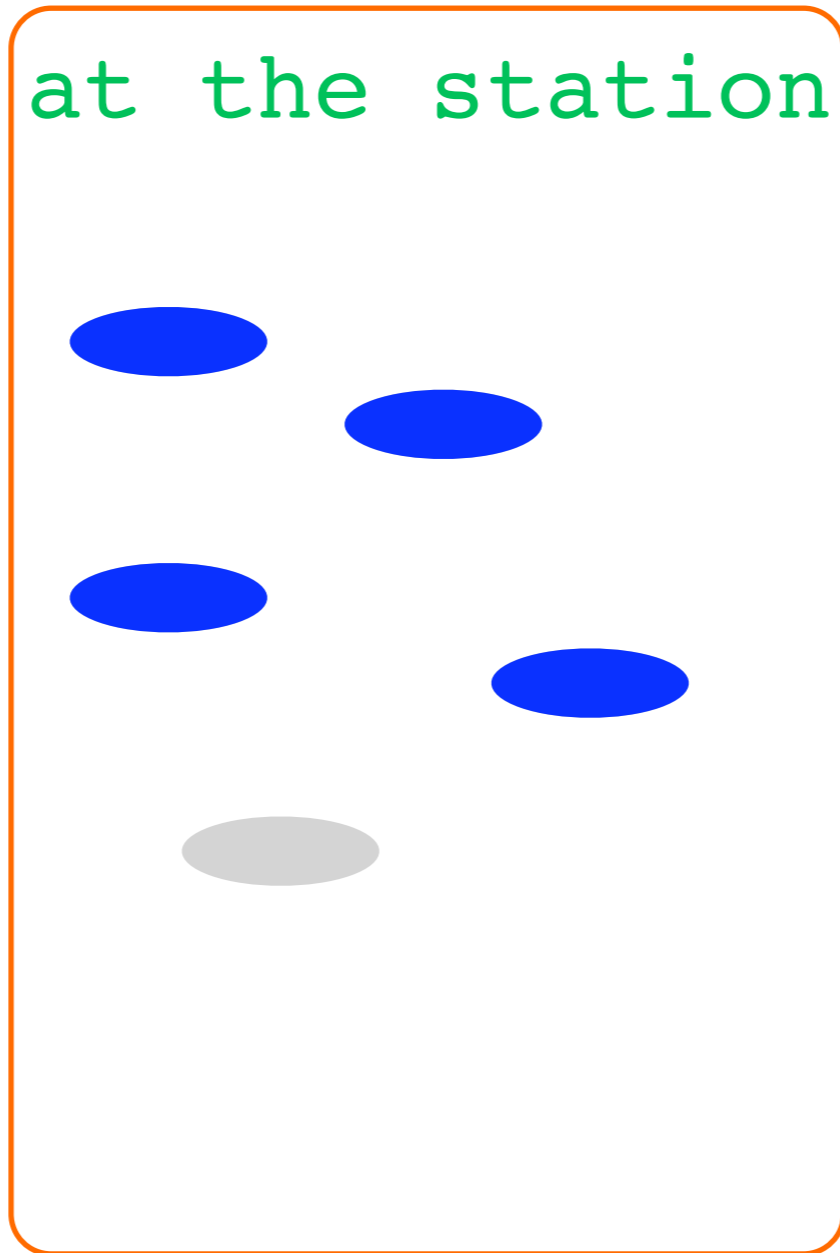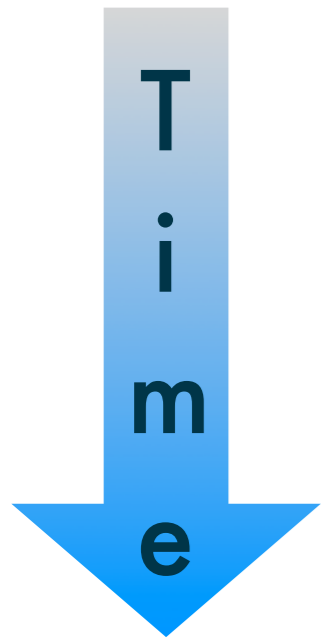
Preferential-looking Studies

