The Effects of Anxiety and Reward Sensitivity on the Interplay Between Emotion and Reward Processing

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Abstract

This study investigated the interplay between reward and emotion processing and examines the influence of individual differences, specifically anxiety and reward sensitivity, on these cognitive processes. Using a within-subjects design, 50 university students completed three associative matching tasks: emotional valence, value-based reward, and a control task. Participants' accuracy and response times (RTs) were measured alongside self-reported questionnaires assessing state-trait anxiety and sensitivity to reward.

The results demonstrated significant prioritisation effects for both reward and emotion processing. Participants showed higher accuracy and faster RTs for positive emotional stimuli (happy) and higher reward stimuli (medium and high rewards). The medium reward condition yielded the highest accuracy, suggesting a non-linear processing scale in reward evaluation. For emotional valence, happy stimuli were processed more accurately and faster than neutral or sad stimuli. Notably, sad stimuli also showed prioritisation over neutral stimuli, indicating that negative emotions can similarly enhance cognitive performance due to their evolutionary significance.

Individual differences played a crucial role in modulating these effects. Higher levels of state and trait anxiety were associated with reduced accuracy for happy stimuli. Conversely, no significant correlations were found between reward sensitivity and the prioritisation effects in either accuracy or RT, suggesting that reward sensitivity may not significantly influence these cognitive processes within the sample.

These findings align with behavioural studies that emphasise how emotional valence and reward magnitude can affect cognitive performance. The implications for clinical practice include the potential for personalised therapeutic interventions tailored to individuals' anxiety and reward sensitivity profiles. Future research should incorporate more diverse samples and employ realistic stimuli to enhance ecological validity. Additionally, further exploration of individual differences is essential. For instance, the observed influence of anxiety on cognitive processing highlights the need to better understand how anxiety affects prioritisation of emotional stimuli. Likewise, improving the measurement of reward sensitivity is also important, as current tools may not fully capture its nuances. Addressing these areas will provide a more comprehensive understanding of the complex dynamics of reward and emotion processing.

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Chapter 1. Introduction

Motivational factors, particularly those involving reward and emotion processing, play a pivotal role in human cognition by significantly influencing behaviour, decision-making, and overall well-being (Kringelbach & Berridge, 2017; Pessoa, 2018). Research into these processes has enhanced our comprehension of the neural and cognitive mechanisms that underlie human actions and responses across diverse scenarios (Fehr & Camerer, 2007; Ochsner & Gross, 2005). For example, studies on reward processing have shed light on the neural underpinnings of anhedonia – a core symptom of depression characterised by a diminished capacity to experience pleasure or interest in previously enjoyable activities (Treadway & Zald, 2011). Similarly, emotion processing research has highlighted the cognitive and neural bases of emotional regulation challenges faced by individuals with anxiety disorders. These challenges often include an increased sensitivity to negative emotional stimuli and a reduced ability to down-regulate negative emotions (Cisler & Koster, 2010; Etkin & Wager, 2007). Additionally, recent neuroimaging studies have revealed that specific brain regions such as the prefrontal cortex and amygdala, are critically involved in modulating these processes, suggesting an interconnected nature between reward and emotion processing (Hiser & Koenigs, 2018; McTeague et al., 2020).

Despite significant advancements in understanding reward and emotion processing independently, the nature of their relationship remains an ongoing debate (Berridge & Kringelbach, 2013; Pessoa, 2018; Yankouskaya et al., 2022a). The primary research gap involves determining whether reward and emotion processing share common cognitive mechanisms or if they operate through distinct processes. Addressing this gap is crucial for developing targeted interventions and treatments for mental health disorders, where disruptions in these processes often coexist and exacerbate symptoms. Furthermore, previous studies have highlighted the importance of individual differences in interpreting the interplay between reward and emotion processing (Kanske & Kotz, 2011; Sutton & Davidson, 1997). For instance, variations in personality traits, such as reward sensitivity and affective style, can significantly influence how individuals process and prioritise emotional and reward-related stimuli (Corr & Cooper, 2016).

This study aims to examine the relationship between reward and emotion processing, focusing on their overlaps and distinctions through a cognitive task. Additionally, it investigates how individual differences, measured through self-reported questionnaires, modulate these processes. Integrating these differences will provide a nuanced understanding of the dynamics between reward and emotion processing. Furthermore, the findings will enable practitioners to be more informed about the interplay of these processes, assisting in the development of appropriate treatment strategies for mental health disorders.

1.1. Reward Processing

Reward processing is a fundamental aspect of human cognition and behaviour, involving the evaluation, anticipation, and response to desirable or valuable stimuli (Pessiglione et al., 2006). For example, consider an employee who initially struggles to meet sales targets. As they gain experience and begin achieving these targets, they start associating their efforts with the rewards of earning bonuses and receiving recognition. This association reinforces their motivation to strive for higher sales, thereby improving their performance over time.

