Modelling the Effects of Formal Literacy Training on Language Mediated Visual Attention

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Background

Visual World Paradigm

Participants view a visual display and hear a spoken utterance while their eyegaze is recorded. Here, the display varies in their relationship (e.g. semantic or phonological) to the spoken target word.

Method

Neural network model with four visible layers connected via a central resource (400 units):
- Vision Layer: Provides input of visual information from four locations in the visual field (80 units)
- Semantic Layer: Allows model to learn semantic properties (160 units)
- Auditory Layer: Provides time variant auditory input (60 units)
- Eye Layer: Unit activation represents fixation associated region of visual field (4 units)

Artificial Corpus:
- 200 items: each form has unique
  - visual representation
  - semantic representation
  - auditory representation
- Competitors & Targets embedded: Competitors and Target share additional properties in a single modality of representation

Theoretical Model

Literate improves phonological processing
- Castro & Snowling, 2004; Monaghan, Caramazza, & Butterworth, 1997
- Muter, Hulme, & Snowling, 1997
- Literates also display...
  - Reduced sensitivity to fine grain differences of the spoken signal (Muter, Hulme, & Snowling, 1997)
  - High phonological awareness (Reis & Castro, 2005)
  - Phonological segmentation (Caldas, 1997)
  - Semantic processing affected by semantic overlap (Hulme, 2002)

Psycholinguistic Grain Size Theory

(Engle &(forms 1997)
- Process in written words results in a change in the granularity of processing of words
- Literates, and therefore more likely to process the sounds of a word at a larger grain size

Research Question

Can differences in the granularity of speech processing offer explanation for differences observed between High and Low Literates in Language Mediated Visual Attention?

Training

Models were trained on 4 tasks to simulate prior knowledge about words’ sound, meaning, and visual form:
- Vision → Semantics (Accuracy = 97.98%)
- Auditory → Semantics (100%)
- Vision → Semantics + Location (99%)
- Vision + Auditory → Location (96-98%)

Models:
To simulate different grain-sizes of speech representation from three forms of auditory input were constructed:
- Finer models differ only in respect to the granularity of auditory representations
- Overall similarity between representations was controlled.

Testing:
Models were tested on scenes containing:
- 1 auditory competitor
- 1 semantic competitor
- 2 unrelated distractor

Granularity of Speech Processing

Coarse
- Representation: 1 component per word
- All components unique
- 60 features per component

Results:
- Coarse model only model NOT to display early preference for phonological competitor

Moderate
- Representation: 2 components per word
- All components unique
- 30 features per component

Results:
- No difference between models in fixation of phonological competitor

Fine
- Representation: 6 components per word
- Set of 20 possible components
- 10 features per component

Results:
- Interaction between model and time with models more differentiated in time steps 7–20.

Conclusions

- Differences in the granularity of speech processing can lead to modulation of the phonological effect in language mediated visual attention
- The results of Huettig, Singh and Mishra (2011) are consistent with the argument that formal literacy training leads to increased granularity in speech processing
- However: 1) Very Coarse grain structure is required to eliminate the phonological effect as observed in Low Literates
- Therefore, either speech processing in low literates relies on very coarse grained representations or literacy leads to a tighter coupling between activation of fine grained linguistic representations and the control system eye movements.
- 2) Differences in the granularity of speech processing do not explain differences in fixation of semantic competitors
- An additional mechanism is required to explain the quantitative difference in sensitivity to semantic overlap displayed between High and Low literates.

(e.g. General Processing Speed: Salthouse, 1996)

References

4. Literacy improves phonological processing.  
7. Literates also display...  
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