

The Role of Perceptual Fan in Explicit Recognition: Functional Neuroimaging Evidence



Michelle R. Simmons*, Lynne M. Reder

Carnegie Mellon University

Julie A. Fiez

University of Pittsburgh

* Corresponding Author: 354C Baker Hall, Dept of Psychology,
Carnegie Mellon University, Pittsburgh, PA 15213
email: mrs@andrew.cmu.edu

Background

∞ Classic fan effect:

- Recognition memory for any particular item declines when participants have studied more items related to that concept.
- e.g., *Anderson (1974); Reder & Anderson (1980)*

∞ Font fan effect:

- Recognition memory for any particular word declines when the font that the word is presented in is also seen with other words.
- *Reder, Donavos, and Erickson (2000)*

∞ Analogous Processes

- Past behavioral research has shown these two types of fan to have parallel effects on latency and accuracy.
- *Simmons, Reder, Donavos, & Fiez (2000)*

Objectives

∞ Investigate neural substrates underlying fan effects.

∞ May find three types of regions showing effects of fan:

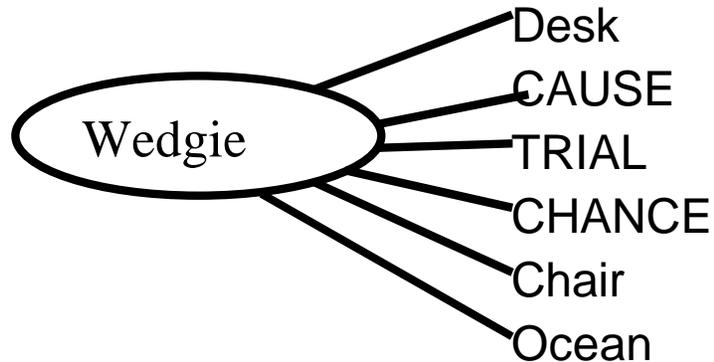
- Domain specific regions reflecting an effect of only one type of fan, i.e.,
 - A perceptual (or orthographic) fan region
 - A lexical-semantic fan region
- Domain general regions showing similar effects of perceptual and lexical-semantic fan. These regions may be in frontal regions previously shown to be important for episodic retrieval.

Operational Definition of Types of Fan

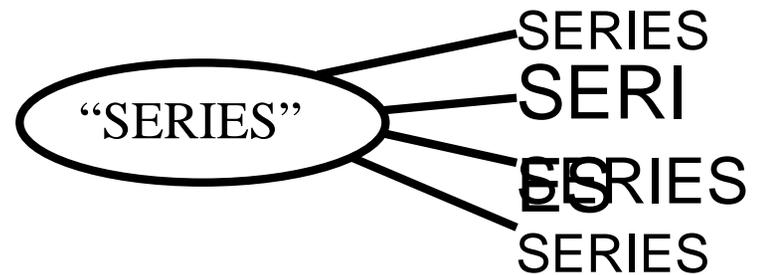
- ⌘ Manipulated font fan by varying the number of words associated with a particular font. This manipulation produces more *lexical-semantic interference* in the high font fan condition relative to the low font fan condition.
- ⌘ Manipulated word fan by varying the number of fonts associated with a word. This manipulation produces more *perceptual-orthographic interference* in the high word fan condition relative to the low word fan condition.

Levels of the Study Factors

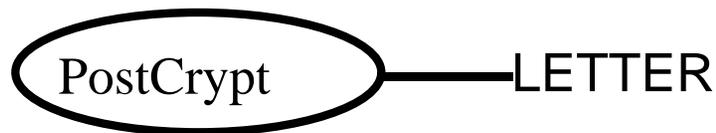
High Font Fan



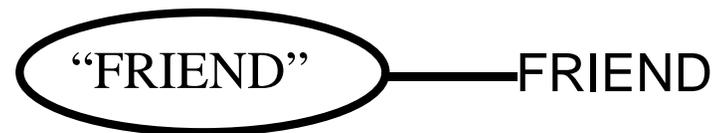
High Word Fan



Low Font Fan



Low Word Fan



Levels of the Test Factors

Original e.g., TRIAL LETTER

Swapped e.g., FRIEND DESK

Behavioral Task

∞ Study

- Words shown in various distinctive fonts one at a time in center of screen
- Task
 - rate (from 1 to 4) appropriateness of the visual characteristics of the font for meaning of the word
 - try to memorize pairs for later recognition test
- Each word-font pairing presented 5 times