From a cognitive and behavioural standpoint, reward processing is a complex process that involves representing the value of rewards, comparing potential rewards, and utilising reward information to guide decision-making and learning (Hikosaka et al., 2008). Rewards can be divided into intrinsic and extrinsic categories. Intrinsic rewards derive from the activity itself and provide inherent satisfaction, such as the joy of learning or personal achievement

(Ryan & Deci, 2000). In contrast, extrinsic rewards are external incentives, like money or praise, provided to motivate behaviour towards specific goals (Deci et al., 1999).

One widely studied aspect of reward processing involves individuals learning to associate specific cues or stimuli with varying amounts of monetary reward. Early research in this area such as studies by Sui et al. (2012), which examined how self-associated stimuli influence perceptual matching tasks, and Stolte et al. (2021), which investigated how associations with self and value-based rewards impact attentional bias. These studies added to the understanding of the mechanisms underlying reward processing using associative matching tasks (AMT). Building on this, Yankouskaya et al. (2022a) employed a paradigm in which participants completed either a monetary value-based reward task or an emotional valence AMT. In the value-based task, participants exhibited faster response times (RT) and greater accuracy for shapes associated with high-reward compared to low-reward values, highlighting a general bias towards higher rewards. This finding reflects previous research outcomes (Stolte et al., 2021; Yankouskaya et al., 2017). However, the study has several limitations that warrant consideration. For instance, the use of only two reward stimuli (high vs low) rather than three or more (e.g., medium) may limit the depth of understanding regarding the gradation of reward effects. The gradation is important because it allows us to determine the specific points at which different levels of reward begin to influence performance. Previous studies have established that greater rewards generally lead to increased attention and motivation. However, by including a medium reward level, we can examine whether there is a threshold effect where moderate rewards might elicit a different response compared to high or low rewards. Moreover, using only two extreme levels (high and low) may guarantee an effect, potentially oversimplifying the relationship between reward and behaviour. This can help identify at which stage the impact of reward becomes significant and how incremental changes in reward influence behaviour. Furthermore, the absence of a control task in their design restricts the ability to fully isolate the effects of reward and emotion processing from other cognitive influences. Including a control task helps to identify and account for potential biases that could arise from general cognitive processes unrelated to reward and emotion. By comparing performance on tasks specifically designed to assess reward and emotion processing with a control task, it can more accurately determine whether observed effects are truly due to reward and emotion or if they are influenced by other cognitive factors. Addressing these limitations in future research may enhance the robustness and applicability of the findings.

The bias towards higher rewards has significant implications for understanding human decision-making and behaviour. Pessiglione et al. (2006) demonstrated this by manipulating dopaminergic function in healthy participants using drugs (Haloperidol or L-DOPA) during a task that involved choosing between visual stimuli to maximise monetary gains. The results showed that those given L-DOPA, which increases dopaminergic function, were more likely to choose the most rewarding action compared to those given Haloperidol, which decreases dopaminergic function. This suggests that dopamine modulates the value of rewards within the striatum, a crucial part of the brain's reward system. By increasing the propensity to choose the most rewarding action, dopamine drives individuals to seek and obtain valuable resources, leading to adaptive behaviour that maximises gains and achieves goals.

Further studies have indicated that the brain's reward system is inherently biased towards higher rewards due to their greater motivational salience (Berridge & Kringelbach, 2013). This bias ensures that individuals allocate more attention and cognitive resources to stimuli associated with higher rewards, enhancing performance in tasks involving such stimuli (Engelmann et al., 2009). However, the propensity for seeking higher rewards can also lead to maladaptive behaviours, such as addiction. Volkow et al. (2016) reviewed substance abuse literature and found that addiction can desensitise reward circuits, reducing an individual's motivation to pursue goals, thus creating a challenging cycle to break. This desensitisation is characterised by diminished responsiveness to natural rewards, which can perpetuate the cycle of seeking out addictive substances to achieve the desired level of reward stimulation.

Furthermore, dysfunction in reward processing is also implicated in anhedonia, a core symptom of depression. This reduced reward sensitivity can be linked to abnormalities in the brain's dopaminergic pathways, particularly involving the striatum and prefrontal cortex. Studies using functional magnetic resonance imaging (fMRI) have shown that individuals with depression exhibit decreased activation in these brain regions in response to rewarding stimuli, highlighting the neural basis of anhedonia (Pizzagalli et al., 2009; Whitton, et al., 2015). Anhedonia also affects their motivation and decision-making processes. For example, Pizzagalli et al. (2009) demonstrated that depressed individuals show less engagement in tasks that typically elicit reward responses, correlating with reduced activation in reward-related brain areas. This finding suggests anhedonia can hinder an individual's ability to pursue and experience rewards, further contributing to the maintenance of depressive symptoms.

