Neural Correlates of Categorization: An fMRI study of Probabilistic Classification using the Weather Prediction Task

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In the probabilistic classification task, participants study stimuli consisting of features that are probabilistically associated with a particular outcome. Participants decide for each stimulus which outcome is associated with it, and are given feedback. Across trials, participants learn to classify stimuli.

The goal of the present study was to investigate the neural bases of probabilistic classification learning using functional MRI. Five right-handed participants completed the study. Imaging was performed with a 1.5T whole-body MRI scanner. A small head coil was used for signal reception. Head movement was minimized using a bite bar formed with each participant's dental impression. A T2* sensitive gradient 3D echo spiral sequence was used for functional imaging with parameters of TR = 900 ms, TE = 40 ms, and flip angle = 22 degrees. Four interleaves were obtained for each image with an acquisition time (sampling interval) of 4.32 sec per image. Sixteen 4-mm thick slices were acquired in the horizontal plane of the Talairach and Tournoux atlas (1988) starting from 12 mm below the anterior-commisure (AC)- posterior commisure (PC) line, with a 0 mm inter-slice interval. Data were analyzed using the cross-correlation method described by (Friston et al., 1994).

Weather problems were designed as a test of probabilistic categorization. The cards contain cues (circles, diamonds, triangles, squares) which can be used to predict the weather (rain or sunshine). Each pattern was associated with rain or sunshine, (Knowlton & Squire, 1996).*Control problems* were designed to equate for perceptual input and motor output in the weather prediction problems. These problems consisted of random presentation of the same fourteen patterns as above.

Each participant performed four scans of the weather/control task. In each scan, there were six alternating blocks with four weather problems and four control problems. Each problem was presented for 5 seconds. For Weather problems, participants had to identify whether the pattern represented rain or sunshine. Participants were given feedback for two seconds to each of these problems with the word "rain" or "sunshine". For Control problems, participants had to decide if the pattern contained two cards. Participants responded by squeezing a squeeze ball in their right hand.

Two areas of the frontal lobes were active in this task across all participants: dorsolateral prefrontal and rostrolateral prefrontal cortex. The dorsolateral activations were on the whole bilateral, whereas the rostrolateral activations were right-lateralized. The HERA model (Nyberg, Cabeza, & Tulving, 1996) posits that the right prefrontal cortex is involved in episodic memory retrieval while the left prefrontal cortex is more involved in retrieving information from semantic memory and encoding novel information into episodic memory. In our task, the right prefrontal cortex may be involved in retrieving learned categories while the left prefrontal cortex may be involved in encoding new categories.

Frontal/parietal areas involved in working memory and reasoning (Prabhakaran et al., in press) were activated during initial performance of the task. As subjects learned to associate patterns with different outcome there was a reduction in activation in the frontal/parietal areas, while temporal and occipital areas maintained similar activation levels seen in earlier tasks. In the probabilistic classification task, areas involved in reasoning may be involved in forming categorical relations between visual patterns and outcomes.

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