Abstract and concrete noun processing in healthy older adults using fMRI

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*This work was completed at the University of Texas at Austin

Background

❖Behavioral data from both normal and brain-injured subjects suggests that abstract words and concrete words are processed differently

❖Dual Coding Theory (Paivio, 1991)

- ❖Suggests two systems for encoding words into semantic memory
  - ❖Verbal (linguistic): Abstract words are encoded into the semantic system with only verbal information
  - ❖Nonverbal (sensory): 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, 2007)

❖An issue yet unaddressed in the current literature is the processing of abstract and concrete nouns in normal, healthy older adults, although neural activation patterns in response to different cognitive processes has been shown to change as a function of age (Cabeza, 2001)

❖Patients with aphasia, who typically fall into the category of older adults, are hypothesized to use the right hemisphere for semantic processing instead of the damaged left hemisphere

❖If concrete words are processed bilaterally, then patients with aphasia will exhibit preference for concrete words, which has been shown behaviorally (Nickels & Howard, 1995; Barry & Gerhand, 2003; Kiran, Abbott, & Sandberg, 2009)

❖In order to test these hypotheses, we must establish a healthy older adult neural activation baseline against which to compare neural activation in patients with aphasia

Methods

Participants

❖N=10; 5 male, 5 female. Age range: 50-63 (Mean: 57).

❖Right-handed, monolingual English speakers

❖No history of neurological disease, trauma, or disorders. Normal cognitive and linguistic functioning.

Tasks

Lexical Decision (replicated from Binder et al., 2005)

❖50 abstract words, 50 concrete words, 100 pseudowords

Word Judgment

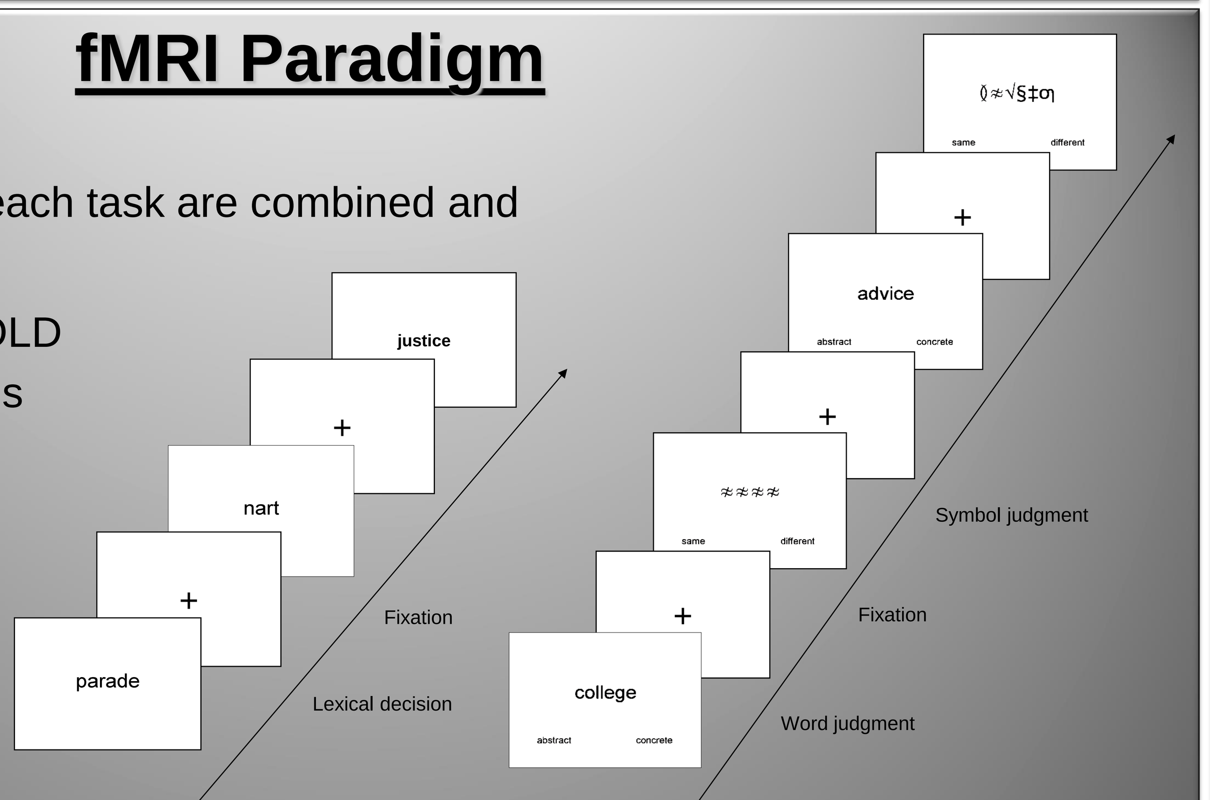
❖50 abstract words, 50 concrete words, 50 same symbol strings, and 50 different symbol strings

