Neural correlates of treatment effects on abstract and concrete words in aphasia: A pilot study

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Background

- Behavioral data from both normal and brain-injured subjects suggests that abstract words and concrete words are processed differently (i.e., ***concreteness effect***). For example, the Dual Coding Theory (Paivio, 1991) suggests that ***abstract*** words are encoded into the semantic system with only verbal information and ***concrete*** words are encoded into the semantic system with both verbal and multi-modal sensory information.
- Evidence from recent neuroimaging studies suggests the possibility of ***dissociable neural correlates*** for abstract and concrete word processing (Binder et al., 2009, Sandberg & Kiran, manuscript in preparation).
- Patients with ***aphasia*** exhibit an ***exaggerated concreteness effect*** behaviorally (Nickels & Howard, 1995; Barry & Gerhand, 2003) and concreteness has been successfully manipulated in treatment to increase effectiveness (Kiran, Abbott, & Sandberg, 2009).
- Do neural activation patterns following the treatment of abstract words support the hypothesis that training complex (abstract) concepts engages the less complex (concrete) concept network?

Participants

Patients with aphasia

- *N*=3; R-handed; monolingual English-speaking
- CVA in LH with subsequent difficulties in word retrieval

	Age	Sex	MPO	Aphasia Type	Severity (WAB AQ)	BNT
P1	56	F	39	Anomia	96.7 (very mild)	93.3%
P2	55	M	77	Conduction	77.7 (mild to moderate)	86.7%
P3	59	M	25	Transcortical Motor	82.2 (mild to moderate)	83.3%

Note: MPO = months post onset; WAB AQ = Western Aphasia Battery Aphasia Quotient; BNT = Boston Naming Test

Treatment Protocol

Semantic Feature Analysis (variation of Boyle & Coelho, 1995)

- Training set of 10 words
- For each word, participant:
  1. Chooses 6 features that belong to the word
  2. Answers 15 yes/no questions about the word
  3. Identifies whether word is abstract or concrete
  4. Generates a synonym for the word

P1: 10 weeks of treatment; *abstract* words in context of *hospital*

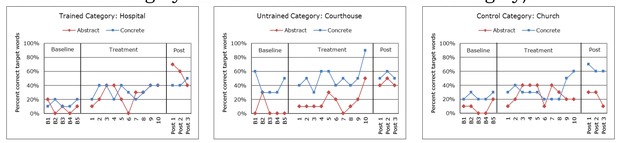
P2: 4 weeks of treatment; *abstract* words in context of *hospital*

P3: 10 weeks of treatment; *abstract* words in context of *courthouse*

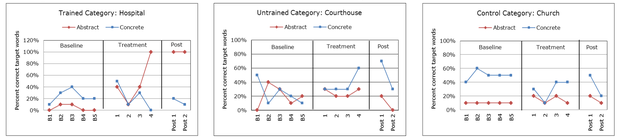
- Untrained contexts used as controls

Treatment Results

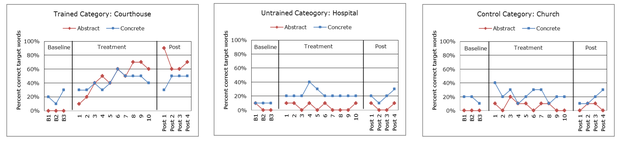
P1: Improved on trained abstract items; generalized to concrete items in same context (also slightly improved on abstract items in untrained category and concrete items in control category).



P2: Improved on trained abstract items only.



P3: Improved on trained abstract items; generalized to concrete items in same context.



fMRI Paradigm

- Event-related design
  - 3T Phillips; T1 structural: TR=26ms, 128 1.3mm slices; BOLD: TR=2000ms, 31 3mm slices
- Patients scanned both before and after treatment, data analyzed with SPM8

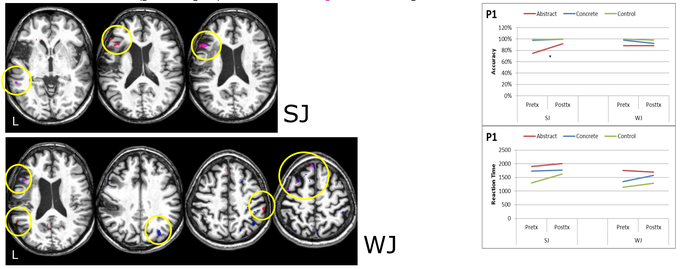
Tasks

- Word Judgment
  - 50 abstract / 50 concrete words
    - 25 vowel / 25 consonant strings
  - Is the word abstract or concrete?
  - Is the letter string consonants or vowels?
- Synonym Judgment
  - 50 abstract / 50 concrete word pairs
    - 100 nonword pairs
  - Are these words similar in meaning?
    - Are these nonwords the same?

