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Effect of failure/success feedback and the moderating influence of personality on reward motivation

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While motivation to pursue goals is often assumed to be a trait-like characteristic, it is influenced by a variety of situational factors. In particular, recent experiences of success or failure, as well as cognitive responses to these outcomes, may shape subsequent willingness to expend effort for future rewards. To date, however, these effects have not been explicitly tested. In the present study, 131 healthy individuals received either failure or success feedback on a cognitive task. They were then instructed to either ruminate or distract themselves from their emotions. Finally, they completed the Effort Expenditure for Rewards Task, a laboratory measure of reward motivation. Results indicate that participants who received failure feedback relied more strongly on the reward magnitude when choosing whether to exert greater effort to obtain larger rewards, though this effect only held under conditions of significant uncertainty about whether the effort would be rewarded. Further, participants with high levels of trait inhibition were less responsive to reward value and probability when choosing whether to expend greater effort, results that echo past studies of effort-based decision-making in psychological disorders.

Keywords: Reward; Feedback; Behavioural inhibition; Failure; Motivation.

The capacity to appreciate and seek out rewarding stimuli drives much of everyday behaviour. An important focus of current research is to understand factors both within the individual and in the environment that influence reward motivation. The present study examined whether the propensity to exert effort to obtain monetary reward is influenced by having just received failure or success feedback on an unrelated task. We further examined the influence that individual differences in self-reported reward and/or threat (behavioural activation and behavioural inhibition) sensitivity have on effort-based decision-making following such failure or success feedback.

Effort-based decision-making as a component of reward motivation

Reward-related behaviour consists of multiple psychological components. Whereas "liking" or

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consummatory pleasure refers to the subjective capacity to experience pleasure upon obtaining reward, "wanting" or anticipatory motivation precedes the receipt of reward and facilitates goal-directed behaviour (Berridge & Robinson, 2003) An important behavioural measure of anticipatory motivation is effort-based decision-making, or the choice to expend effort in order to pursue reward. People are continually faced with opportunities in which increasing their efforts might yield a higher reward. They must allocate their resources effectively across these various opportunities, taking into consideration both the value of the reward as well as the costs of expending resources to pursue it (Kruglanski et al., 2012). Effort-based decision-making reflects how an individual processes this cost and benefit information before making such a decision.

Preclinical research on the neurobiological basis of effort-based decision-making has identified a critical role for dopamine in promoting motivated behaviour (Salamone & Correa, 2012). In animal studies, rodents preferences for a high effort/high reward option (in which the rat had to negotiate a barrier to obtain a larger food reward) vs. a low effort/low reward option (with easy access to a smaller food reward), were substantially modulated by attenuation or potentiation of mesolimbic dopamine levels (Bardgett, Depenbrock, Downs, Points, & Green, 2009;). This work has recently been adapted to study human behaviour using the Effort Expenditure for Rewards Task (EEfRT; Treadway, Buckholtz, Schwartzman, Lambert, & Zald, 2009). In this task, participants repeatedly choose between a low effort (easy) motor task to obtain a smaller reward and a high manual effort (hard) motor task to obtain a higher monetary reward. In addition to varying the effort costs, this task also varies the probability cost. Specifically, not all successfully completed trials result in a "win" (lead to reward upon success). In parallel with the rodent literature, using the EEfRT, studies found that potentiation of dopamine increased the willingness to work for reward (Wardle, Treadway, Mayo, Zald, & de Wit, 2011). Additionally, individual differences in dopaminergic function in reward-related neural regions (e.g., ventral striatum) were correlated with a willingness to expend high effort, particularly when the probability of reward receipt was low (Treadway et al., 2012).

Despite this progress, little is known about the specific role of the situational context in which effort-based decision-making occurs. This is important because certain situational factors may make it more or less likely that individuals choose effortful, rewarding behaviours. In fact, research suggests that after receiving failure feedback on a task, individuals exert less effort and perform worse on a similar task (e.g., Hutchinson, Sherman, Martinovic, & Tenenbaum, 2008). Importantly, this effect of failure feedback may generalise to subsequent unrelated tasks. For example, participants who received false failure feedback on a social competence task subsequently performed worse on an unrelated letter-cancellation task compared to those who received no feedback (Brunstein & Gollwitzer, 1996). Generalised motivational effects of failure may trigger a pattern in which a person fails to consider alternate avenues of reinforcement when one avenue fails, creating a cycle of low motivation and failure as seen in depression (Hiroto & Seligman, 1975).

Whereas past research indicates that failure feedback lowers performance on subsequent cognitive tasks, few studies have examined the impact of failure on the decisional component of motivation. The EEfRT captures this motivational component by measuring how individuals respond to varying probability costs and reward magnitudes. For example, it may be expected that receiving failure feedback on a previous task makes individuals more sensitive to the probability costs involved in expending effort on a subsequent different task.