Recent advancements in neuroimaging have provided insight into the neural circuitry underpinning reward processing, suggesting potential therapeutic targets (Knutson & Cooper, 2005; Schultz, 2016). Additionally, behavioural methodologies such as those employed by Yankouskaya et al. (2022a, 2022b), offer valuable frameworks for investigating the interplay between reward and emotion processing.

1.2. Emotion Processing

Emotion processing is a crucial component of human cognition and social interaction, involving the perception, evaluation, and interpretation of emotionally significant stimuli. For instance, individuals proficient at detecting subtle emotional cues in others, such as a slight smile or a furrowed brow, tend to navigate social interactions more effectively and form stronger interpersonal relationships (Zaki & Ochsner, 2009; Zaki & Williams, 2013). Research in this area has focused on uncovering the neural and cognitive mechanisms that enable the recognition and discrimination of various emotional expressions, including happiness, sadness, and fear (Adolphs, 2002; Ekman, 1993; Lindquist et al., 2016).

A key finding in emotion processing research is the presence of biases towards certain emotional stimuli. For example, studies have shown that individuals more readily and accurately identify happy faces compared to sad or other negatively valenced expressions (Leppänen & Hietanen, 2004; Vuilleumier & Schwartz, 2001). This phenomenon, known as the happy face advantage, is believed to stem from the evolutionary importance of recognising and responding to positive social signals that promote cooperative behaviour and social bonding (Becker et al., 2011). Conversely, other studies have identified an angry face advantage, where individuals detect angry faces more quickly and accurately than happy or neutral faces, underscoring the importance of recognising potential threats in an individual's environment (Calvo & Nummenmaa, 2015; Garrido & Prada, 2017). However, Yankouskaya et al. (2022a) found that participants responded faster to shapes associated with both happy and sad emotions compared to neutral stimuli in the emotional valence task. This suggests that the prioritisation effect may not be exclusive to positive or negative emotions as previously described by opposing research findings, highlighting the need for further research to understand the factors influencing these biases in emotion processing. Notably, individual differences may play a significant role in emotion processing prioritisation effects, and many studies have not adequately controlled for these variables (Kanske & Kotz, 2011).

Preferential processing of certain emotional expressions can influence how individuals perceive and interpret the emotions of others, subsequently affecting their decisions and actions in social contexts (Adolphs, 2002). Additionally, atypical emotion processing biases, such as heightened sensitivity to negative emotional stimuli, are linked to various psychopathological conditions, including anxiety and depression (Bar-Haim et al., 2007). For instance, Somerville et al. (2004) examined the amygdala's response to happy and neutral facial expressions, excluding negatively-valenced expressions. The amygdala, a brain region integral to fear processing and the fight-or-flight response, plays a significant role in anxiety-related behaviours (Janak & Tye, 2015). Their results indicated that higher state anxiety was associated with increased amygdala activity in response to neutral faces, suggesting that anxious individuals perceive neutral stimuli as potentially threatening, thereby maintaining anxiety symptoms (Shin & Liberzon, 2010). However, the exclusion of negatively-valenced stimuli in such studies potentially limits the generalisability of their findings. By not including a full spectrum of emotional stimuli, these studies might not fully capture the range of emotion processing biases that individuals may exhibit. Gaining a deeper understanding of the cognitive mechanisms underlying these biases is crucial for developing targeted interventions for those with emotion processing difficulties.

1.3. Interplay Between Reward and Emotion Processing

Research has identified notable similarities between reward and emotion processing at both neurological and cognitive levels. Neurologically, both processes involve attentional biases, where individuals are drawn to stimuli perceived as rewarding or emotionally significant (Anderson, 2016; Chelazzi et al., 2013). Meta-analyses by Cromwell et al. (2020) and Lindquist et al. (2016) indicate that motivational stimuli activate overlapping neural regions, including the cingulate cortex, anterior insula, ventral striatum, and prefrontal cortices. Additionally, positive emotions exhibit significant overlap with value-based processing, involving shared activation in the medial prefrontal node of the Default Mode network and the left posterior parietal node of the Frontoparietal network (Yankouskaya et al., 2022a, 2022b). In contrast, negative emotions primarily overlap with the medial prefrontal node of the Default

Mode network. This neural overlap across various reward and emotion-based tasks suggests that common underlying systems may govern both reward and emotion processes.

However, other studies highlight differences between reward and emotion processing. Diekhof et al. (2012) conducted a meta-analysis using fMRI to examine the neural correlates of these processes. They found that while common brain regions are involved in both reward and emotion processing, specific subregions of the striatum and prefrontal cortex are uniquely associated with either reward or emotion processing. A notable limitation identified was the increased signal-dropout, geometric distortion, and susceptibility artifacts in regions near air-filled sinuses, such as the orbitofrontal cortex (OFC). Despite its well-documented involvement in reward processing in animal studies, these technical challenges hinder the consistent observation of the OFC in human studies (Van Duuren et al., 2008).