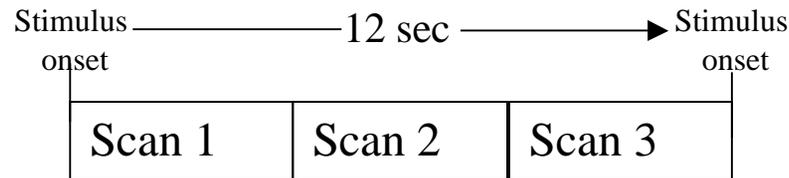
∞ Test

- Studied words shown in either original or swapped fonts
- Task: “Did you see *this word in this font* during the ratings task?”

fMRI Parameters

Event-related Design

- functional scans obtained during test phase
- 12 sec SOA between test words
- 1 full scan every 4 sec, i.e., 3 images per test trial



Functional Scans

- GE Signa 1.5 Tesla research scanner
- 3.75 x 3.75 x 3.8 mm voxels
- 26 oblique slices parallel to the AC-PC line
- 2-shot gradient-echo spiral acquisitions
 - TE=35, TR=2000, FA=70

fMRI Data Analysis

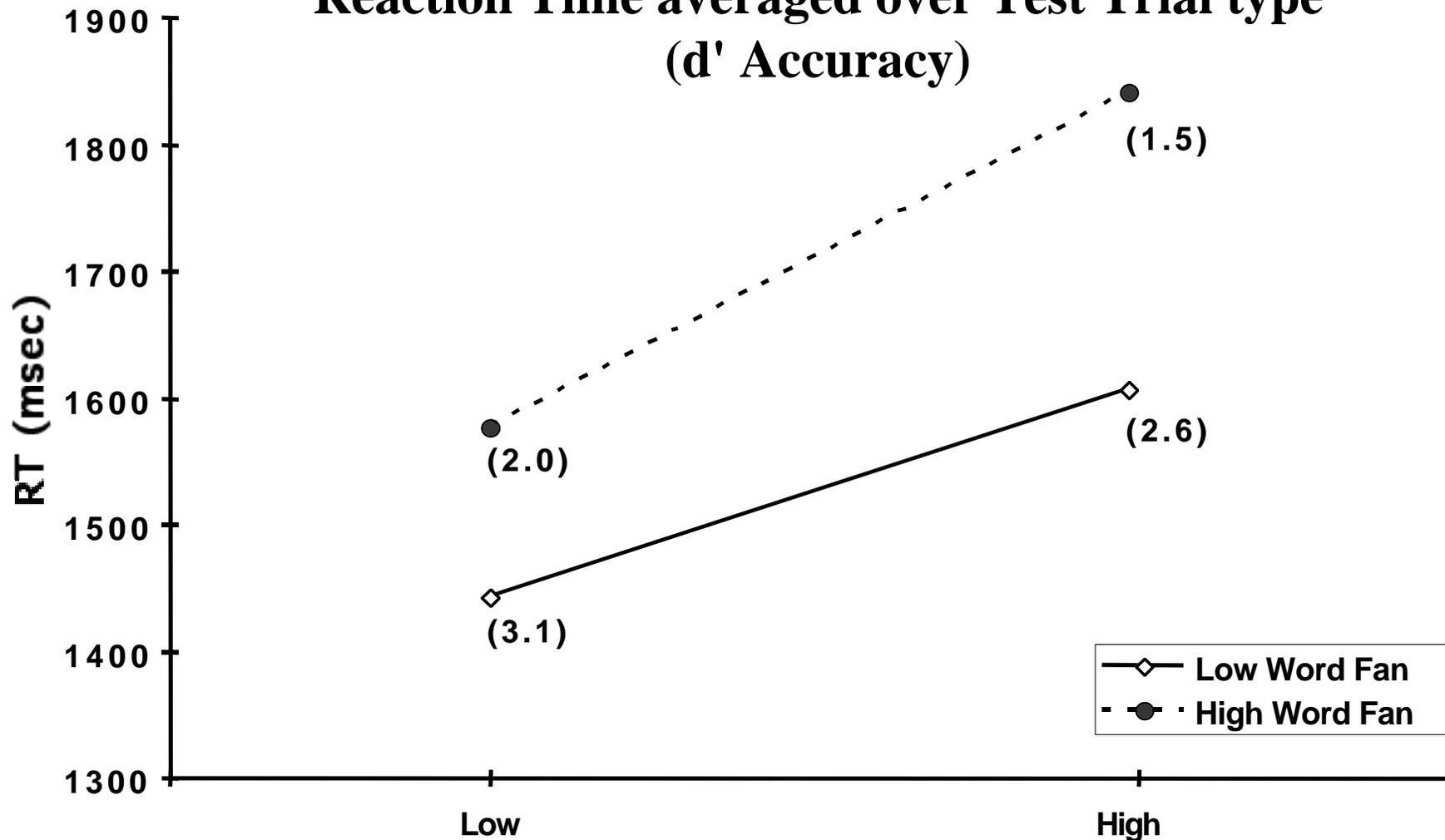
∞ Processing of individual data:

- detrended to remove slow drift
- mean normalized to a constant value across participants
- spatially transformed each participant's data into Talairach space to permit a group analysis

∞ Group analysis:

- Voxel-wise 2 (high Font Fan, low Font Fan) x 2 (high Word Fan, low Word Fan) repeated measures ANOVA
- Planned comparisons: voxel-wise 2-tailed t-tests
- Original test trials with correct responses only
- defined ROIs as regions with at least 5 contiguous voxels showing an effect at $p \leq .01$

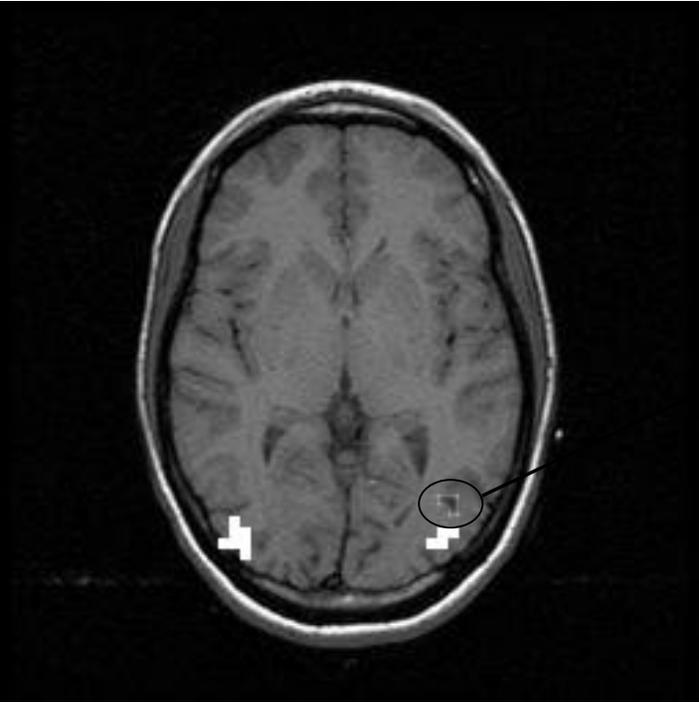
Reaction Time averaged over Test Trial type (d' Accuracy)