Moreover, failure feedback is known to impact individuals differently based on the subjective cognitive response to this feedback. Specifically, individuals who tend to ruminate on the meaning, causes and consequences of their emotions following failure typically experience greater dysphoria compared to those that distract attention away from themselves (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Therefore, the effect of failure feedback may be stronger for individuals who ruminate after a failure experience compared to individuals who distract attention away from their emotions.

Finally, research thus far has not examined the extent to which individual differences in personality profiles influence effort-based decision-making. Gray (1981) proposed that behaviour is guided by two neuropsychological systems related to motivation. The behavioural activation system (BAS) facilitates reward-oriented behaviour (Depue & Collins, 1999). The behavioural inhibition system (BIS), on the other hand, is responsible for inhibiting behaviour in response to aversive states of threat and non-reward (Carver, Sutton, & Scheier, 2000).

In the context of effort-based decision-making, individual differences in BIS and BAS sensitivity may influence processing of the costs and benefits of reward pursuit. Whereas BAS sensitivity might be expected to govern approach tendencies towards the higher reward. BIS activity may be sensitive to the risk of expending unrewarded effort. Such temperamental characteristics would be expected to moderate the effect of failure and success feedback on effort-based decision-making. For instance, individuals with high BAS activity may continue to be motivated towards the high reward regardless of the prior feedback received. Individuals with high BIS activity may in turn be impacted more highly by failure feedback (perceived as a threat cue), making them less likely to expend effort for reward.

Present study

Using the EEfRT, the present study examined whether receiving false failure or success feedback on a prior unrelated task influences the decision to expend effort and tolerate probability costs for the sake of a higher reward. By doing so, this study aimed to extend previous research on the motivational effect of false feedback by studying how feedback influences how people process cost-benefit information involved in reward pursuit.

It was hypothesised that failure (compared to success) would cause participants to become more conservative on a subsequent task in expending effort to pursue reward. This could manifest in two ways: after failure feedback, participants will display an overall preference for the easy task over the hard task, showing reduced intent to exert effort for reward; or participants will show higher selectivity in choosing the hard task by increasing reliance on the probability cost and reward value while making the decision.

Additionally, it was hypothesised that the effect of failure described above would be stronger for participants who ruminated on their emotional experience. Therefore, a self-focus manipulation condition was included, in which participants were randomly assigned to either ruminate or distract for eight minutes after receiving the false feedback. Finally, this study examined the influence of BAS and BIS sensitivity in influencing effort-based decision-making. It was hypothesised that approach tendencies associated with elevated self-reported BAS would result in a greater overall preference for the hard task. By contrast, it was predicted that avoidance tendencies, as indexed by elevated self-reported BIS, would be associated with increased selectivity of effort expenditure. We also explored whether the motivational impact of false feedback would be moderated by BIS and BAS sensitivity such that elevated BIS sensitivity would enhance the effect of failure feedback, whereas elevated BAS sensitivity would reduce it.

METHOD

Participants

Participants were 131 strongly right- or left-handed undergraduate students (average age = 18.8 years; 59.6% female) enrolled in Introduction to Psychology at Northwestern University. Ambidextrous participants, as indicated by the Chapman Handedness Questionnaire (Chapman & Chapman, 1987), were excluded to reduce variability in the differential difficulty of the hard vs. easy tasks on the EEfRT. Given research linking diagnoses of major depressive disorder to EEfRT performance (Treadway et al., 2012), depressive symptoms were assessed with the Inventory of

Depression and Anxiety Symptoms (Watson et al., 2007). The inventory of anxiety and depression symptoms general depression subscale indicated low levels of depression [mean item score = 2, standard deviation (SD) = 0.6]. Data were excluded for participants with invalid data on the EEfRT for any of the following: (1) used the incorrect hand on more than two trials (n = 7), (2) did not complete the required number of button presses on more than 10 trials (n = 6) and (3) data were not recorded due to technical difficulties (n = 7). Additionally, one outlier was excluded whose BIS score was less than the mean score by over 3 SDs. Excluded participants did not differ from included participants in their likelihood of being assigned to different Feedback (χ^2 (1, N = 130) = .01, p = 1.0) or Self-focus (χ^2 (1, N = 130) = .656, p = 0.49) Conditions. Excluded partcipants also did not differ from included participants on BIS (F(1,129) = 2.25, p = .14) or BAS (F(1,129) = .03, p = .87) scores. The final sample consisted of 110 participants (64% female).

Procedure

Participants first completed the False Feedback Task, followed by the Self-focus Task, and finally the Effort Expenditure for Reward Tasks (all tasks are described below; see Table 1 for the number of participants in each condition). To test the effectiveness of the manipulations, participants rated their positive and negative mood immediately before (Time 1) and after (Time 2) the False Feedback Task, and immediately after the Self-focus Manipulation Task (Time 3). All participants provided consent and completed the Behavioural Inhibition and Behavioural Activation Scale (BIS/BAS; Carver & White, 1994) prior to the laboratory session.