fMRI Paradigm

Event-related design

Experimental stimuli for each task are combined and randomly presented

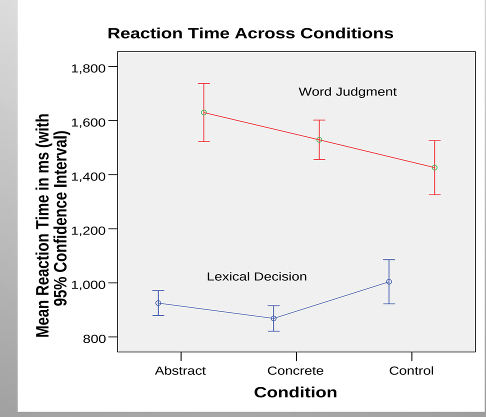
Allows for analysis of BOLD signal for each stimulus

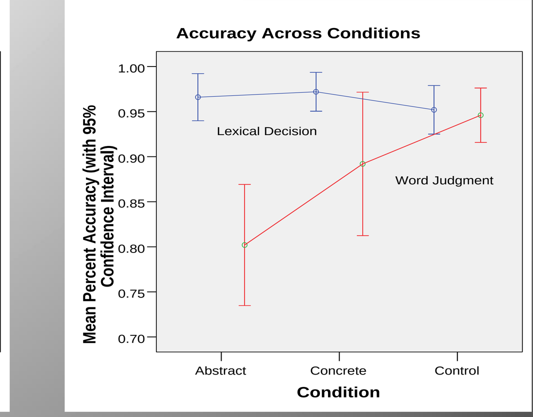


Task	Lexical Decision	Word Judgment
Example	*nart* - yes or no *parade* - yes or no	*advice* - abstract or concrete *college* - abstract or concrete *#####* - same or different *?*#!%* - same or different
Response type	button press	button press
Initial baseline	8 sec	8 sec
Pseudo-randomized ISI (fixation cross)	1.5/3.0/4.5 sec	1.5/3.0/4.5 sec
Total ISI duration per run	153 sec	153 sec
Stimulus duration per run	50 stimuli x 2 sec = 100 sec	50 stimuli x 3 sec = 150 sec
# runs, # items per run	4 runs, 50 items per run	3 runs, 50 items per run
Total time in minutes	17.4 minutes	15.6 minutes

Behavioral Results

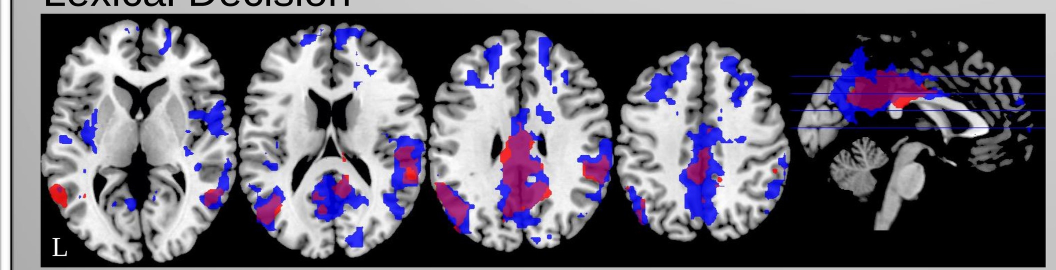
Lexical Decision	Reaction Time		Accuracy	
	Mean	SD	Mean	SD
Abstract	922.91	234.55	96.60%	18.14%
Concrete	869.71*	206.87	97.20%	16.51%
Control	1003.40*	256.23	95.10%	21.60%
Word Judgment	**Reaction Time**		**Accuracy**	
	Mean	SD	Mean	SD
Abstract	1629.30*	495.30	80.16%*	39.92%
Concrete	1524.40	490.54	89.16%	31.12%
Control	1420.90*	354.70	93.00%*	25.54%