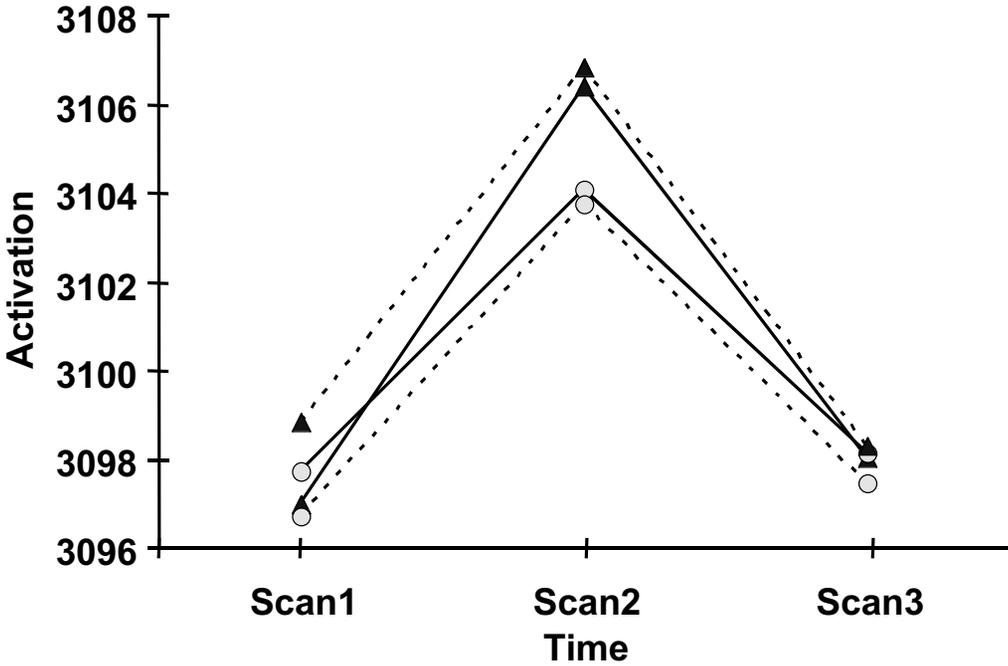
Font Fan

RT reliably increased with higher levels of Font Fan and higher levels of Word Fan. These effects were additive. Parentheses give accuracy as measured by d' which reliably decreased with higher levels of Font Fan and Word Fan.

Greater perceptual fan (i.e., a larger number of fonts fanning off the word node) produced a larger hemodynamic response in the left fusiform gyrus.



Right Left

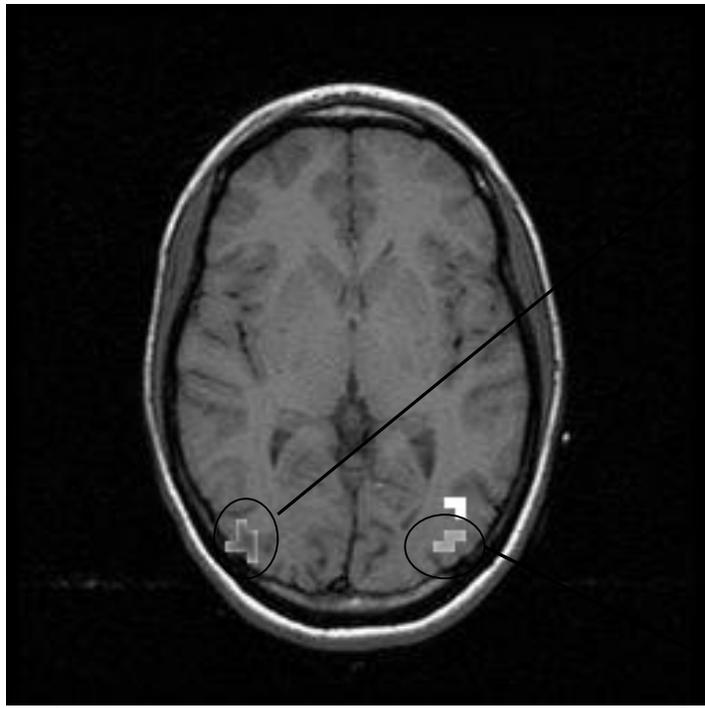


- ▲— HiWordFan-HiFontFan
- -▲- - HiWordFan-LoFontFan
- LoWordFan-HiFontFan
- -○- - LoWordFan-LoFontFan

Peak Activation		
Talairach Coordinates		
x	y	z
-38	-58	-9

Left BA 37, fusiform gyrus

Greater perceptual fan (i.e., a larger number of fonts fanning off the word node) produced a larger hemodynamic response in bilateral extrastriate cortex.