Table 1. *Cell size across feedback and self-focus conditions*

		Feedback		
		Failure	*Success*	*Total*
Self-focus	Rumination	26	30	56
	Distraction	27	27	54
Total		53	57	110

False feedback task

Participants were randomly assigned to receive either false failure (n = 53) or false success (n = 57) feedback at the end of the False Feedback Task, in which participants solve Compound Remote Associates (CRA) problems (Bowden & Jung-Beeman, 2003) that have been normed on undergraduate students at Northwestern University. For these problems, participants are provided with three words on a computer screen and must type out a fourth word that relates to the three. For example, for the problem words “safety”, “cushion” and “point”, the correct response would be “pin”. At the beginning of the task, participants read through a script describing the importance of the cognitive skill being measured and that their performance was predictive of important future academic and professional outcomes.

Of thirty CRA problems in the False Feedback Task, half were “easy” (solved by over 55% of the undergraduate population) and half were “difficult” (solved by less than 21% of this population) to maximise credibility of the false feedback. Participants received accurate feedback about their performance immediately after each individual problem; responses that were incorrect or in excess of the 15-second time limit were given accurate failure feedback with the correct answer to that problem before proceeding. After all the problems were completed, the false feedback manipulation was provided on participants’ overall task performance. Participants in the failure condition were told that their performance was in the bottom 23rd percentile, and those in the success condition were told that they performed in the 76th percentile of the Northwestern University undergraduate population. Problems were presented in random order on the computer monitor using E-Prime 1.1 software (Psychology Software Tools, Inc.). The task took approximately 15 minutes to complete.

Self-focus manipulation

Following the False Feedback Task, participants were administered an eight-minute self-focus manipulation, widely used in experimental investigations of rumination (Nolen-Hoeksema et al., 2008). Participants were randomly assigned to either ruminate (n = 56) or distract (n = 54) from their current feelings. Participants read through a booklet consisting of 45 statements relevant to their assigned condition (Nolen-Hoeksema & Morrow, 1991). Participants were told that this was an "imagination exercise" in order to mask the true intent of the manipulation. Statements in the rumination condition directed participants to focus on their current physical and emotional experience (e.g., "think about why you react the way you do"), while those in the distraction condition directed participants to focus attention away from themselves (e.g., "imagine a boat slowly crossing the Atlantic"). Content of both conditions was purposely kept neutral in valence to avoid inducing either negative or positive mood.

Reward motivation task

Participants were next administered the EEfRT (Treadway et al., 2009) to examine the effect of success/failure feedback on reward pursuit. This is a multi-trial task during which participants choose between an easy and hard task on each trial. For the "hard" task, participants were asked to successfully make 100 button presses using the little finger of their non-dominant hand within 21 seconds. The "easy" task involved making 30 button presses with the dominant index finger within 7 seconds. Participants were eligible to win $1.00 upon successful completion of the easy task, and a variable amount ranging from $1.24 to $4.12 for the hard task.

To manipulate the probability cost, participants were not guaranteed to win on every trial. Before choosing between the hard and easy task, participants were told the probability of a "win" in which successful completion of the trial resulted in reward. These probabilities varied across three levels—88% probability, 50% probability and

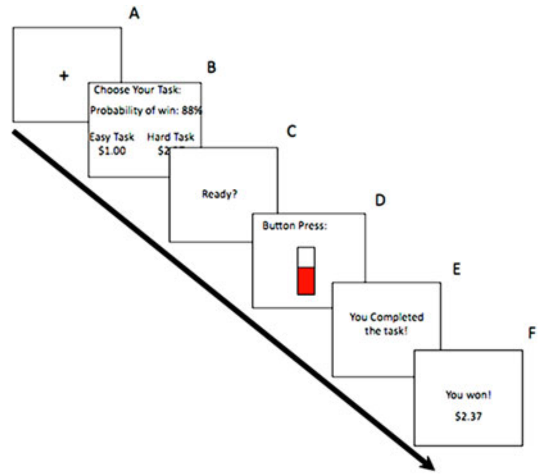

Figure 1. *Schematic diagram of a single trial of the EEfRT. Reprinted from "Worth the EEfRT? The EEfRT as an objective measure of motivation and anhedonia." by Treadway et al., (2009). Copyright: 2009 Treadway et al. Reprinted with permission.*

12% probability. If the trial was a "no win" trial, then the reward won was $0 regardless of the performance. Equal proportions of each probability were included across all trials and presented in the same random order to all participants.