fMRI Results

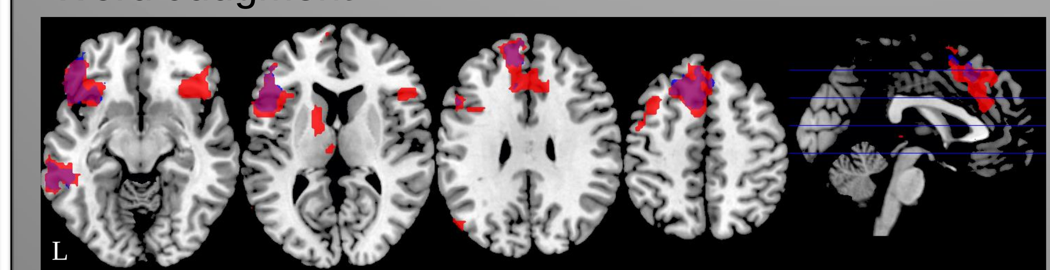
Lexical Decision



Red = activation during abstract word processing
Blue = activation during concrete word processing
Purple = overlap in activation

Abstract > Pseudoword: Structure	x	y	z	Z-score	Concrete > Pseudoword: Structure	x	y	z	Z-score
L Angular g.	-46	-68	36	3.17	L Angular g.	-44	-70	40	3.35
L Supramarginal g.	-60	-50	28	3.3	L Supramarginal g.	-58	-52	28	3.7
R Supramarginal g.*	58	-40	28	3.51	R Supramarginal g.*	58	-28	20	3.85
L Superior Temporal g.	-42	-56	12	3.17	L Superior Temporal g.	-56	-12	2	3.26
R Superior Temporal g.	54	-44	22	3.12	R Superior Temporal g.	64	-22	14	3.7
L Middle Temporal g.*	-62	-50	2	3.81	L Middle Temporal g.*	-48	-66	22	4.24
R Middle Temporal g.	52	-58	4	3.06	L Insula*	-40	-10	6	3.32
L Cingulate g.*	-4	-38	38	3.53	L Cingulate g.*	-8	-42	40	3.8
L Posterior Cingulate g.	-8	-56	24	3.33	L Posterior Cingulate g.	-2	-56	24	3.64
R Posterior Cingulate g.	10	-46	22	3.25	L Precuneus	-14	-52	24	3.66
L Precuneus	-8	-64	24	3.27	R Precuneus	10	-54	32	3.65
R Postcentral g.	54	-22	16	3.29	L Superior Frontal g.	-14	38	48	3.52
					R Superior Frontal g.*	18	40	42	3.33
					L Middle Frontal g.*	-34	28	40	3.63
*** = cluster peaks**					R Middle Frontal g.	30	22	44	3.19

Word Judgment

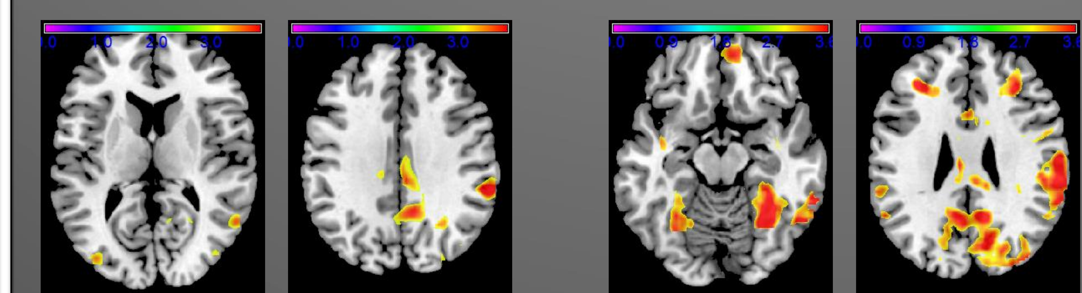


Red = activation during abstract word processing
Blue = activation during concrete word processing
Purple = overlap in activation

Abstract > Symbols: Structure	x	y	z	Z-score	Concrete > Symbols: Structure	x	y	z	Z-score
L Inferior Frontal g.*	-54	30	-6	4.99	L Inferior Frontal g.*	-52	22	-8	4.59
R Inferior Frontal g.*	36	24	-8	3.95	L Medial Superior Frontal g.*	-10	50	36	4.66
L Middle Temporal g.*	-66	-38	-6	4.1	L Superior Frontal g.	-24	24	54	3.71
L Anterior Cingulate g.	-6	32	26	3.93	L Inferior Temporal g.	-60	-40	-16	3.04
L Cingulate g.*	-6	22	46	4.4	L Middle Temporal g.*	-66	-36	-10	3.89
L Superior Frontal g.	-14	40	38	3.83	**Abstract > Concrete**				
L Caudate*	-14	12	6	3.78	**Structure**	**x**	**y**	**z**	**Z-score**
L Thalamus	-6	-20	4	3.09	R Postcentral g.*	44	-26	56	3.4
					R Precentral g.	40	-10	48	3.23
*** = cluster peaks**					R Middle Frontal g.	40	0	56	2.82

