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Research report

Effects of optimism on gambling in the rat slot machine task

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HIGHLIGHTS

- We identified rats displaying 'pessimistic' and 'optimistic' traits.
- We determined how these traits affect behavior in the rat Slot Machine Task.
- 'Optimistic' rats were more likely to gamble in the hopeless 'clear loss' situation.
- We demonstrated interrelation between optimism and gambling in an animal model.

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ABSTRACT

Although gambling disorder is a serious social problem in modern societies, information about the behavioral traits that could determine vulnerability to this psychopathology is still scarce. In this study, we used a recently developed ambiguous-cue interpretation (ACI) paradigm to investigate whether 'optimism' and 'pessimism' as behavioral traits may determine the gambling-like behavior of rodents. In a series of ACI tests (cognitive bias screening), we identified rats that displayed 'pessimistic' and 'optimistic' traits. Subsequently, using the rat slot machine task (rSMT), we investigated if the 'optimistic'/'pessimistic' traits could determine the crucial feature of gambling-like behavior that has been investigated in rats and humans: the interpretation of 'near-miss' outcomes as a positive (i.e., win) situation. We found that 'optimists' did not interpret 'near-miss', 'near loss', or 'clear win' as win trials more often than their 'pessimistic' conspecifics; however, the 'optimists' were statistically more likely to reach for a reward in the hopeless 'clear loss' situation. This agrees with human studies and provides a platform for modeling interactions between behavioral traits and gambling in animals.

1. Introduction

Cognitive theories of psychiatric disorders have articulated the mediating role of cognitive biases, distortions in reasoning, and errors in judgment in the phenomenology of behavioral addictions, such as gambling disorder [1–3]. One of the errors in reasoning that may be critically involved in gambling disorder is cognitive judgment bias that is manifested by excessive optimism. According to Carver and Scheier [4], the generalized positive outcome expectancies of optimists result persistence in attempting to accomplish goals in the face of adversity, whereas the generalized negative outcome expectancies of pessimists result in withdrawal. Thus, the benefits of optimism may arise primarily in situations in which this persistence is rewarded. Unfortunately, not all situations and tasks have positive outcomes. Gambling is one important domain in which persistence is unlikely to be consistently rewarded and in which optimism may be a liability [5]. In agreement with this assumption, recent research on optimism and gambling has found that optimists had more positive expectations for gambling than did pessimists and were less likely to reduce their betting after poor outcomes [5]. Despite these findings, there is still a dearth of information concerning the interaction of optimism and gambling in both humans and rodents, and despite the important role of cognitive biases in psychopathologies, they have not been the subject of much preclinical behavioral research.

Although several research groups over the past decade have attempted to measure the effects of various behavioral and pharmacological manipulations on 'optimistic' and 'pessimistic' judgment biases [6–13], almost none of them have investigated 'optimism'/'pessimism' as an enduring and stable behavioral trait that could be used to evaluate its implications for psychiatric conditions, such as gambling disorder.

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We have recently shown that, similar to humans, the cognitive judgment bias of animals has components of both enduring traits and transient states [14]. A trait is the stable level of an individual's 'pessimism'/'optimism' that is generally experienced, whereas a state represents the valence of cognitive judgment bias that may change based upon the situation or contextual factors. We also have identified a relationship between cognitive judgment bias as a behavioral trait and vulnerability of animals to stress-induced anhedonia [14] as well as a correlation between the level of optimism and motivation [15].

In the present study, we used multiple ambiguous-cue interpretation (ACI) tests [10,11,13] to isolate two groups of rats that consistently differed in their cognitive judgment bias over time [14,15]. These two groups of 'pessimistic' and 'optimistic' rats were subsequently trained and tested for the propensity to gamble in the rat slot machine task (rSMT) [16]. In this behavioral paradigm subjects respond to a series of three flashing lights, loosely analogous to the wheels of a slot machine, causing the lights to set to 'ON' or 'OFF'. A winning outcome is signaled if all three lights were illuminated. At the end of each trial, rats chose between responding on the 'collect' lever, resulting in reward on win trials, but a time penalty on loss trials, or starting a new trial. Recent studies using this task revealed important role of dopamine in pathological gambling [16–18].

We hypothesized that, similar to humans, rats display different propensities to gamble in association with traits of 'optimism' and 'pessimism.'