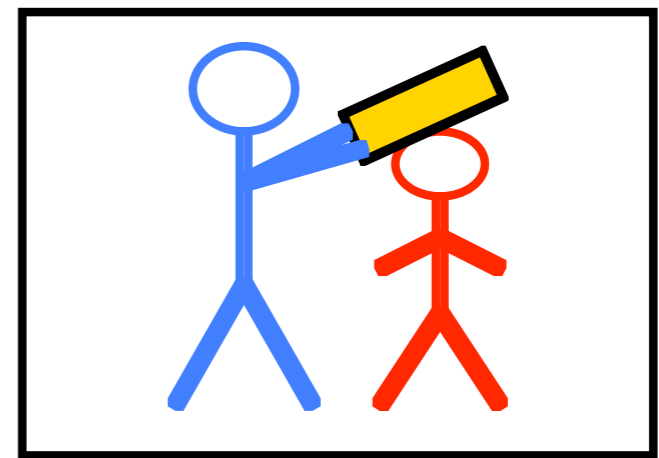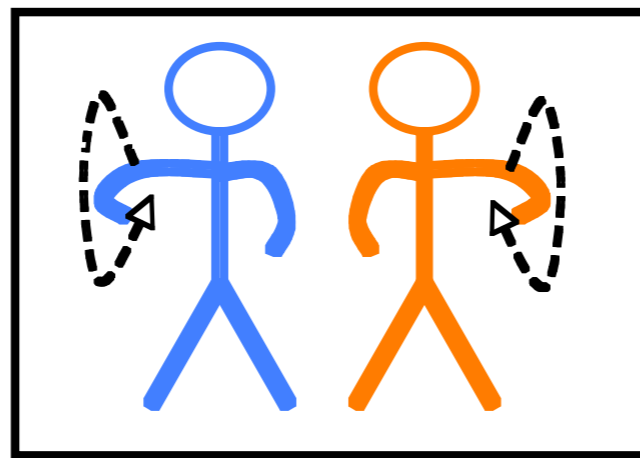- Monitor infants' preference of visual stimuli based on linguistic stimuli