Each trial began with a 1-second fixation cross, followed by a 5-second choice period when subjects were presented with both the probability of a "win" trial, and the reward magnitude for the hard task on that trial (see Figure 1). Subjects were instructed to choose either the easy or hard task within these 5 seconds to avoid being randomly assigned for that trial. Following each trial, participants received feedback about their performance and the amount of money won before proceeding. Subjects were informed before starting that four win trials from the whole task would be randomly selected as "incentive trials" for which they would receive the actual amount won on those trials. Participants were allowed a total of 20 minutes for the task, regardless of what trials they chose. Therefore, the number of trials administered depended upon the participant's choices. The odds of choosing the hard over the easy task on each trial constituted the dependent variable. Participants were video monitored to ensure correct hand use.

Self-report measures

Behavioural inhibition and behavioural activation scale)

This measure assesses dispositional sensitivities for the behavioural inhibition (threat sensitivity) and behavioural activation (incentive responsiveness) systems (Carver & White, 1994). It involves 20 items with response options ranging from 1 (strongly disagree) to 4 (strongly agree). Alpha reliabilities for BIS were .74 and for the three BAS subscales ranged between 0.66 and −0.76 (Carver & White, 1994). A composite BAS score was used which combined scores on the three subscales.

Handedness Questionnaire

This questionnaire was administered to check for ambidexterity (Chapman & Chapman, 1987).

Inventory of depression and anxiety symptoms

This measure assesses multiple dimensions of anxiety and depression with alpha reliabilities ranging from 0.77 to 0.89 in a college sample (Watson et al., 2007). The General Depression Scale and a composite of the anxiety subscales were used to assess the symptom levels in the current sample.

Items from the Motivational States Questionnaire

Four positive affect (PA) items (calm, relaxed, excited, alert) and four negative affect items (tense, gloomy, nervous, unhappy) were used to assess both high and low arousal mood at multiple points during the study. These items were selected from the Motivational States Questionnaire (Revelle & Anderson, 1998). Participants responded to each item using a 100-point visual analogue scale presented on a computer screen.

RESULTS

Manipulation check

To check the effectiveness of the feedback manipulation, mood ratings before (Time 1) and after (Time 2) the feedback task were compared for those who received failure feedback to those who received success feedback. Repeated measures analysis of variance tests were conducted with positive and negative mood ratings as dependent variables, and the Feedback Condition as the predictor, with performance accuracy on the False Feedback Task included as a covariate. Because participants received accurate trial-by-trial feedback on this task, it was possible that the efficacy of the false summary feedback was moderated by their actual performance on the task. Results showed that negative mood scores increased after the False Feedback Task regardless of the nature of feedback received ($F(1,103) = 5.92$, $p < .05$, $\eta_p^2 = .05$). The effect of the feedback manipulation on mood was in the predicted direction ($M_{\text{Time 2}}-M_{\text{Time 1}} = 12.21$ for failure; $M_{\text{Time 2}}-M_{\text{Time 1}} = 6.28$ for success) but did not reach significance $F(1,103) = 2.56$, $p = .11$, $\eta_p^2 = .02$). No significant effect of feedback on PA was observed. Performance accuracy did not appear to influence change in mood following false feedback.

To test the effectiveness of the self-focus manipulation, mood ratings before (Time 2) and after (Time 3) this manipulation were examined with the Self-focus and Feedback Condition as predictors. Participants in both distraction and rumination conditions experienced a decrease in negative mood after the Self-focus Task ($F(1, 106) = 20.12$, $p < .01$, $\eta_p^2 = .16$). The Self-focus manipulation significantly influenced negative mood ($F(1,105) = 11.1$, $p < .05$, partial $\eta^2 = .1$) such that participants in the distraction condition experienced a greater decrease in negative mood ($M_{\text{Time 3}}-M_{\text{Time 2}} = 10$) compared to those who were induced to ruminate ($M_{\text{Time 3}}-M_{\text{Time 2}} = 1.48$). Feedback Condition did not moderate this effect of self-focus. Further, the effect of self-focus on positive mood was not significant.

Effort-based decision-making

Generalised linear mixed (GLM) models were used to evaluate the effect of both between-subject (False Feedback, Self-focus, BIS and BAS) and within-subject (Reward amount, Probability of reward)

Table 2. *Hard task choice odds: base model including probability and reward as within-subject predictors*

	Estimate	*SE*	*z*	*P(>|z|)*	*OR*
Intercept	−0.67	0.17	−3.89	<0.001***	1.95
Probability (linear)	3.6	0.25	14.26	<0.001***	36.6
Probability (quadratic)	−0.27	0.17	−1.57		1.31
Reward	1.84	0.14	12.84	<0.001***	6.29
Probability (linear) × Reward	1.05	0.22	4.84	<0.001***	2.86
Probability (quadratic) × Reward	−0.02	0.2	.1		1.02

Prob (linear), linear effect of reward probability; Prob (quadratic), quadratic effect of reward probability; Rew, reward amount; OR, odds ratio.
$^{***}p < 0.001$.

