

Articles - Behavioral/Cognitive:**Impaired Neural Response to Negative Prediction Errors in Cocaine Addiction**

Muhammad A. Parvaz, Anna B. Konova, Greg H. Proudfit, Jonathan P. Dunning, Pias Malaker, Scott J. Moeller, Tom Maloney, Nelly Alia-Klein, and Rita Z. Goldstein

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[Abstract](#)[Full Text](#)[Full Text \(PDF\)](#)**Impaired RPE signaling in substance dependence: comment on Parvaz et al.**

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The recent article by Parvaz et al. utilized a component of the event-related brain potential (ERP) called the feedback error-related negativity (FN) to investigate the neural mechanisms of substance dependence. As stated therein, their central hypothesis was to "leverage feedback error related negativity (FN) to index reward prediction error signals (RPE) in addiction", which they claimed had yet to be done: "Previous studies in addiction have investigated FN as a marker of sensitivity to reward expectation ... or of outcome evaluation ... but importantly never as a marker of RPE". Yet in a series of studies, first published in 2011 in *Addiction Biology* entitled "Individual differences in substance dependence: at the intersection of brain, behaviour and cognition" (Baker et al., 2011; see also Baker et al., 2008, 2013; Baker, 2012), we did exactly this -- with results that both anticipated and conflict with Parvaz et al.'s main findings.

The FN is an ERP component that is sensitive to the valence of positive vs. negative outcomes in guessing and learning tasks. A prominent theory of this component suggests that it reflects a reward-prediction error signal (RPE), being relatively negative to unpredicted bad outcomes and relatively positive to unpredicted good outcomes (Holroyd and Coles, 2002). Parvaz et al analyzed the FN in a control group and in two groups of subjects with cocaine use disorder, categorized according to whether they tested positive [CUD+] or negative [CUD-] for cocaine on the study day. Among other observations, they found that only the control sample but not the CUD samples produced a larger negativity to unpredicted vs predicted losses and concluded that the RPE signals are disrupted in CUD. However, these results should be interpreted with caution, for the following reasons. First, Parvaz et al. did not statistically compare the data across groups, leaving open the possibility that FN amplitude did not in fact differ between the control participants and the individuals with CUD. Second, the findings were based on the participants' subjectively reported estimates of reward probability, rather than on the objective reward probabilities (as is common practice) - perhaps because in their study the latter appear to elicit normal FNs across conditions and groups. And third, Parvaz et al found a larger negativity in their FNs to predicted vs unpredicted wins in their control sample, a finding that conflicts with the majority of previous FN studies (see Sambrook & Goslin, 2015, for a recent meta-analysis).

By contrast, we previously found that young adults meeting criteria for substance dependence, as compared to control subjects, exhibited an attenuated FN: The negative-going deflection in the ERP following reward trials mirrored the negative going deflection in the ERP following no- reward trials, consistent with a disrupted positive RPE signal in this population (Baker et al. 2011; Baker et al. 2013). Parvaz and colleagues' failure to replicate this finding likely results from measuring the FN with a mean amplitude method (200-350 ms), which confounds the measure with other ERP components such as the P300 (Holroyd & Krigolson, 2007). By contrast, the "difference-wave" method that we utilized, which has been recommended in the recent meta-analysis of FN studies (Sambrook & Goslin, 2015), isolates the FN by taking the difference between the ERPs to positive and negative feedback. Visual inspection of Figure 2 in Parvaz et al. suggests that application of the difference wave approach would have yielded findings consistent with our own.

Baker TE, Stockwell T, Barnes G, Holroyd CB. (2011). Individual differences in substance dependence: at the intersection of brain, behaviour and cognition. *Addict Biol* 16: 458-466.

Baker TE, Stockwell T, Barnes G, Holroyd CB. (2008). Neural and cognitive mechanisms of addiction. *International*

Journal of Psychology (Vol. 43, No. 3-4, pp. 263-263). UK: PSYC PRESS.

Baker TE. (2012): Genetics, Drugs, and Cognitive Control: Uncovering Individual Differences in Substance Dependence. Unpublished PhD Dissertation. University of Victoria, Canada.

Baker TE, Stockwell T, Barnes G, Haesevoets R, Holroyd CB. (2013): Top-Down vs. Bottoms-Up? Intermediate phenotypes for cognitive control and personality mediate the expression of dopamine genes in addiction. In Journal of Cognitive Neuroscience. Abstract, p 143. USA: MIT PRESS

Holroyd CB, Coles MG. (2002). The neural basis of human error processing: reinforcement learning, dopamine, and the error-related negativity. Psychol Rev 109: 679-709.

Holroyd CB, Krigolson OE. (2007). Reward prediction error signals associated with a modified time estimation task. Psychophysiology, 44: 913 -917.

Sambrook TD, Goslin J. (2015). A neural reward prediction error revealed by a meta-analysis of ERPs using great grand averages. Psychol Bull 141: 213-235.

Conflict of Interest None declared

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