Preferential-looking Studies

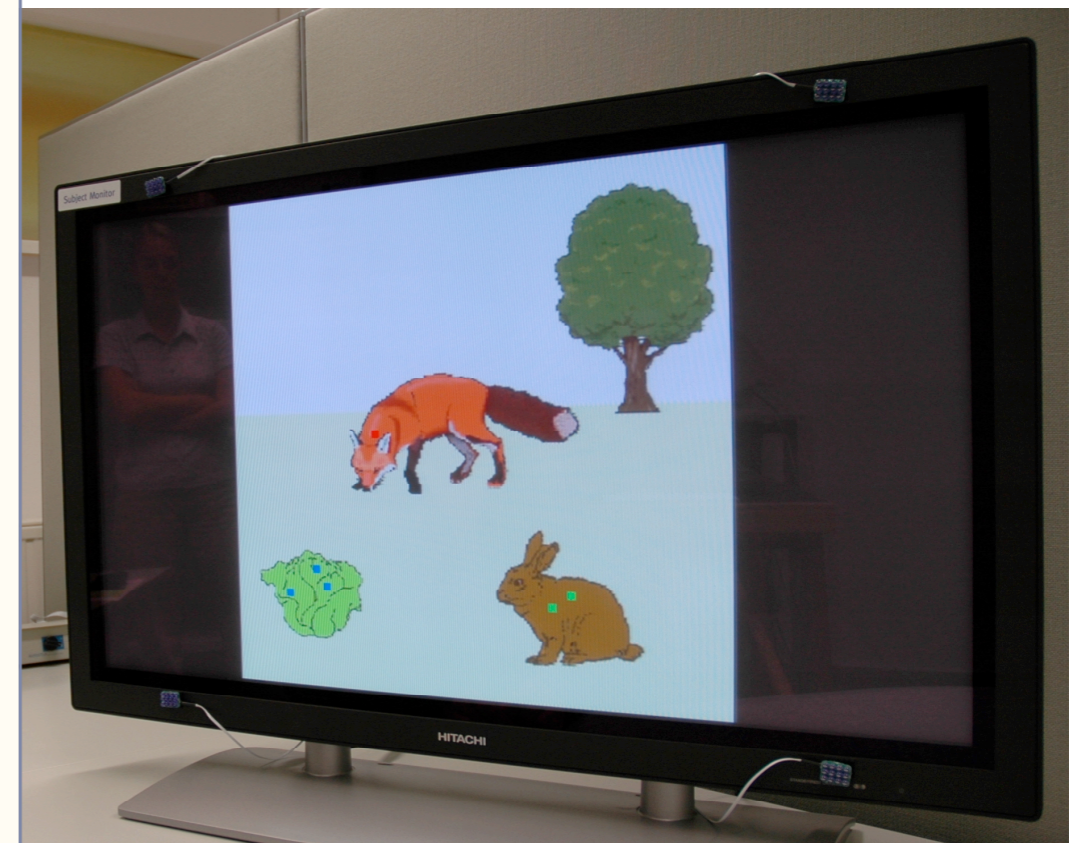- Monitor infants' preference