variables on the binary response variable (choice of easy or hard task on the EEfRT), specifying a binomial distribution and logistic link function (Bolker et al., 2009). This approach permitted analysis of repeated measures on both items and subjects (Baayen, Davidson, & Bates, 2008). To determine the best random effect structure, a backwards model selection approach was used comparing a maximally specified random effects structure with nested models of reduced complexity via likliehood ratio tests (Baayen, Davidson, & Bates, 2008). Comparisons showed that the maximal random-effects structure justified by the data was by-subject random intercepts and slopes for Reward Value, Reward Probability and the Probability × Reward Value interaction and by-trial intercepts. Fixed effect estimates reported below represent the change in log odds of choosing the hard task with one unit change (or between contrast levels) in the predictor variable, and parameter significance was estimated based on the Wald (*z*) test. All analyses were conducted using *R* (R Development Core Team, 2013) using the lme4 package.

Likelihood ratio tests were used to compare models with and without key effects (Pinheiro & Bates, 2000). First, a base model was specified which included only the within-subject fixed effects as predictors [Akaike information criterion (AIC) = 4221.4, Bayesian information criterion (BIC) = 4406.3]. Next, a full model was specified which included the between-subject predictors, and then compared to the within-subject predictor model. Significant results within the more complex model were interpreted when they provided significantly better fit to the data according to the liklihood ratio test.

In the base model, the dependent variable was the odds of choosing hard vs. easy task on each trial of the EEfRT. The within-subject fixed-effects factors for this model were (1) Reward Value, refering to the monetary reward amount for a given trial of the hard task of the EEfRT ($1.24–$4.12) and (2) Probability, referring to the probability that the given trial in the EEfRT would be a "win" trial or yield reward should the participant successfully complete the task (12%, 50% or 88%). Orthogonal polynomial contrasts were used to test both the linear and quadratic effects of probability in all the models. All possible simple main effects and interactions between Reward and Probability were included in this model.

Fixed effect estimates, errors and odds ratios (ORs) of this model are reported in Table 2. The significant negative intercept estimate indicates that across participants and trials, there was a tendency to choose the easy task over the hard task. An OR of 1.95 indicates that the odds of choosing the easy task were almost two times the odds of choosing the hard task. A significant positive linear simple main effect[1] of Probability indicated that an increase in "win" probability from 12% to 50%, or 50% to 80% was associated

[1] Main effects of probability and reward were significant at varying levels of each other and within each experimental condition. Results are available on request.

with a 38-fold increase in the odds of a hard task choice. A simple main effect of Reward Value indicated that participants were more likely to choose the hard task on a trial when the task was associated with a higher reward amount (OR = 6.29). The significant positive interaction between Reward Value and Probability indicates that the effect of reward value on the odds of choosing the hard task was greater with increasing probability that the trial was a "win trial". Follow-up analyses were conducted to examine the effect of Reward within each Probability level, by specifying models with only the fixed effect of Reward on subsets of the data. These analyses showed that the OR associated with Reward was 2.75 among 12% Probability trials, 6.46 among 50% Probability trials and 14.39 among 88% Probability trials. This confirms that participants relied more strongly on the hard task reward value during decision-making when there was a higher probability that effort would lead to a win for that trial.

Next, a model was specified in which between-person fixed effects (Feedback Condition, Self-focus Condition and mean-centred BIS ($M(110) = 21.58$, SD = 3.18)[2] were added to the base model described above (AIC = 4245.6, BIC = 4708; see Table 3). Deviation coding was used to examine the odds of choosing the hard task on the EEfRT as a function of feedback in the Feedback Task (failure coded as −0.5 and success coded as +0.5) and Self-focus Conditions (rumination coded as −.5 and distraction coded as +.5). Once again, all possible simple main effects and interactions among the predictors were included in this model. The more complex between-person model provided a significantly better fit to the data than the base model ($\chi^2(42) = 59.76$, $p < .05$).

In the between-person model, parameter estimates of Reward Value, Probability and Reward × Probability were similar in magnitude and remained significant. Additionally, Feedback Condition in the False Feedback Task moderated the interactions between Reward Value and the linear effect of Probability ($b = .77$, SE = .28, $z = 2.74$, $p < .01$, OR = 2.15). To unpack this three-way interaction, models were specified including all fixed effects above for subsets of the data consisting of high, medium and low probability trials seperately. In these models, Feedback moderated the effect of Reward Value only among the medium probability trials, such that Reward Value had a stronger effect on the odds of choosing the hard vs. easy task in the failure condition compared to the success condition (Reward Value × Feedback −$b = -.55$, SE = .27, $z = -2.07$, $p < .05$, OR = 1.73; Figure 2).

