Behavioral Economics of Positive and Negative Reinforcement in Rats after Mild Traumatic Brain Injury

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1. Introduction

Mild traumatic brain injury (mTBI) has long been considered a significant risk factor for major depressive disorder (MDD) [1]. Anhedonia, a core symptom of MDD [2], has shown to have two components by a recent research: consummatory anhedonia and motivational anhedonia [3]. Moreover, MDD is also associated with a negative bias, such that individuals with depression are more prone to attend to aversive events at the expense of attending to appetitive events. To determine whether anhedonia negative bias are enhanced following mTBI as a symptom of MDD, we used a novel behavioral economics approach to assess hedonic value and motivation to obtain both positive (sucrose) and escape or avoid negative reinforcement after lateral fluid percussion (LFP) injury.

2. Methods

Rats were matched on pre-injury sensory reactivity (assessed using acoustic startle response (ASR) paradigm) and randomly assigned to SHAM and mTBI conditions. Lateral fluid percussion injury (17-21 psi, directed on to the parietal lobe) was induced using a computer control voice-coil device developed by Bryan Pfister (NJIT). In Experiment 1, we assessed the motivation to obtain appetitive reinforcement such as sucrose pellets in operant lever press conditioning task (positive reinforcement) 2 weeks post-injury. For this purpose, a progressive ratio schedule was employed, where the number of lever-presses required obtaining a single sucrose pellet was progressively increased. Reinforcing value was assessed as the level of consumption when the cost approaches to 0 (Q_0) and motivation was the willingness to work for sucrose as the work requirement progressively increases (demand; α). In Experiment 2 and 3, we modified the progressive ratio schedule we used to assess motivation to obtain positive reinforcement to assess motivation to escape or avoid negative reinforcement such as foot shock. Such that, reinforcing value was defined as the level of escape and avoidance when the cost approaches to 0 (Q_0)

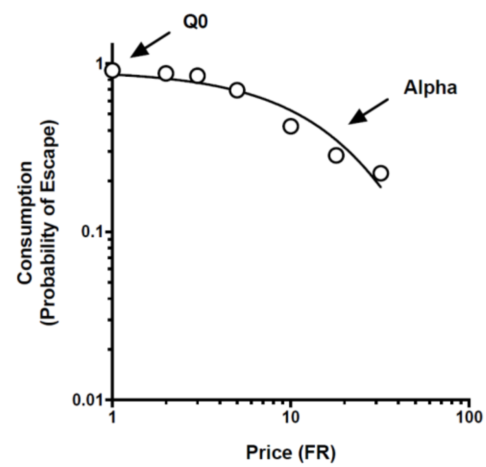

Figure 1. Representative demand curve plotting consumption (proportion of successful escape) as a function of price (FR). The open circles represent the number of successful sucrose rewards, escapes, and avoids made by subjects and the solid line represents the fitted demand curve determined by the exponential demand equation. The values of Q_0 and α are determined by the exponential demand equation. The hedonic value of obtaining sucrose, escaping or avoiding foot shock (Q_0) is shown graphically as the y-intercept. The motivation to obtain sucrose, escape or avoid foot shock (α) is represented graphically as the rate of change in the slope.

and motivation was the willingness to escape or avoid the foot shock as the work requirement progressively increases (α).

3. Results

Results from experiment 1 showed that hedonic value and motivation to obtain positive reinforce does not change after mTBI, as α and Q_0 values did not differ between SHAM and mTBI rats. Similarly, motivation to escape foot shock was not also altered by mTBI as shown in Experiment 2. However, motivation to avoid foot shock was profoundly increased after mTBI, as both α and Q_0 were different between mTBI and SHAM rats.

4. Conclusions

Previously, we found that mTBI impairs avoidance learning in male rats [4]. This data supports the hypothesis that mTBI impacts avoidance learning by reducing the reinforcing value of an avoidance response and the motivation to avoid. This effect is selective for avoidance because neither reinforcing value nor motivation for sucrose and escaping foot shock were observed after mTBI. Future studies should investigate the effects of mTBI on brain substrates for negative reinforcement, especially those mechanisms involved in avoidance.

Acknowledgment

The present study was funded by the Biomedical Laboratory Research and Department of Veterans Affairs Office of Research & Development (I01BX000132), New Jersey Commission on Brain Injury Research (CBIR11PJT003 and CBIR14FEL014), National Institutes of Health (RO1-NS44373), and the Stress and Motivated Behavior Institute.

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