of visual stimuli based on linguistic stimuli
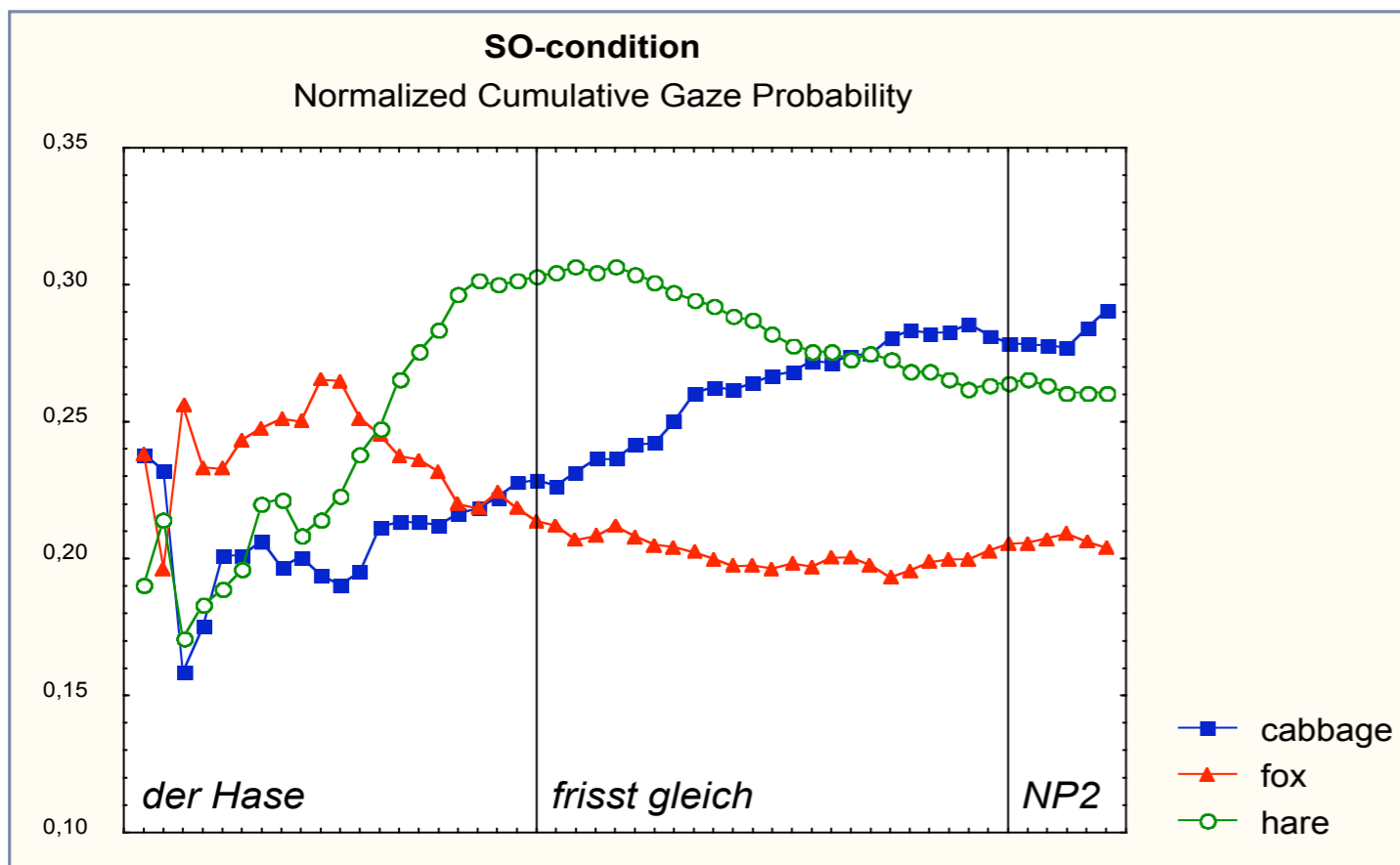