The effect of Reward Value among medium probability trials was examined separately among participants in the failure and success conditions. These follow-up analyses revealed significant effects of Reward Value in both the failure ($b = 2.1$, SE = .25, $z = 8.32$, $p < .01$, OR = 8.17) and success conditions ($b = 1.59$, SE = .27, $z = 5.86$, $p < .01$, OR = 4.9). Specifically, whereas higher reward amount was associated with a greater likelihood of choosing the hard task in both Feedback Conditions, this effect was stronger for participants in the Failure Feedback Condition. In other words, when there was maximum uncertainty of receiving reward, having received failure feedback (compared to success feedback) on a prior unrelated task enhanced responsiveness to Reward Value while choosing between the hard vs. easy task (i.e., effort-based decision-making).

Further, the moderating impact of feedback was explored at different levels of reward amount. This was done by examining the coefficient corresponding to the main effect of feedback when centring the reward variable and the highest, middle and lowest reward value. These analyses revealed that feedback significantly influenced hard task choice only at the lowest value of reward amount ($b = 1.01$, SE = .40, $z = 2.52$, $p = .01$). Thus, findings thus far suggest that at lower levels

[2]We were unable to test a model that included all relevant between-person predictors, i.e., Feedback Condition, Self-focus Condition, BIS and BAS scores because this would have resulted in more parameters than available degrees of freedom. Such a model would have been underidentified. Therefore, BIS and BAS scores were included in separate models.

Table 3. *Hard task choice odds: Between-subject predictor model including feedback condition, self-focus condition and BIS as between-subject predictors*

	Estimate	*SE*	*z*	*P(>|z|)*	*OR*
Intercept	−0.68	0.17355	−3.907	<0.001***	1.97
Probability (linear)	3.62	0.24886	14.56	<0.001***	37.34
Probability (quadratic)	−0.30	0.17425	−1.728		1.34
Reward value	1.84	0.14352	12.821	<0.001***	6.3
Feedback	0.17	0.30532	0.549		1.19
BIS	0.03	0.04892	0.631		1.03
Self-focus	−0.49	0.30536	−1.615		1.63
Probability (linear) × Reward	1.00	0.21554	4.619	<0.001***	2.72
Probability (quadratic) × Reward	0.03	0.20201	0.141		1.03
Probability (linear) × Feedback	0.27	0.40872	0.65		1.31
Probability (quadratic) × Feedback	−0.06	0.19897	−0.287		1.06
Reward × Feedback	−0.17	0.21386	−0.778		1.19
Probability (linear) × BIS	−0.14	0.06568	−2.134	<0.05*	1.15
Probability (quadratic) × BIS	0.03	0.0323	0.79		1.03
Reward × BIS	−0.07	0.03435	−1.99	<0.05*	1.07
Feedback × BIS	0.08	0.09782	0.787		1.08
Probability (linear) × Self-focus	0.27	0.40875	0.656		1.31
Probability (quadratic) × Self-focus	−0.03	0.19896	−0.157		1.03
Reward × Self–focus	−0.41	0.21389	−1.938		1.51
Feedback × Self-focus	0.18	0.61055	0.298		1.2
BIS × Self-focus	−0.11	0.09782	−1.162		1.12
Probability (linear) × Reward × Feedback	0.77	0.27926	2.744	<0.01**	2.16
Probability (quadratic) × Reward × Feedback	0.44	0.23014	1.893		1.55
Probability (linear) × Reward × BIS	−0.02	0.04513	−0.378		1.02
Probability (quadratic) × Reward × BIS	−0.02	0.03747	−0.655		1.02
Probability (linear) × Feedback × BIS	−0.28	0.13128	−2.129	<0.05*	1.32
Probability (quadratic) × Feedback × BIS	−0.02	0.06454	−0.325		1.02
Reward × Feedback × BIS	0.02	0.06859	0.245		1.02
Probability (linear) × Reward × Self-focus	−0.41	0.27944	−1.452		1.51
Probability (quadratic) × Reward × Self-focus	0.26	0.2301	1.134		1.3
Probability (linear) × Feedback × Self-focus	0.70	0.81721	0.851		2.01
Probability (quadratic) × Feedback × Self-focus	0.32	0.39753	0.809		1.38
Reward × Feedback × Self-focus	0.12	0.42748	0.29		1.13
Probability (linear) × BIS × Self-focus	0.24	0.13131	1.857		1.27
Probability (quadratic) × BIS × self-focus	−0.02	0.06456	−0.281		1.02
Reward × BIS × Self-focus	0.03	0.06862	0.389		1.03
Feedback × BIS × Self-focus	0.02	0.19561	0.117		1.02
Probability (linear) × Reward × Feedback × BIS	−0.20	0.0899	−2.254	<0.05*	1.22
Probability (quadratic) × Reward × Feedback × BIS	0.13	0.07477	1.778		1.14
Probability (linear) × Reward × Feedback × Self-focus	0.07	0.55792	0.131		1.07
Probability (quadratic) × Reward × Feedback × Self-focus	0.13	0.45949	0.287		1.14
Probability (linear) × Reward × BIS × Self-focus	0.25	0.08988	2.729	<0.01**	1.28
Probability (quadratic) × Reward × BIS × Self-focus	−0.06	0.0748	−0.838		1.06
Probability (linear) × Feedback × BIS × Self-focus	0.13	0.26249	0.488		1.14
Probability (quadratic) × Feedback × BIS × Self-focus	−0.25	0.12902	−1.948		1.28
Reward × Feedback × BIS × Self-focus	−0.02	0.13712	−0.135		1.02
Probability (linear) × Reward × Feedback × BIS × Self-focus	0.03	0.17949	0.194		1.03
Probability (quadratic) × Reward × Feedback × BIS × Self-focus	0.03	0.14949	0.21		1.03