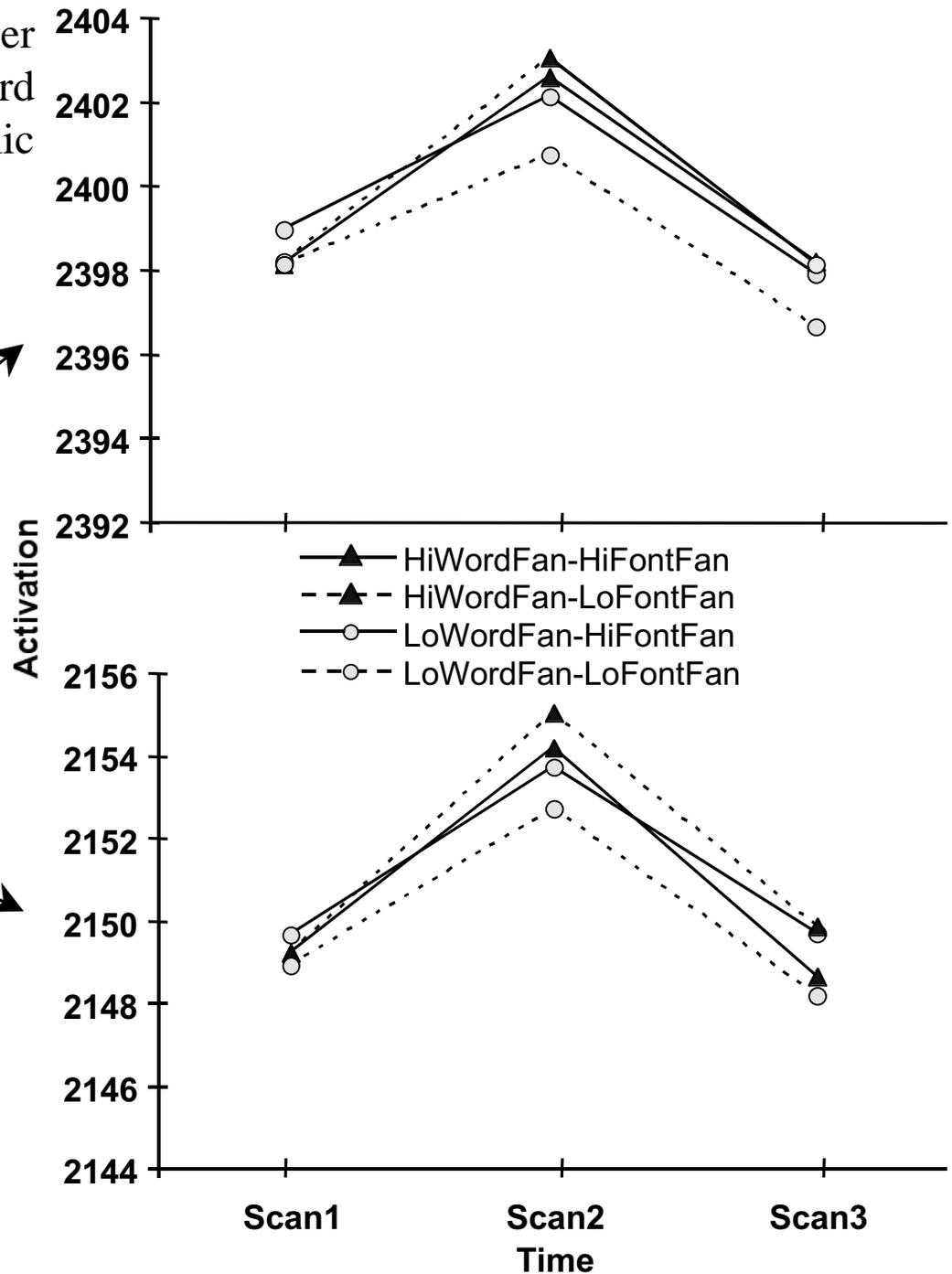


Right

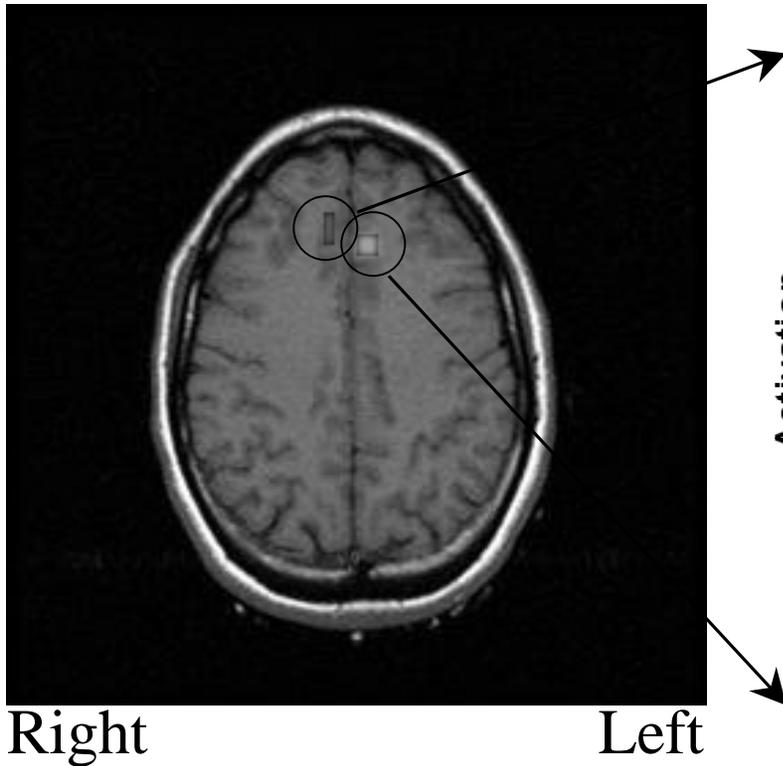
Left

	Peak Activation Talairach Coordinates		
	x	y	z
Right	40	-85	2
Left	-40	-80	0