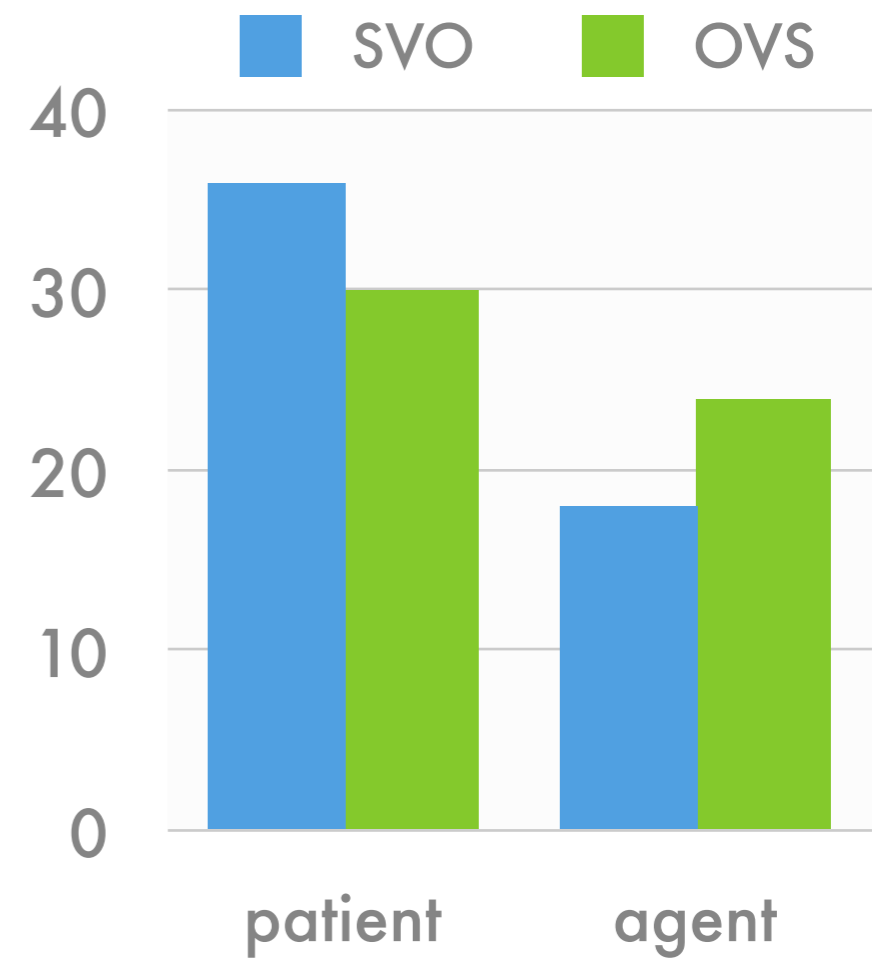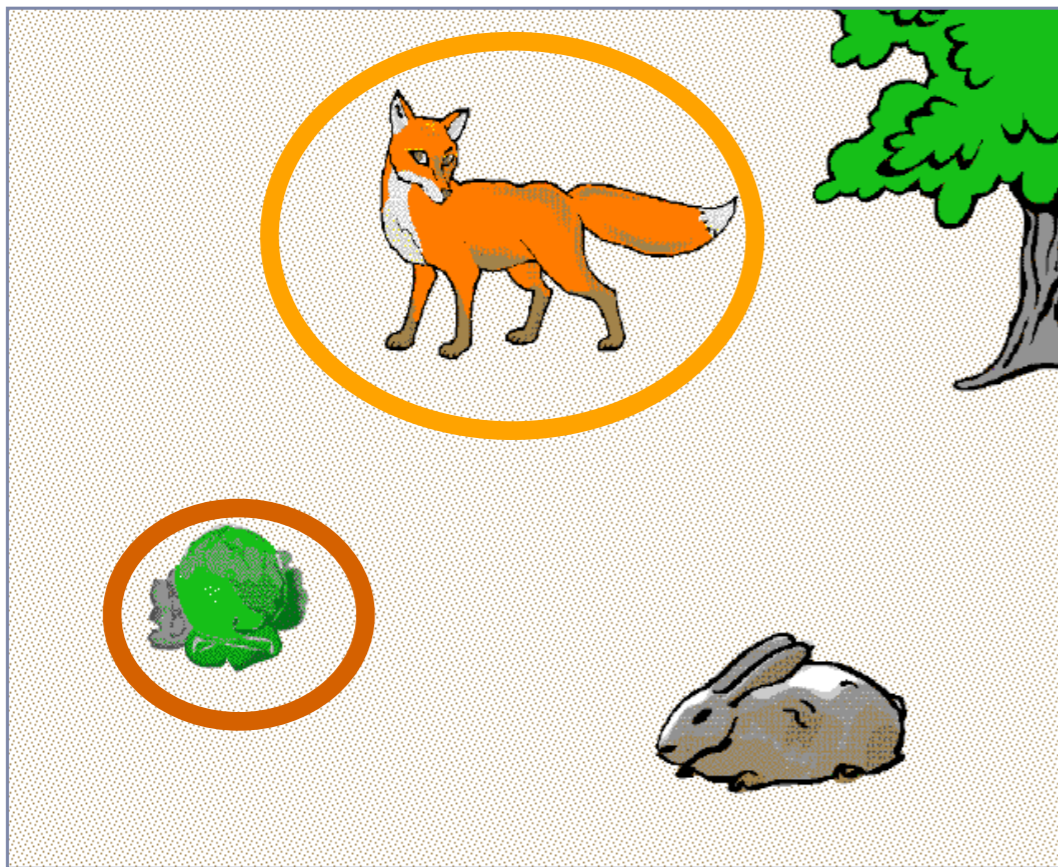
Comprehension in Visual Scenes

