Commentary

Brain Reward Responses Are Behaviorally Relevant: The Authors Respond

THE PRECEDING COMMENTARY by Dr. Roger Meyer (2018—this issue) refers to an article by our group (Courtney et al., 2018—this issue) that provides clear evidence of a relationship between activity in reward regions of the brain and drinking behavior in college students. The commentary raises three main points regarding the original study, as well as brain imaging studies of reward and addiction more generally, as follows: (a) that the original study does not establish a causal relationship between alcohol cue reactivity and real-world drinking, (b) that brain reward responses are not behaviorally relevant, and (c) that neuroimaging studies are limited in scope and have not been informative for policy decisions.

The first point of the commentary is that we overstate the relationship between reward activity to alcohol cues and self-reported drinking by using the term *predicts.* The original study did not use the term *predicts* to invoke causal prediction, but empirical prediction (Shmueli, 2010)—in a correlational relationship an individual's value on one variable predicts his or her value on the other. The commentary raises an important point, however, as use of this term is not standard across fields and might be more carefully reserved for causal relationships. But we further emphasize that we are agnostic to the directionality of the relationship highlighted in our original article. In fact, reward learning is an iterative process—heavier drinkers have more experience associating alcohol cues and drinking than casual drinkers, and stronger associations should more reliably drive drinking in the presence of alcohol cues. But this does not preclude future inquiries into the causality of this relationship.

Indeed, previous research has demonstrated a temporal relationship and dose-response (Anderson et al., 2009) between alcohol marketing exposure and alcohol use. The aim of our simplified model of drinking behavior was to establish the biological plausibility of this relationship by suggesting a potential mechanism—through sensitization of the reward system. Although our findings were incremental, they set the foundation for future research to test more sophisticated causal models that might incorporate additional epidemiological, demographic, and self-report data (as suggested by the commentary). These incremental steps in understanding the relation between an advertising source and behavior are necessary for determining whether a causal relationship exists. Determining causality is the basis for regulatory action that would restrict advertisers from communicating with the underage segment.

Second, the commentary makes the point through anecdote that consumer decision-making is not influenced by rewarded options or by targeted exposure (e.g., a drug company–sponsored pizza party), as an indication that neuroimaging studies of reward are not predictive of behavior (drug prescribing by residents). This is a strong claim about the efficacy of reward learning and advertising. The reward learning literature is replete with studies demonstrating that rewarded options are chosen more frequently and are associated with increased activation in canonical reward regions (e.g., Heekeren et al., 2007). There is an equally active literature on the potency of advertising to influence and persuade decision-making, although these effects may be sensitive to specific contexts and conditions (Tellis et al., 2000). Moreover, recent events from the prescribed-opiate epidemic argue against this point of the commentary. There is ample evidence to support the argument that Purdue's Oxycontin marketing campaign changed physician prescribing patterns and contributed to the opiate epidemic (Government Accounting Office, 2004). In fact, this evidence is the basis for lawsuits by State Attorneys General against these companies (e.g., Ohio Attorney General, 2017).

The weaker claim—that reward system activation is not behaviorally relevant—as applied to the original study is undercut by the study's results, in which reward activation in response to alcohol ads in a predicted region of interest (the left orbitofrontal cortex) related to our behavioral measure of interest, namely drinking. In fact, this activation explained 13.7% of the variance in self-reported drinking behavior.

Last, although neuroimaging is a rather expensive technology with high standards for data quality and clean study designs, it has the potential to complement epidemiological approaches by identifying biological risk factors of addiction and disorder. And indeed, research on the neurobiology of addiction has guided prevention and treatment options and driven public policy changes (Volkow et al., 2016). Our

research suggests that alcohol use might co-opt the same mechanism as food reward and addiction, and future research can work toward identifying boundary conditions and moderators of the relationship.

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References

Anderson, P., de Bruijn, A., Angus, K., Gordon, R., & Hastings, G. (2009). Impact of alcohol advertising and media exposure on adolescent alcohol use: A systematic review of longitudinal studies. *Alcohol and Alcoholism, 44,* 229–243. doi:10.1093/alcalc/agn115

Courtney, A. L., Rapuano, K. M., Sargent, J. D., Heatherton, T. F., & Kelley, W. M. (2018). Reward system activation in response to alcohol advertisements predicts college drinking. *Journal of Studies on Alcohol and Drugs, 79,* 29–38. doi:10.15288/jsad.2018.79.29

Government Accounting Office. (2004). OxyContin abuse and diversion and efforts to address the problem: Highlights of a government report. *Journal of Pain & Palliative Care Pharmacotherapy, 18,* 109–113.

Heekeren, H. R., Wartenburger, I., Marschner, A., Mell, T., Villringer, A., & Reischies, F. M. (2007). Role of ventral striatum in reward-based decision making. *NeuroReport, 18,* 951–955. doi:10.1097/WNR.0b013e3281532bd7

Meyer, R. E. (2018). Back to the future . . . or . . . is that all there is? A commentary on Courtney et al. (2018). *Journal of Studies on Alcohol and Drugs, 79,* 39–40. doi:10.15288/jsad.2018.79.39

Ohio Attorney General. (2017, May 31). *Attorney General DeWine files lawsuit against opioid manufacturers for fraudulent marketing; fueling opioid epidemic* [Press release]. Retrieved from http://www.ohioattorneygeneral.gov/Media/News-Releases/May-2017/Attorney-General-DeWine-Files-Lawsuit-Against-Opio

Shmueli, G. (2010). To explain or to predict? *Statistical Science, 25,* 289–310. doi:10.1214/10-STS330

Tellis, G., Chandy, R., & Thaivanich, P. (2000). Which ad works, when, where, and how often? Modeling the effects of direct television advertising. *Journal of Marketing Research, 37,* 32–46. doi:10.1509/jmkr.37.1.32.18716

Volkow, N. D., Koob, G. F., & McLellan, A. T. (2016). Neurobiologic advances from the brain disease model of addiction. *The New England Journal of Medicine, 374,* 363–371. doi:10.1056/NEJMra1511480