Lexical Decision > Word Judgment

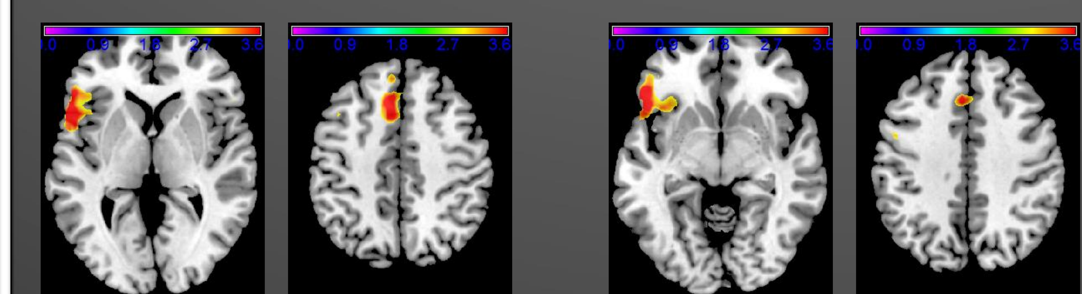
Abstract | Concrete



❖When lexical decision was directly compared to word judgment, right supramarginal gyrus, right superior frontal gyrus, and left lateral occipital cortex were more active during abstract words. Right temporal fusiform and left middle frontal gyrus were more active during concrete words.