- Monitor gaze as people hear a spoken utterance

  - listeners fixate objects which are mentioned

  - anticipatory eye-movements reflect interpretation

# Anticipation in Visual Worlds

SVO: *Der Hase frisst gleich* **den Kohl**
"The rabbit eats soon the cabbage"
OVS: *Den Hasen frisst gleich* **der Fuchs**
"The rabbit is eaten soon by the fox"

Kamide, Scheepers & Altmann, *JPR,* **2003**

Neuroscientific Measures

- Event-Related Potentials (ERPs)

    - syntactic and semantic processes are partially revealed by patterns in EEGs

- Syntactic Anomaly

    - P600 or SPS

- Semantic Anomaly
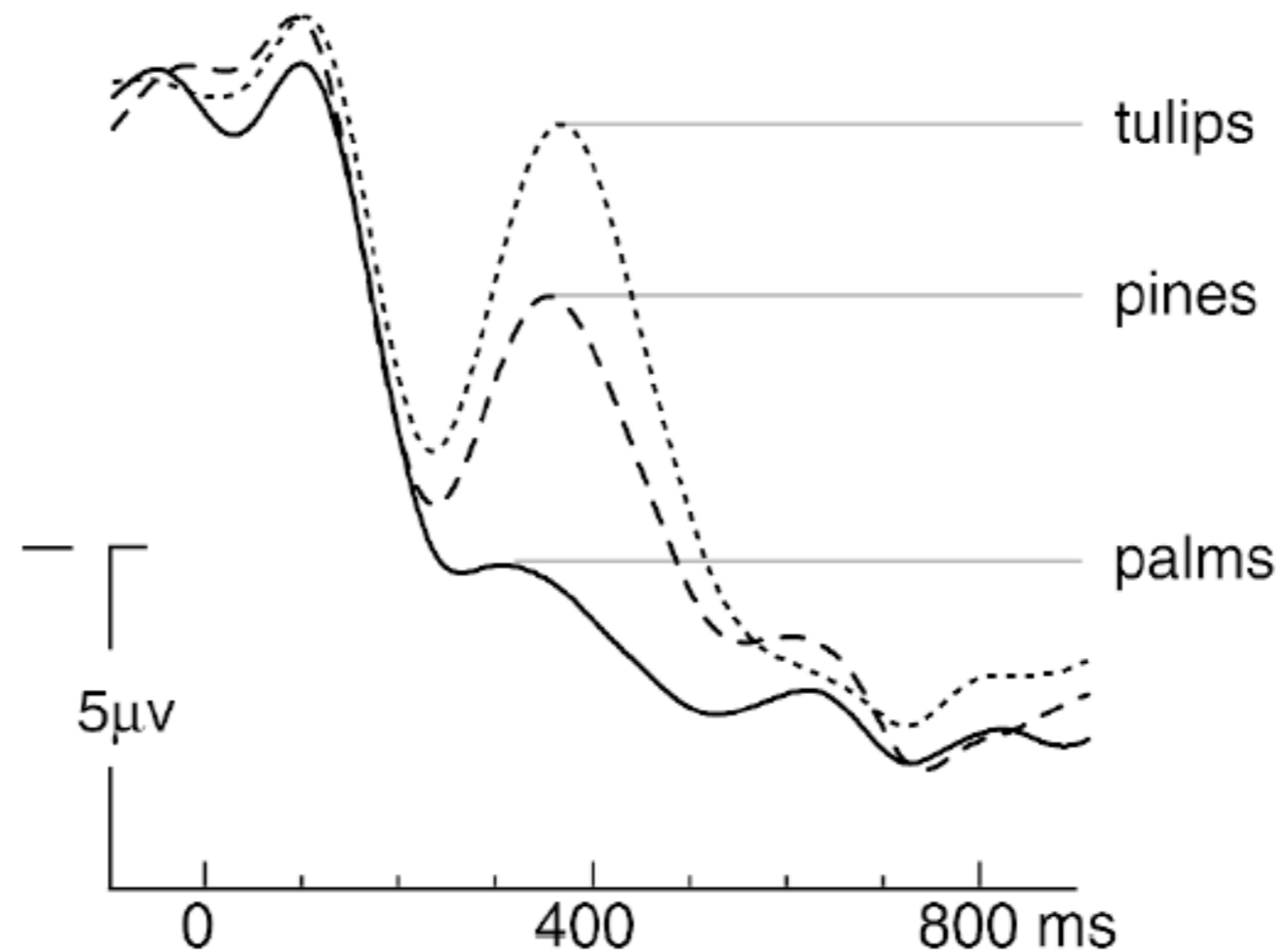
    - N400

Syntactic Anomaly: P600
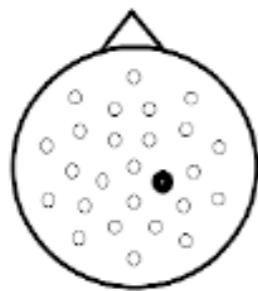

Number agreement, normal prose
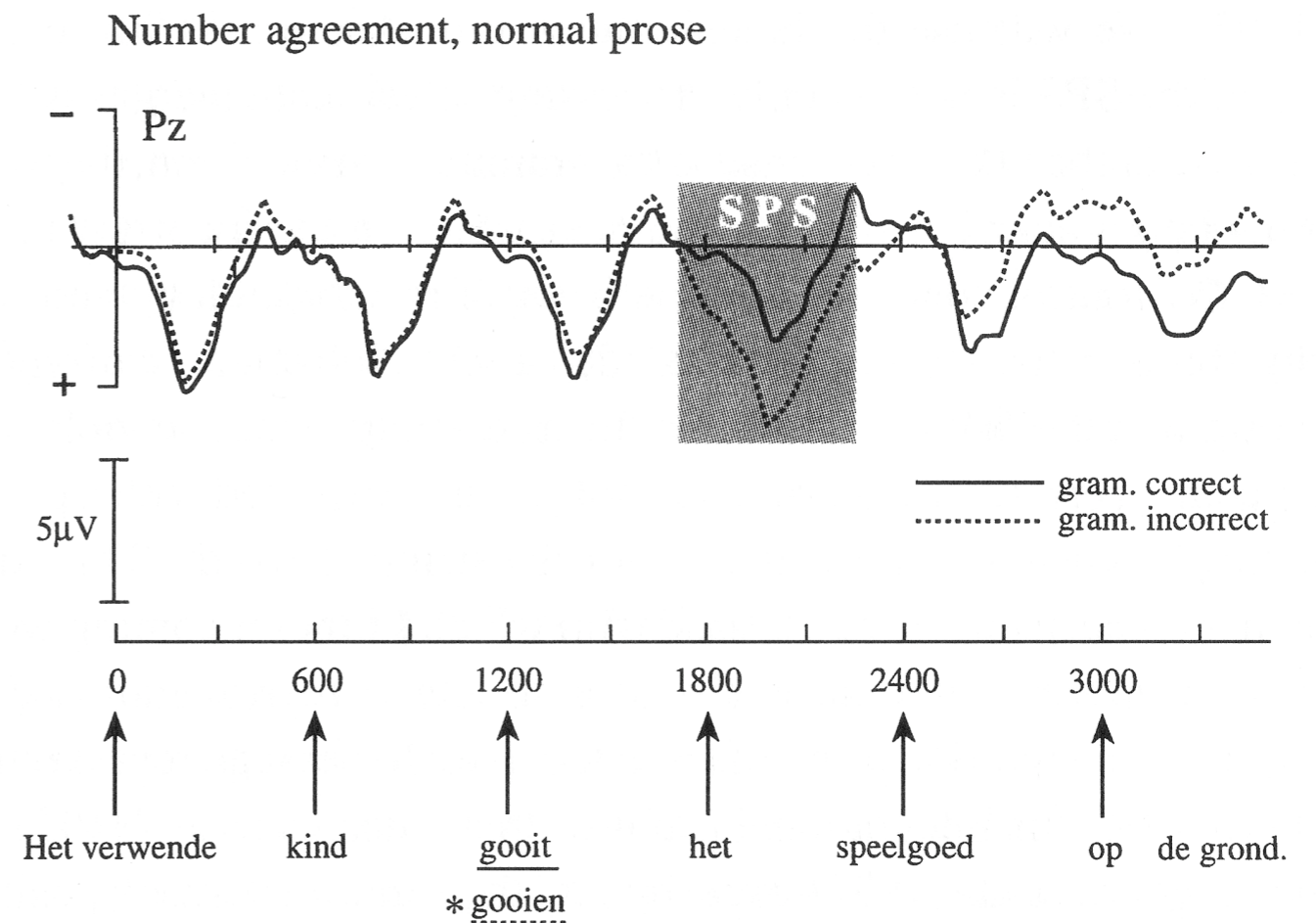
"The spoilt child throw(s) the toy on the ground"

Semantic Anomaly: N400

'They wanted to make the hotel look more like a tropical resort. So along the driveway they planted rows of ...'

R. medial central

tulips

pines

palms

5μv

0   400   800 ms

trends in Cognitive Sciences

Linking Hypotheses

- Reading times: relative processing difficulty

  - correlated with processing complexity and reanalysis

- Visual attention: reference and anticipation

  - correlated with interpretation and inference

- N-400: semantic anomaly

  - correlated with semantic integration

Summary

- People construct interpretations word-by-word

  - people must resolve ambiguity

  - sometimes they must revise their interpretation of the sentence so far

- On-line measures can tell us about how/when this occurs

  - reading times, ERPs, gaze in visual scene

Modularity Revisited

- Does incremental language processing challenge the notion of modularity?

  - e.g., evidence from studies on spoken comprehension in visual scenes

- What does the close mapping from speech to visual attention imply for the modularity thesis?