Note: Self-focus interactions not including Feedback Condition were not interpreted as it was hypothesised that Self-focus would moderate the effect of Feedback.
OR, Odds Ratio.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

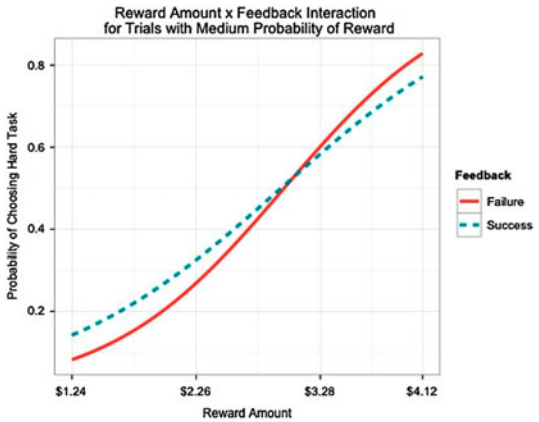

Figure 2. *Reward amount x failure feedback interaction among trials with medium probability of reward (50% chance of winning).*

of reward, individuals who received failure feedback relied more strongly on the reward amount when choosing whether to expend effort for reward. Self-focus Condition did not moderate the effect of feedback in the False Feedback Task on the EEfRT.

There were significant two-way interactions of BIS with Probability (b = −.14, SE = .07, z = −2.13, p < .05, OR = .87) and Reward Value (b = −.06, SE = .03, z = −1.99, p < .05, OR = .93). The negative coefficients indicate that high BIS was associated with a weaker effect of both Probability (linear) and Reward Value. Additionally, there was a three-way interaction betwen BIS, Feedback and the linear effect of Probability (b = −.28, SE = .13, z = −2.25, p < .05, OR = .76) as well as a four-way interaction between BIS, Feedback, Reward Value and the linear effect of Probability (b = −.20, SE = .09, z = −2.25, p < .05, OR = .82). To examine these higher order interactions, the effect of BIS was examined using subsets of data that included high (88%), medium (50%) and low (12%) probability trials separately. Results from these follow-up analyses did not yield significant results. Also, no significant effects were obtained when the effect of BIS was examined for participants in the Failure and Success Feedback conditions separately.

Finally, a BAS model was specified which included Feedback Condition, Self-focus Condition and mean-centred BAS scores[3] (M(110) = 38.94, SD = 4.77) as between-person predictors and Reward Value and Probability as within-person predictors. This model did not provide a significantly better fit to the data than did the base within-person model, suggesting that individual differences in BAS did not account for further variance in effort expenditure.

DISCUSSION

The present study examined the influence of false failure/success feedback and individual differences in self-reported threat and reward sensitivity on how individuals respond to effort and probability costs when choosing to pursue monetary reward (effort-based decision-making). Additionally, a self-focus manipulation examined whether rumination vs. distraction modulated the impact of failure/success feedback on motivation.

With regard to the effect of failure feedback, two patterns of results were hypothesised: failure (vs. success) feedback would result in either an overall reduced frequency of choosing the hard task, or a more selective approach to effort expenditure, such that participants exposed to failure feedback would rely more strongly on the probability and magnitude of reward when making their choice. In partial agreement with the second hypothesis, participants who received failure feedback were more responsive to the reward magnitude when choosing to expend effort. However, this effect was observed only among trials wherein the probability that success would lead to a reward was 50%. This suggests that the effect of failure on effort-based decision-making was noticeable when

[3] Analyses were run for each of the BAS subscales separately since BAS-reward responsiveness and BAS-drive could be theorised to be more applicable to reward sensitivity compared to BAS-fun (Franken & Muris, 2006). However, as with the composite, no significant results were found in these analyses.

there was maximum uncertainty about receiving a "win" upon success. On the other hand, when the probability of reward was low or high, participants may have been more influenced by the probability level (declining the hard task in low probability and accepting it in the high probability condition), regardless of the feedback received.