Word Judgment > Lexical Decision

Abstract | Concrete

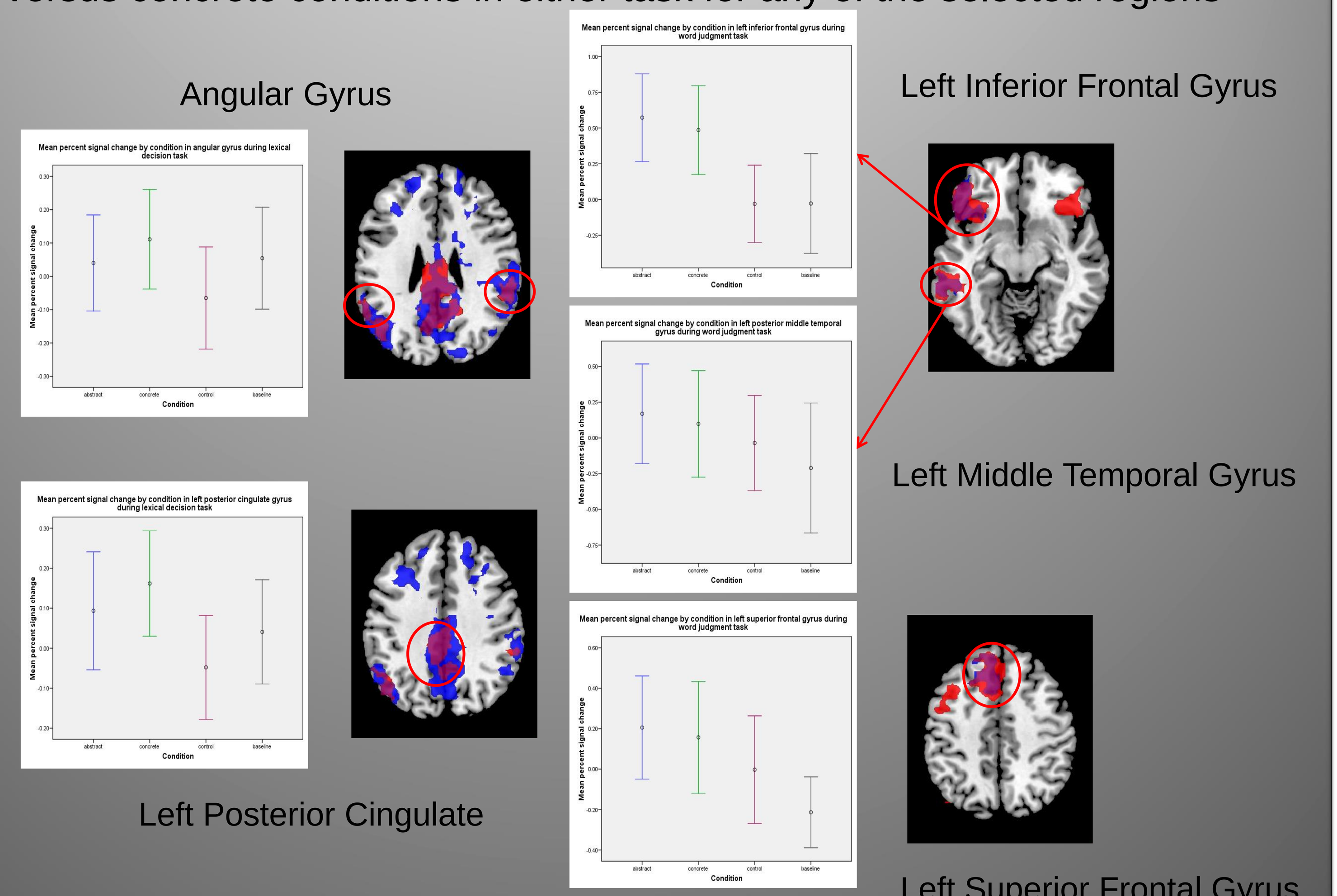


❖When word judgment was directly compared to lexical decision, left inferior frontal gyrus and left dorsomedial prefrontal cortex were more active for both abstract and concrete words.

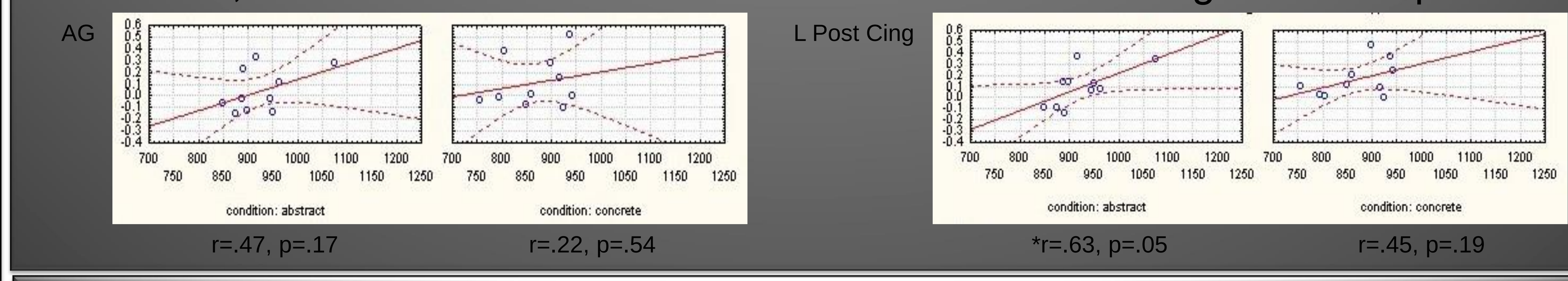
Region of Interest Analysis

❖Performed ROI analysis on areas of overlap which coincided with areas set forth by Binder, Desai, Graves, & Conant (2009) as semantic processing areas

❖No significant differences were found between the mean percent signal change of abstract versus concrete conditions in either task for any of the selected regions



❖However, correlation between RT and ROI revealed interesting relationships…



Discussion

❖The areas of overlap obtained in the lexical decision task (angular gyrus bilaterally and left posterior cingulate gyrus) agree with suggested areas of general semantic processing.

- ❖These areas did not show a preference for either abstract or concrete word processing.
- ❖However, RT in the lexical decision task during abstract processing had a positive correlation with activation in left posterior cingulate.
- ❖Overall, more areas of activation were found bilaterally for concrete words during the lexical decision task. This may be due to similarities in processing between abstract words and pseudowords (see behavioral data).

❖The areas of overlap obtained in the word judgment task (left inferior frontal gyrus, left posterior middle temporal gyrus, and left superior frontal gyrus) also agree with suggested areas of general semantic processing.

- ❖These areas also did not show a preference for either abstract or concrete word processing.
- ❖Overall, more areas of activation were found for abstract words bilaterally during the word judgment task, specifically in the IFG. This may be due to task difficulty and/or effects of healthy aging.

Conclusion

❖In general, this study agrees with previous neuroimaging studies exploring neural correlates of semantic processing.

❖However, the left-lateralized processing of abstract words and bilateral processing of concrete words was not specifically supported

❖This may be due to the effects of normal aging.

❖Future research should focus on a larger sample, with a wider age range.

References

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