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Human oscillatory activity associated to reward processing in a gambling task

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Abstract

Previous event-related brain potential (ERP) studies have identified a medial frontal negativity (MFN) in response to negative feedback or monetary losses. In contrast, no EEG correlates have been identified related to the processing of monetary gains or positive feedback. This result is puzzling considering the large number of brain regions involved in the processing of rewards. In the present study we used a gambling task to investigate this issue with trial-by-trial wavelet-based time–frequency analysis of the electroencephalographic signal recorded non-invasively in healthy humans. Using this analysis a mediofrontal oscillatory component in the beta range was identified which was associated to monetary gains. In addition, standard time–domain ERP analysis showed an MFN for losses that was associated with an increase in theta power in the time–frequency analysis. We propose that the reward-related beta oscillatory activity signifies the functional coupling of distributed brain regions involved in reward processing.

Keywords: Feedback; Gambling; Medial frontal negativity; Reward; Wavelet analysis

1. Introduction

In order to successfully navigate through a busy day, we need to constantly assess the values and uncertainties attached to different options and to adapt our behavior according to the outcome of an action which might or might not match our predictions and hopes. The function of positive (rewards) and negative feedback signals (punishments) in this scenario is to guide behavior and to mediate learning (Schultz, 2006). The brain network activated in reward processing comprises the orbitofrontal cortex, amygdala, ventral striatum/nucleus accumbens, prefrontal cortex and anterior cingulate cortex (Delgado, Nystrom, Fissell, Noll, & Fiez, 2000; Gottfried, O'Doherty, & Dolan, 2003; Knutson, Fong, Bennett, Adams, & Hommer, 2003; Knutson, Westdorp, Kaiser, & Hommer, 2000; O'Doherty, Kringelbach, Rolls, Hornak, & Andrews, 2001). However, although the neural circuit involved in reward processing is quite well defined, the specific roles of each region and the integration of information in this circuit are not well understood.

Several authors have proposed that in order to integrate a disparate number of different rewards the brain uses a common network that converges in a final pathway that informs about the nature of the reward (comparison process) and about the possible courses of action in the future (Montague & Berns, 2002; Shizgal, 1997). Neurophysiological studies in animals revealed dopaminergic neurons in the midbrain projecting, among other regions, to the ventral striatum responding selectively to unpredicted events: (i) they are mostly responsive to appetetive events that are better than predicted, (ii) they do not respond to well-predicted rewards, and (iii) a negative signal (i.e. decreased activity) is elicited when an appetetive event is worse than predicted (Mirenowicz & Schultz, 1994; Schultz, Dayan, & Montague, 1997; Tremblay & Schultz, 2000; for similar results in humans: Berns, McClure, Pagnoni, & Montague,

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