Activation of Semantic Regions by the Printed Word: An fMRI Study
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Introduction

One theory of semantic processing posits that knowledge about objects is organized in the brain according to how the knowledge was acquired, i.e., that sensorimotor feature knowledge is stored in modality-specific semantic systems.

This is in contrast to theories that state semantics is organized along broader categories such as living things vs. artifacts.

Task:

Normal or corrected - to - normal vision, English as native language.

Trials:

Mean age 27 years (18 – 48), Mean schooling 16 years (12 – 23)

FMRI Method

Participants:

-25 (17 male, 8 female), right-handed neurologically intact adults.
-Non or corrected to normal vision. English as native language
-Mean age 27 years (18 – 48), Mean schooling 16 years (12 – 23)

Experimental Parameters:

-Stimuli:
-600 Concrete words, 300 Abstract words.
-300 Non-words generated using constrained trigram statistics.
-All strings were 3 to 9 letters in length
-All concrete words of each length (84 for 9 letters)
-43 abstract and 43 non-words of each length (42 for 9 letters)
-All strings within a letter length were matched for frequency, orthographic neighborhood size, and bi- and trigram statistics.
-600 Fixation Trials (baseline).
-Trials:
-10 runs of 180 trials each (1800 Trials total).
-1s stimulus presented for 1s followed by jittered fixation of 1s, 3s, 5s...
-Task:
-Participants were instructed to press one response key for objects (things that can be seen, heard, manipulated, etc.) and another key for nonobjects (which included abstract words and nonwords).

FMRI Behavioral Results

-There were significant differences between the three conditions for both accuracy and reaction time. Abstract words were the least accurate and the slowest to respond to.
-Given these differences, both stimulus type and reaction time were included in the regression analyses.

Attribute Ratings

-Using an online form, we collected perceptual ratings on 900 words (600 concrete and 300 abstract) from 342 participants.
-Participants rated words for Sound, Color, Manipulability, Motion, and Emotion using a 7-point scale (13-point for Emotion).

Correlations for all words (n=900) "p < .05.

Table 1. Correlations for Concrete (n=600) & Abstract (n=300) items

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Concrete</th>
<th>Abstract</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound</td>
<td>0.85</td>
<td>0.80</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>Color</td>
<td>0.70</td>
<td>0.80</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>Manipulation</td>
<td>0.65</td>
<td>0.50</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>Motion</td>
<td>0.50</td>
<td>0.50</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>Emotion</td>
<td>0.45</td>
<td>0.50</td>
<td>&lt; .05</td>
</tr>
</tbody>
</table>

Table 2. Correlations for all words (n=900) "p < .05.

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<td>0.50</td>
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Global Comparisons

-Concrete vs. Abstract

Global Comparisons

-Word vs. Non-Word

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Functional Analysis

-Images registered to decrease motion effects
-Multiple regression analysis using AFNI program 3dDoConVolve
-Impulse response functions estimated for the following regressors: attribute ratings, word onset, nonword onset, individual RTs.
-Parameter images smoothed using a 6mm FWHM Gaussian kernel
-Random effects group analyses computed and converted to Z-scores.

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The main area in which activation was correlated with sound ratings was the left angular gyrus (AG). Motion ratings were also correlated with activation in the left AG, partly overlapping the area associated with sound salience. Manipulation salience activated regions in the AG and posterior temporal lobe bilaterally, as well as posterior cingulate, medial frontal lobe, and right hippocampus. Color salience activated large regions in L > R ventromedial temporal lobe, posterior cingulate, medial frontal lobe, and right lateral temporal lobe. Finally, emotion ratings were correlated mainly with activation in the left superior frontal gyrus. Thus, sound, motion, manipulation, color, and emotion attributes of object concepts activate overlapping but partly distinct brain regions. These distinct regions reflect the separate cortical organization of auditory, visual, somatosensory, motor, and affective processing systems.