BA 19, inferior occipital gyrus

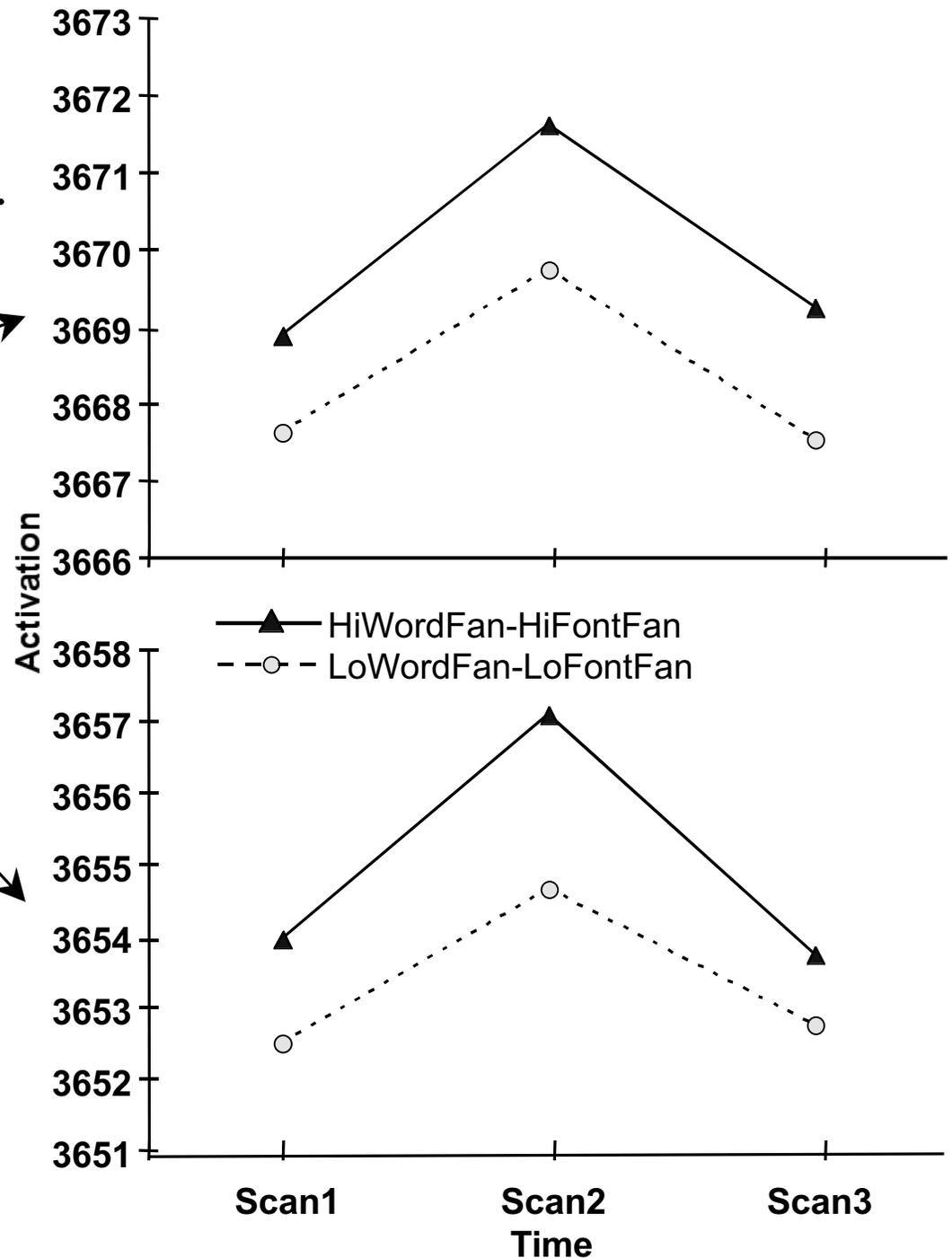


High fan produced a larger hemodynamic response in bilateral medial frontal cortex.



