Reading Comprehension Ability and Semantic Activation to Single Words and Discourse

An fMRI Partial Least Squares Analysis

Kayleigh Ryherd[1], Emily Baron[2], Kaja Jasinska[2], W. Einar Mencl[2], Nicole Landi[1, 2, 3]

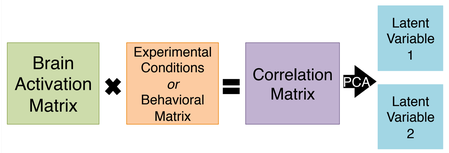
[1]University of Connecticut, Dept. of Psychology & Language Plasticity IGERT; [2]Haskins Laboratories; [3]Yale Child Studies Center

Introduction

Some children exhibit reading comprehension (RC) deficits despite intact word reading and phonological processing (Nation & Snowling, 1998). We propose that these deficits may be due to **weak semantic processing systems** for printed and spoken language comprehension.

Here we examine neural activity (with fMRI) underlying both word- and passage-level processing in the visual and auditory modalities and its relation to RC using Partial Least Squares analysis (PLS).

PLS



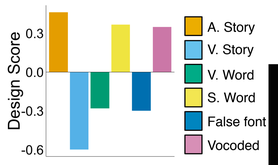
- Multivariate data-driven method
- Identifies relationships among variables without pre-specified contrasts.

Task PLS: Brain activation & experimental conditions.

Behavioral PLS: Brain activation and behavioral data

Design scores: how each LV relates to the conditions of the experimental design.

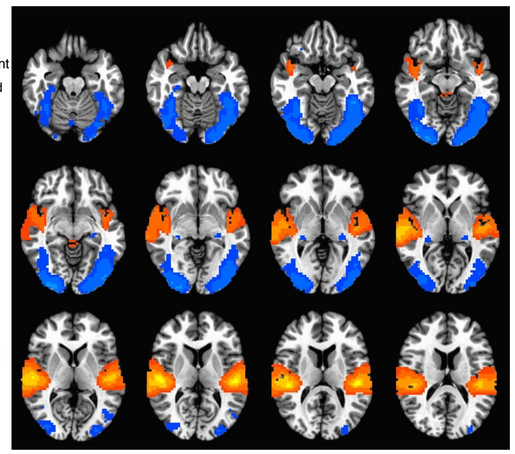
Results I: Task PLS



Hypothesis 1

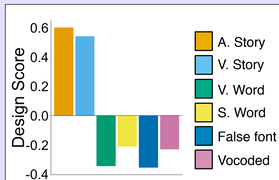
Blue regions show more activation during **visual** conditions.
- fusiform gyrus/ visual wordform area (VWFA)
- extrastriate cortex

Red regions show more activation during **auditory** conditions.
- superior temporal gyrus (STG)



LV 1

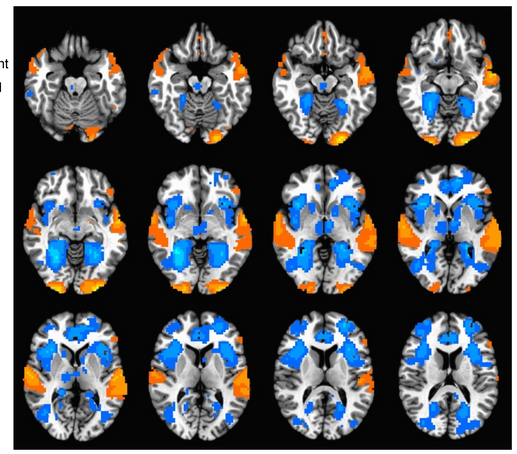
50.93% of covariance, $p < 0.001$



Hypothesis 2

Blue regions show more activation during the word task.
- anterior cingulate cortex (ACC)
- Dorsolateral prefrontal cortex (DLPFC)

Red regions show more activation during the story task.
- MTG
- Left inferior frontal gyrus pars orbitalis (LIFGpo)



LV 2

41.33% of covariance, $p < 0.001$

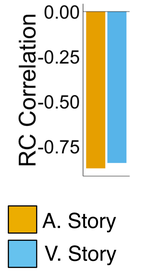
Hypotheses & Methods

Modality & Processing-level Hypotheses:
1) Print and speech conditions should dissociate across tasks.
2) Story and Word tasks should dissociate.

Reading Comprehension Hypotheses:
3) RC is related to activation in semantic areas during passage comprehension, regardless of modality.
4) RC is related to the difference in activation in semantic areas during written word and passage comprehension.

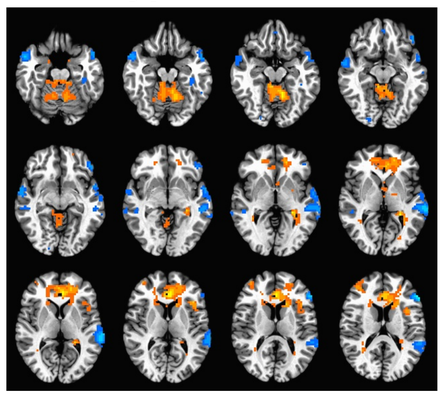
Two fMRI tasks (N = 32, M Age = 17, 14 M):
- **Word Task** (4 event types) *event-related*
  - Visual word: Printed real words, e.g. roof
  - Spoken word: Spoken real words, e.g. "post"
  - False font: Printed symbols, e.g. ♦□♓●
  - Vocoded speech
- **Story Task** (2 block types) *block*
  - Excerpts of a narrative presented aurally (Audio condition) or visually (Visual condition)
- **Behavioral Measures**
  - Kaufman Test of Education Acheivement (KTEA) reading comprehension

Results II: Behavioral PLS



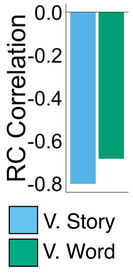
Hypothesis 3

84.52% of covariance $p < 0.001$



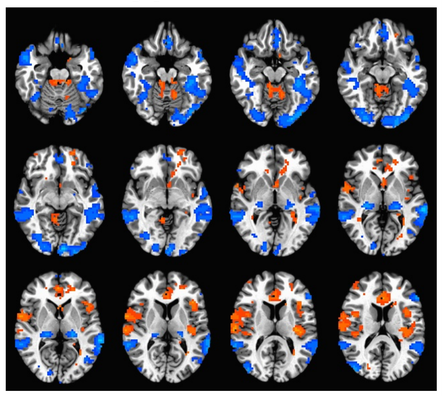
Better comprehenders (BC) activate in **blue**:
- LIFGpo
- MTG

Poor comprehenders (PC) activate in **red**:
- ACC
- Insula
- Parahippocampal gyrus



Hypothesis 4

62.68% of covariance $p < 0.001$



Better comprehenders (BC) activate in **blue**:
- VWFA
- Inferior/middle occipital
- LIFG pars triangularis, MTG

Poor comprehenders (PC) activate in **red**:
- ACC
- insula

Discussion

Modality & Processing Level

1) Visual areas do activate differently than auditory areas in visual vs. auditory conditions of both tasks.
2) Areas involved in comprehending sentences activate more in the story task, and regions involved in cognitive control and switching among stimuli activate more in the word task.

Reading Comprehension

3) BC show more semantic activation regardless of modality.
4) BC show more visual and semantic activation during printed single words and passages. PC show phonological processing and cognitive control.

Conclusion: Comprehending speech and print is effortful for PC and involves less semantic processing. Their decoding is adequate but possibly less efficient than better comprehenders'.

Future Directions: Do PC have trouble attaching word labels onto concepts? What kind of information can they use to create a novel semantic representation?