2. Methods

2.1. Ethics statement

All described experimental procedures were conducted in accordance with the NIH Guide for the Care and Use of Laboratory Animals and were approved by the Committee for Ethics in Animal Experiments at the Institute of Pharmacology Polish Academy of Sciences.

2.2. Subjects and housing

We used 24 male Sprague Dawley rats (Charles River, Germany) that weighed between 175 and 200 g upon arrival. The animals were housed in groups of five, in a temperature ($21 \pm 1\,^{\circ}$C) and humidity (40–50%) controlled room under a 12/12 h dark/light cycle (lights on at 07:00 h). The animals were habituated to the housing conditions and experimental facility for two weeks after arrival and before the start of experiments. In all experiments, the animals received 15–20 g of food per rat per day (standard laboratory chow), which corresponds to mild food-deprivation. The food deprivation began seven days prior to beginning of the training. The rats were weighed once a week. The water was provided ad libitum . The animals were trained and tested during the light phase of the dark/light cycle. The rats were habituated to the experimental room for 30 min prior to training and testing sessions and were tested once daily.

2.3. Ambiguous-cue interpretation test

2.3.1. Apparatus

The experiments were conducted in eight computer-controlled, operant conditioning boxes (Med Associates, St. Albans, Vermont, USA). The boxes were equipped with lights, speakers, liquid dispensers (0.1 ml of 5% sucrose solution), electric grid floors, and two retractable levers. The levers were located on both sides of the liquid dispenser. The experimental protocols were written in Med State notation code (Med Associates).

2.3.2. Behavioral training

The experimental training and testing procedures for the ACI paradigm that was used in this study were modified from procedures previously described by Enkel et al. [10] and have been described in detail elsewhere [13,14,19–23].

In brief, initially the animals were trained to press one lever when a 'positive' tone (2000 Hz at 75 dB) signaled the availability of a reward (5% sucrose solution) and to press second lever when another, 'negative' tone (9000 Hz at 75 dB) signaled a forthcoming punishment (0.5 mA, 10 s). By pressing appropriate levers the animals could either receive a reward or avoid punishment. The tone presentations were separated by 10 s intertrial intervals (ITI) and each training session lasted 30 min. The animals had to fulfill the criteria of at least 90% of accurate responses to the tone signaling reward availability maintained over three consecutive training sessions and, at least 60% of correct punishment-prevention responses maintained over three consecutive training sessions, to proceed to the discrimination training.

During the discrimination-training phase, the animals were trained to discriminate between pseudo-randomly presented positive (20) and negative (20) tones by responding to the appropriate levers (as learned in the previous training stages), thereby minimizing punishment and maximizing reward delivery. Each discrimination training session lasted 40 min. The animals had to achieve a minimum of 70% correct responses with each lever, maintained over three consecutive discrimination sessions to be qualified for the ACI testing.

As for an animal it is really difficult to learn instrumental avoidance reaction in anticipation of punishment, the criterion at the stage of 'negative tone' training was lower than for the 'positive tone' training. However, at the stage of discrimination, all animals were trained until they reached equally stable discrimination ratio for both tones—minimum 70%.

2.3.3. Ambiguous-cue testing

During the ACI testing sessions the animals were exposed to 20 negative, 20 positive, and 10 ambiguous (5000 Hz at 75 dB) tone presentations. The tones were played in a pseudo-randomized order and were separated by 10 s ITIs. The responses to each tone (positive, ambiguous and negative) during the ACI testing were analyzed as the proportion of the overall number of responses to a given tone. To calculate the cognitive bias index, we subtracted the proportion of negative responses to the ambiguous-cues from the proportion of positive responses to the ambiguous-cue, which resulted in values ranging between −1 and 1. After median split, values above 0.14 indicated an overall positive judgment and 'optimistic' interpretation of the ambiguous-cue while the values below 0.14 indicated overall negative judgment and 'pessimism'.

2.3.4. Cognitive bias screening (CBS)

The CBS procedure has been described in detail elsewhere [14]. Briefly, to assess the cognitive judgment bias as a trait, we examined the animals using a series of 10 consecutive ACI tests that were conducted at one-week intervals. Based upon the average cognitive bias index that was obtained from these 10 ACI tests, the rats were divided into two subgroups: 'optimistic' and 'pessimistic'.

2.4. Rat slot machine task test

The experimental set-up, training and testing procedures for the rSMT paradigm used in this study were adapted and modified from procedures that were previously described by Winstanley et al. [16].