Peak Activation Talairach Coordinates			
	x	y	z
Right	9	37	37
Left	-4	30	38

BA 8, medial frontal gyrus



Discussion

∞ Left Fusiform Gyrus

- Past research has suggested that the left fusiform gyrus participates in orthographic processing in word reading tasks (Fiez & Petersen, 1998).
- The left fusiform has also been implicated in picture-naming tasks suggesting that this region plays a role in semantic processing (Price, 1998).
- Our data support the hypothesis that the fusiform is more involved in an orthographic level of processing, and we find no evidence that it participates in semantic processing.
- Our data further suggest that the fusiform does not maintain abstract, font-invariant representations. On the contrary, it appears that the fusiform may preserve or act on low-level perceptual information.

Discussion

✧ Extrastriate Cortex

- Some investigators (e.g., Tulving & Schacter, 1990) have suggested that perceptual information is treated differently from conceptual information, and have posited a Perceptual Representation System (PRS) to account for implicit memory phenomena.
- Past research has shown priming effects in extrastriate cortex and it has been hypothesized that this may be the locus of the PRS (Badgaiyan, Schacter, & Alpert, 2001).
- We have shown effects of fan in bilateral extrastriate cortex in an entirely explicit recognition memory paradigm.

✧ Frontal Cortex

- Our frontal activations are near areas postulated to be involved in effortful search of episodic memory (Schacter & Buckner, 1998).
- Our data suggest that these regions reflect effort rather than more general processes associated with recognition of previously presented words, as suggested by Heun, et al. (1999).

Future Directions

➤ Why did we find no regions related to Font Fan?

- One possibility is the relative uniqueness of the fonts as compared to the relative commonality of the words.
- This may have produced a stronger effect for Word Fan compared to a weaker effect for Font Fan.
- Since we do see a behavioral effect of Font Fan, this suggests that we may need greater power or more precise measurement tools to see an effect in the noisy neural data.

➤ On-going analyses of these data and future ERP experiments may help us address these issues.

References

- Anderson, J. R. (1974). Retrieval of propositional information from long-term memory. *Cognitive Psychology*, 5, 451-474.
- Badgaiyan, R. D., Schacter, D. L., & Alpert, N. M. (2001). Priming within and across modalities: Exploring the nature of rCBF increases and decreases. *Neuroimage*, 13, 272-282.
- Fiez J. A., & Petersen S. E. (1998). Neuroimaging studies of word reading. *PNAS*, 95, 914-921.
- Heun, R., Klose, U., Jessen, F., Erb, M., Papassotiropoulos, A., Lotze, M., & Grodd, W. (1999). Functional MRI of cerebral activation during encoding and retrieval of words. *Human Brain Mapping*, 8, 157-169.
- Price, C. J. (1998). The functional anatomy of word comprehension and production. *Trends in Cognitive Science*, 2, 281-288.
- Reder, L. M., & Anderson, J. R. (1980). A partial resolution of the paradox of interference: The role of integrating knowledge. *Cognitive Psychology*, 12, 447-472.
- Reder, L.M., Donavos, D.K., & Erickson, M.A. (2000). The role of perceptual match in direct tests of memory: Evidence against multiple systems. Manuscript submitted for publication.
- Schacter, D. L., & Buckner, R. L. (1998). On the relations among priming, conscious recollection, and intentional retrieval: Evidence from neuroimaging research. *Neurobiology of Learning and Memory*, 70, 284-303.
- Simmons, M. R., Reder, L. M., Donavos, D. K., & Fiez, J. A. (2000, November). The role of perceptual and conceptual fan in explicit recognition: Analogous processes. Poster presented at the 41st Annual Meeting of the Psychonomic Society, New Orleans, Louisiana.
- Tulving, E. & Schacter, D. L. (1990). Priming and human memory systems. *Science*, 247, 301-306.

Acknowledgements



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