



Neurally reconstructing expected utility

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Abstract

While the concept of “expected utility” informs many theories of decision making, little is known about whether and how the human brain might compute this quantity. This article reviews a series of functional magnetic resonance imaging (fMRI) experiments designed to localize brain regions that respond in anticipation of increasing amounts of monetary incentives. These studies collectively suggest that anticipation of increasing monetary gains activates a subcortical region of the ventral striatum in a magnitude-proportional manner. This ventral striatal activation is not evident during anticipation of losses. Actual gain outcomes instead activate a region of the mesial prefrontal cortex. During anticipation of gain, ventral striatal activation is accompanied by feelings characterized by increasing arousal and positive valence. These findings affirm the role of emotion in the anticipation of incentives, and may provide an initial step towards a neural reconstruction of expected utility.

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1. Background

Psychology has historically taken a descriptive stance by describing *actual* behavior. Economics, on the other hand, has typically adopted a prescriptive (or normative) stance

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by prescribing *ideal* behavior (with the exception of recent hybrid offshoots such as “behavioral decision making”). However, a judicious combination of both descriptive and prescriptive approaches may be necessary in order to specify how people can move from nonoptimal but actual behavior to more optimal or ideal behavior.

Our laboratory has taken a descriptive approach in attempting to isolate and understand the neural underpinnings of desire. Decades of psychometric research indicate that much of the variance in peoples’ ongoing affective states (including emotions, moods, attitudes, and preferences) can be described in terms of two independent dimensions termed valence (going from bad to good) and arousal (going from low to high) (Thayer, 1989; Watson and Tellegen, 1985). Using this framework, we define the affective component of desire as involving increases in arousal and valence (see Fig. 1). Thus, such a desirous state could also be called a “positive aroused” (PA) state. In accordance with the traditional ethological distinction between appetitive and consummatory phases of incentive processing (Craig, 1918), we further predict that individuals are especially likely to experience PA states in anticipation of acquiring and consuming a reward (Knutson et al., 2001a). Here, a reward is defined simply as anything that an organism will work to acquire.

To evoke PA states in the laboratory, we have utilized a variety of incentive delay tasks. In these tasks, individuals are exposed to a cue that predicts a potential reward, wait an anticipatory delay interval, make a response to obtain the reward, and then receive feedback regarding the outcome of their action. Incentive delay paradigms can be traced back to Pavlov’s classic studies of gastric secretions in dogs (Pavlov, 1927). Although Pavlov primarily focused on the ability of reward cues to elicit salivation, dogs undoubtedly show other behavioral reactions to the presentation of reward-predicting cues including increased locomotor activity, seeking behavior, and even vocalizations. These coordinated behaviors can also be evoked by presentation of other types of reward cues, for instance, presentation of a leash before going on a walk. From an affective neuroscience perspective, we postulate that if the covariant occurrence of these behaviors indexes an affective state, then specific neural events must generate that state (Panksepp, 1998). If the PA state occurs during re-

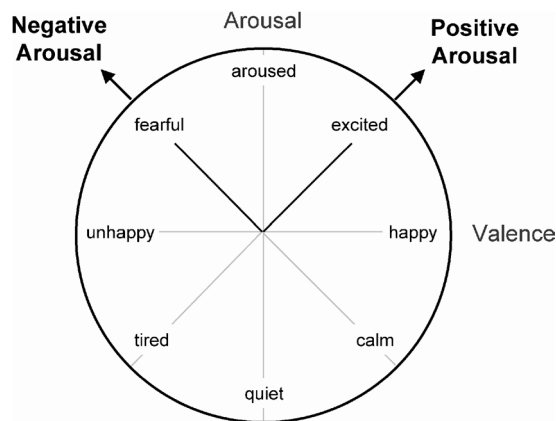


Fig. 1. The affective circumplex (Watson et al., 1999).

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