The contents of predictions in sentence comprehension: Activation of the shape of objects before they are referred to
J. Rommers, A.S. Meyer, P. Praamstra, F. Huettig

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Upcoming words are predicted by readers/listeners (Kamide et al., 1999)

- Reported in
  - Eyetracking
  - EEG
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What kind of information is predicted?
- Semantic features, e.g. eatability (Altmann & Kamide, 1999)
- Semantic categories, e.g. palms/pines/tulips (Kutas & Federmeier, 2000)
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• Shape similarity is used when a word is read/heard, e.g. rope/snake (Dahan & Tanenhaus, 2005)
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Question:
Is shape information also predicted?
Is Shape Predicted?

Contra:
Mostly not relevant for understanding the meaning

Pro:
All associated information could get activated

May also depend on the task
Experiment 1 - Visual World Paradigm

- Hear:
  - Predictive sentence
  - avg. probability .72 (determined in cloze task)
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  - 500 ms before word
  - Picture of 4 objects
  - 3 distractors, target/shape competitor/unrelated
  - Control for familiarity, complexity, name agreement
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  - Look and listen
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**Question:**
Anticipatory eye movements to target/shape competitor/control object?
Experiment 1

- Experiment
  - 96 trials, 32 fillers
  - Sentence/critical object once per participant
  - Critical objects appear in all three conditions
  - Sentences have the same distractors in all conditions

Participants
- 45 participants (34 female), mean age 21
- Dutch native speakers
- Normal hearing, normal/corrected seeing

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In 1969 Neil Armstrong was the first man to set foot on the moon.
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Control

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Results

- General:
  - Less fixation of distractors when target present
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- **General:**
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- **Anticipation:**
  - -250 - 200ms
  - target > competitor > control
  - control = distractor
Results

- Eye movements to predicted item
- More eye movements to shape competitor than to control object
- Conclusion: Shape is predicted (weak effect)

but...
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- Visual presentation may trigger physical properties
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but...

- Visual presentation may trigger physical properties

Question:
What happens if visual stimuli are absent?
Experiment 2 - EEG

- Hear:
  - Predictive sentence
  - Final word: target/shape competitor/unrelated
  - control for shape-similarity, plausibility
  - avg. similarity (1-7):
    - Competitor: Mean = 4.2, SD = .9
    - Control: Mean = 1.9, SD = .7
Experiment 2 - EEG

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- **Instruction:**
  - Listen for comprehension
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**Question:**

N400 effect on target/shape competitor/control words?
N400 (Kutas and Hilyard, 1980)
Experiment 2

- Experiment
  - 32 trials, 64 fillers, 3 lists
  - 50% semantic violation
  - Critical word once per participant
Experiment 2

- **Experiment**
  - 32 trials, 64 fillers, 3 lists
  - 50% semantic violation
  - Critical word once per participant

- **Participants**
  - 24 participants (20 female), mean age 20
  - Dutch native speakers
  - Normal hearing, normal/corrected seeing
  - Right handed
Items

Correct
In 1969 Neil Armstrong was the first man to set foot on the moon.

Shape Competitor
In 1969 Neil Armstrong was the first man to set foot on the tomato.

Unrelated
In 1969 Neil Armstrong was the first man to set foot on the rice.
Experiment 2: EEG

Results

General:
- Difference starts at $\sim 150$ ms

Distribution: more frontal

N400 effect:
1. Semantic violation
   - control $>$ target
   - competitor $\approx$ control
   - competitor $<$ control
Results

- **General:**
  - Difference starts at $\sim 150$ms
  - Distribution: more frontal
  - N400 effect: Semantic violation

- **N400 effect:**
  - control $>\,$ target
  - competitor $>\,$ target
  - 1. competitor $\approx$ control
  - 2. competitor $<$ control
Results

- Smaller amplitude for competitor
Results

- Smaller amplitude for competitor
- Difference control/competitor at 500 - 700 ms (still N400?)
  - + Design: Auditory experiment, word length
  - + Acoustic vs semantic difference
  - - Lower priority for shape information
  - - Shape only activated after mismatch
  - → effect more important than N400

Summary

- Shape effect in both experiments
- Smaller effect than for semantic features
- Shape can be activated without visual context (but not necessarily is)
- Further research: When and why does shape prediction occur?
Results

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Problems

- No comprehension-questions
  - Attention guaranteed?
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- No comprehension-questions
  - Attention guaranteed?
- No clear results
  - Small effect in experiment 1
  - No real N400-effect in experiment 2

Hard to control

Influence of shape
→ what else may influence results? e.g. color...

Which kind of prediction?
Word-to-word association (Neil Armstrong → moon) instead of real anticipation?
Problems

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- No comprehension-questions
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  - Small effect in experiment 1
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  - Influence of shape → what else may influence results? e.g. color...
- Which kind of prediction?
  - Word-to-word association (Neil Armstrong → moon) instead of real anticipation?
Individual differences in language processing e.g. literacy (Huettig, 2011)
Individual Differences

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- Shape prediction may correlate with:
  - Anticipatory attention
  - Vocabulary size
  - Verbal fluency
  - Fluid intelligence (problem solving, pattern recognition)
Individual differences in language processing e.g. literacy (Huettig, 2011)

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- Visual-World-Experiment as before

- Additional tests for individual differences
Tests

- **Category fluency**
  - Produce as many items of a category as possible within 1 min
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  - Location-cue:
    - 50% neutral
    - 50% < or >, 80% validity
  - Press button left/right, where X appears on a screen
  - Measured: ∆reaction time: neutral vs valid
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- **Raven’s Advanced Progressive Matrices**
  - Chose 1 of 8 possible geometric patterns to complete a matrix
Results

- Results of Eyetracking:
  - Comparable to experiment 1
Results

- Results of Eyetracking:
  - Comparable to experiment 1
- Results of Cueing-Task:
  - Cueing-effect found
Correlations

- More fixations of target object:
  - High vocabulary scores
  - High category fluency
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  - High sensitivity to cues
    - Maybe timing instead of effect size?
  - Low fluid intelligence
    - May also be related to working memory capacity, ability to suppress distractors
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Summary

- Lexical knowledge improves anticipation of target words
- Anticipatory attention influences verbal and non-verbal tasks.
References

Marta Kutas, Steven A. Hillyard (1980)
Reading senseless sentences: Brain potentials reflect semantic incongruity
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The contents of predictions in sentence comprehension: Activation of the shape of objects before they are referred to
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*Atten Percept Psychophysics* Volume 77(3), April 2015, Pages 720-73
Thank you for your attention!
### Correlations

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*Significant correlations marked with stars:* *

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