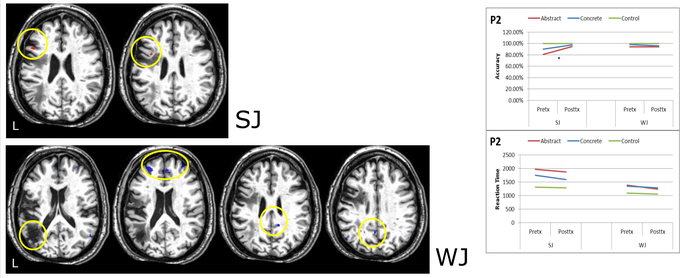
	Word Judgment Task	Synonym Judgment Task
Response type	button press	button press
Pseudo-randomized ISI (fixation cross)	2/3/4 sec	2/3/4 sec
Stimulus duration per run	50 stimuli x 4 sec = 200 sec	50 stimuli x 4 sec = 200 sec
runs, items per run	3 runs, 50 items per run	4 runs, 50 items per run

fMRI Results

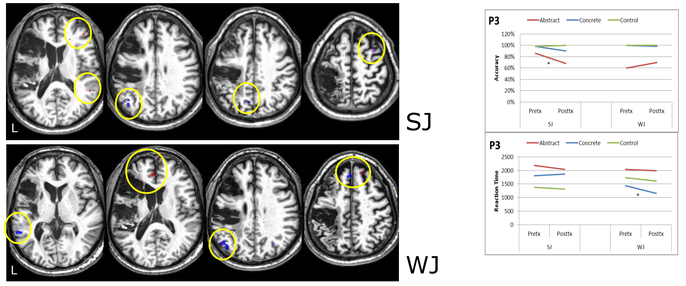
Legend: Red = activation for abstract > control (post > pre) contrast, Blue = activation for concrete > control (post > pre) contrast, Purple = overlap in activation.



P1: Showed increased activation from pre to post-treatment with overlap between abstract and concrete words. Note that more perilesional activation occurred with abstract words and accuracy for abstract words improved during the synonym judgment (SJ) task.



P2: Like P1, showed increased activation post-treatment, but only for abstract words during the SJ task and concrete words during word judgment (WJ). Note that increased activation for abstract words was accompanied by increased accuracy during the SJ task.



P3: Like P1 and P2, showed increased activation post-treatment. Furthermore, he showed increases for both abstract and concrete words in distinct regions. Note this coincides with treatment outcomes.

Discussion

- All three patients improved on the trained abstract words; two patients also generalized to concrete words in the same context.
- All three patients showed increased activation in spared left hemisphere language areas after treatment. This supports the notion that better language recovery in chronic aphasia is associated with transfer of language function from compensation of the right hemisphere to spared language areas of the left hemisphere (Saur et al., 2006)
- In both P1 and P2, much of left IFG was spared by the lesion and in P1, much of the left temporal lobe was also spared; however, P3's lesion was quite large yet he showed similar results as the other two patients.
- Although abstract and concrete nouns tended to overlap in activation both before and after treatment, there were subtle differences that appear to be exaggerated after treatment, possibly becoming more 'normal'.
- Notably, the trained structure (abstract words) showed more increased activation than concrete words. This matches the behavioral results seen both during treatment and while scanning.

Conclusion

- These tentative results suggest:
  - Training abstract words increases activation in the abstract concept network.
  - Generalization from abstract to concrete words coincides with increased neural activation for concrete words in the concrete concept network.
- Note that these patients were more highly functioning than the average aphasic patient with highly accurate responses on the fMRI task even before treatment.
- Future research: utilize effective connectivity to tease apart distinctions between abstract and concrete word processing networks and recruit a larger, more diverse sample.

References

Barry, C., & Gerhand, S. (2003). Both concreteness and age-of-acquisition affect reading accuracy but only concreteness affects comprehension in a deep dyslexic patient. *Brain and Language, 84*, 84-104.

Binder, J. R., Desai, R. H., Graves, W. W., & Conant, L. L. (2009). Where is the semantic system? A critical review and meta-analysis of 120 functional neuroimaging studies. *Cerebral Cortex,* 1-30.

Boyle, M., & Coelho, C. A. (1995). Application of Semantic Feature Analysis as a Treatment for Aphasic Dysnomia. Am J Speech Lang Pathol, 4(4), 94-98.

Cabeza, R. (2001). Cognitive neuroscience of aging: Contributions of functional neuroimaging. *Scandinavian Journal of Psychology, 42*, 277-286.

Kiran, S., Sandberg, C., & Abbott (2009). Treatment for lexical retrieval using abstract and concrete words in persons with aphasia: Effect of complexity. *Aphasiology,* 23, 835-853.

Nickels, L., & Howard, D. (1995). Aphasic naming: What matters? *Neuropsychologia, 33*(10), 1281-1303.

Paivio, A. (1991). Dual coding theory: Retrospect and current status. *Canadian Journal of Psychology, 45*(3), 255-287.

Sandberg, C. & Kiran, S. (n.d.). Analysis of abstract and concrete word processing in persons with aphasia and age-matched neurologically healthy older adults using fMRI. *Manuscript in preparation.*

Saur, D., et al. (2006). Dynamics of language reorganization after stroke. *Brain, 129*(6), 1371-1384