These findings imply an adaptive consequence of having received prior failure feedback. Increased reliance on reward magnitude is likely an effective strategy, particularly when it is uncertain that the effort will be rewarded. This suggests that motivational deficits experienced after failure may result from an adaptive tendency to conserve resources following a thwarted goal. Such a perspective is in line with the Cognitive Energetics Theory by Kruglanski et al. (2012), which proposes that individuals may not spend all available resources while pursuing a goal, but rather the inclination to conserve available resources varies across situations. The present results suggest that failure feedback on a prior goal-directed activity may enhance the inclination to conserve resources on a future task.

With regard to individual differences, it was hypothesised that reward sensitivity (BAS) would be associated with a motivation to pursue the higher reward amount, whereas threat sensitivity (BIS) would be associated with a more selective strategy of effort expenditure. Contrary to this hypothesis, BAS did not predict performance on the effort-based decision-making, nor did it moderate the effect of feedback on effort-based decision-making. The absence of such effects was surprising, particularly given that dopaminergic activity has been linked to both dispositional reward sensitiviy as well as performance on the EEfRT. More research is needed to examine the association between reward sensitivity and effort-based decision-making.

High BIS was associated with a weaker effect of both reward amount and reward probabilility on effort-based decision-making. These results are also not consistent with hypotheses but do reflect patterns of responding observed in clinical populations. Specifically, low sensitiviy to reward amount and probability on the EEfRT has been observed in individuals suffering from depression (Treadway et al., 2012), autism (Damiano, Aloi, Treadway, Bodfish, & Dichter, 2012) and schizophrenia (Gold et al., 2013). Moreover, all three disorders have been associated with high behavioural inhibition (e.g., Kasch, Rottenberg, Arnow, & Gotlib, 2002; Scholten, van Honk, Aleman, & Kahn, 2006; Schwartz et al., 2009). Therefore, rather than being more selective during effort expenditure, highly threat sensitive individuals may be less able to effectively use information related to reward magnitude and probability when choosing to expend effort.

Another explanation for these results is based on the finding that the False Feedback Task was aversive for all participants, leading to an increase in negative mood regardless of the nature of feedback. Following this experience, threat sensitive individuals may have disengaged from the reward task so that they were less reliant on relevant information about reward magnitude and probability during their decision-making.

With regard to the False Feedback manipulations, a differential impact of false feedback on mood was not obtained. Given that participants in both feedback conditions experienced a worsening of mood, it is possible that participants experienced an attenuated response to the success feedback. Indeed, the task itself was difficult, with an average accuracy rate of only 33% (SD = 11.6). Therefore, it is likely that participants felt they had done poorly on the task, and were either confirmed in their expectation of failure or pleasantly surprised with success feedback. Despite this, the nature of feedback received still influenced responses on the reward task. More research is needed to clarify the role of mood in the relationship between feedback and effort-based decision-making. For instance, mechanisms other than mood may play a role in this relationship. Alternatively, the change in mood required to influence reward motivation may be more subtle than can be reflected in changes in people's mood ratings.

The Self-focus manipulation did not moderate the effect of feedback on effort-based decision-making. This was unexpected, given that rumination about failure has been theorised to hijack cognitive resources affecting performance on subsequent cognitive tasks (Brunstein & Gollwitzer, 1996). One reason for this may be that rumination primarily functions to exacerbate the effects of existing negative mood (e.g., Lyubomirsky, Caldwell, & Nolen-Hoeksema, 1998). Since failure feedback did not appear to have a strong impact on negative mood in this sample (relative to success feedback), the Self-focus manipulation may not have taken effect to interact with False Feedback in influencing either mood or effort-based decision-making. Future research may use a False Feedback Task that is more potent in influencing mood in order to verify whether (1) change in mood following failure moderates the effect of feedback on effort-based decision-making and (2) whether ruminative self-focus enhances the effect of failure feedback on effort-based decision-making by intensifying negative mood.

It is important to note that this study was limited by a small sample size. Given that each of the four cells in this 2 × 2 design consisted of 27 participants on average, this study may have been underpowered to detect important higher order interactions (e.g., between BIS and feedback). A design using a larger sample size might help interpret the effects underlying such interactions. Similarly, the study may have been underpowered to detect the effect of false feedback on mood. A second limitation is that this study only compared responses to failure and success feedback, but did not include a "no feedback" condition. Therefore, caution must be applied when interpreting the obtained results as resulting from the sensitivity to negative feedback or positive feedback alone. Additionally, given the large number of effects examined within each GLM model, and the small sample size, there may have been an inflation of Type I error. In particular, the three-way interaction involving BIS must be interpreted with caution for this reason. Finally, the college student sample may not be representative of the general population.

The present study extends research on effort-based decision-making by examining the role of failure/success feedback on this component of motivation. Specifically, it provides preliminary evidence suggesting that after a failure experience, individuals employ an adaptive strategy by becoming more selective when choosing to expend effort in reward pursuit. This finding emphasises the importance of examining the situational context within which such decision-making occurs. Further, results suggest that when deciding whether to pursue effort for reward, high BIS may be associated with a difficulty using information related to the value of reward and the probability of reward receipt.

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