

An fMRI Study of the Effects of Memory and Goal Setting in a Risk Taking Task

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Within the HCI/cognitive engineering community there is wide spread acceptance of the idea that people prefer to use perceptual information over memorized information, and that it is better to do so in terms of task performance. However, there is very little direct evidence for this claim (Gray & Fu 2004). One reason for this is that while it is possible to force people to use memorized information in a task (i.e., by removing the information before the task starts), it is hard to know what is going on when they can see the information during the task. The information can be accessed perceptually but it can also be stored in declarative memory and subsequently accessed from there. Therefore, after the initial perception it is difficult to know if the subject is primarily using perception or memory during the task. Also, if they don't put the perceived information in memory they may still use their memory in some other way to help in the task.

To examine this issue more closely, we used fMRI to examine the effects of perceived versus memorized information. The ACT-R information processing model of cognition (Anderson et al., 2004) relates the dorso-lateral Prefrontal Cortex (dl-PFC) to a retrieval buffer that holds information retrieved from declarative memory. Supporting this, Sohn et al (2005) demonstrated that the dorso-lateral prefrontal cortex is activated in tasks involving the retrieval of information from declarative memory. Sohn et al (2005) also proposed that the Anterior Cingulate Cortex (ACC) is related to goal tracking. Work in the area of situated cognition (Clancy, 1997) has suggested that in addition to reducing the role of memory, relevant perceptual information can cue us in terms of what to do next, thus reducing our reliance on goals held in memory. To examine this factor we also looked at the dorsal Anterior Cingulate Cortex (dACC).

In this study, subjects had to decide between a risky and a safe betting option based on information about the risk of each option. The information for the task was presented on a screen using a projector and could be seen through a mirror mounted to the MRI scanner. In the memory task, two graphs were presented showing the risk for two betting options that were not yet presented. The graphs were then removed and two options for betting were presented. The risk information and the betting information were displayed for three seconds each. Subjects had to choose their bet while the betting information was displayed. Following this there was a three second display giving feedback on the outcome of the bet. In order to use the risk information to choose between the two betting options, subjects needed to retain the risk information in memory. In the perceptual task subjects were presented with a blank display for three seconds followed by the risk information and the betting options displayed together for three seconds. During this

time they chose their bet with index or middle finger of their right hand. This was followed by the three second feedback display. Subjects completed 24 trials in each condition. The conditions were alternated in blocks of four trials each. Eight subjects were tested.

The images were analyzed in terms of mean BOLD % change across trials for the memory and perception conditions. T-tests analysis revealed that activation was significantly higher in the memory condition for both the dl-PFC ($p = .005$) and the dACC ($p = .006$). The dl-PFC result indicates that presenting information perceptually results in a significant decrease in the use of stored information in declarative memory. The dACC result suggests that perceptual information can cue us in terms of what to do next, and that relying on this reduces the cognitive load of goal processing. These results are consistent with the views put forward by proponents of externally representing information. However, in terms of performance, subjects performed significantly better in the memory condition than in the perception condition. This was an interesting finding since both the task analysis and the fMRI results indicate that the cognitive load was higher in the memory condition. What seems to have happened is that reducing the reliance on memory and goal setting allowed subjects to process the information in an easier but less effective way.

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