Behaviourally, studies suggest that both reward and emotion stimuli facilitate cognitive processes such as learning, memory, and decision-making (Ono & Taniguchi, 2017; Stolte et al., 2021). However, some cognitive biases are specific to either reward or emotion processing, indicating they are not entirely interchangeable. For instance, Chiew and Braver (2011) found that while certain biases are common to both types of processing, such as the influence of positive affect on cognitive flexibility and negative affect on cognitive stability, reward processing is more closely associated with approach motivation (e.g., driven by positive or rewarding stimuli), while emotion processing is more closely linked to withdrawal motivation (e.g., driven by the avoidance of negative or aversive stimuli).

Yankouskaya et al. (2022a, 2022b) further explored these behavioural aspects using an emotional valence AMT. They found that participants responded faster to shapes associated with both happy and sad emotions compared to neutral stimuli, suggesting that the prioritisation effect is not exclusive to positive emotions. However, their study has several limitations. For example, they used only two reward stimuli rather than three or more, which might limit the depth of understanding regarding the gradation of reward effects. Additionally, the absence of a control task restricts the ability to fully isolate the effects of reward and emotion processing from other cognitive influences. Despite limitations, the AMT is particularly well-suited for investigating the potential overlap between reward and emotion processing. The AMT allows for the control and manipulation of the stimuli presented to participants, ensuring that any observed effects are directly attributable to the experimental conditions. By associating simple geometric shapes with emotional valences or reward values, the AMT provides a clear and measurable way to assess how these different types of stimuli influence cognitive processing. In addition, AMT enables for the comparison of cognitive responses to both reward and emotion stimuli within the same experimental framework. This comparability is crucial for identifying overlapping cognitive mechanisms. For instance, if participants show similar prioritisation effects, such as faster RTs and higher accuracy for both high-reward and positive emotion stimuli, this suggests that common cognitive processes are at play.

Overall, the findings from studies like Yankouskaya et al. (2022a, 2022b) highlight both the overlapping and distinct aspects of reward and emotion processing. While there are clear overlaps in the neural mechanisms, behavioural studies reveal nuanced differences in how these stimuli are processed. By using tools like the AMT, we can better understand these nuances and the prioritisation effects that reveal the cognitive gains associated with different stimuli.

1.4. Influence of Individual Differences

Individual differences such as reward sensitivity and anxiety levels significantly modulate reward and emotion processing. Research has shown that people with high reward sensitivity exhibit heightened responsiveness to rewarding stimuli, which can enhance learning and decision-making processes (Corr & Cooper, 2016). Conversely, individuals with high anxiety levels tend to have heightened sensitivity to negative emotional stimuli, which can impair their ability to process positive rewards effectively (Bar-Haim et al., 2007). For example, trait anxiety has been linked to increased amygdala activation in response to neutral and negative stimuli, suggesting that anxious individuals may perceive neutral stimuli as threatening, thereby affecting their emotional processing. This heightened sensitivity can lead to maladaptive behavioural patterns, such as avoidance behaviour, where anxious individuals might avoid potentially rewarding situations to evade perceived threats. On the other hand, the same heightened sensitivity might reduce approach behaviours towards rewarding stimuli, limiting their ability to engage in and benefit from positive experiences (Shin & Liberzon, 2010; Somerville et al., 2004). Therefore, it is possible that such individual differences would modulate the interplay between reward and emotion processing.

1.5. Rationale

Given the substantial evidence supporting both the interconnectedness and distinctiveness of reward and emotion processing, this study aims to elucidate whether these cognitive processes overlap or are distinct from one another. The primary focus is on secondary prioritisation effects, which allow us to determine if participants have a preference or bias towards high or medium rewards relative to low rewards and if they exhibit a bias towards positive or negative affect. By examining these prioritisation effects, we can infer whether the same cognitive mechanisms and motivational pathways are engaged when processing reward and emotion. An additional aim of the study is to examine the modulating effects of anxiety and reward sensitivity on reward and emotion processing. This is important as previous studies have failed to adequately control for potential individual differences, which can significantly impact the applicability of the findings to real-world scenarios. For instance, inform therapeutic strategies for individuals with anxiety disorders or depression. Tailoring interventions to account for how anxiety and reward sensitivity influence reward and emotion processing can enhance treatment efficacy. The present study addresses further limitations of previous research. For instance, methodologically, this study improves upon previous designs by including a control task, additional conditions in the reward and emotion valence tasks, and a larger number of participants. These adjustments are made to enhance the robustness and validity of the findings. The inclusion of a control task allows for a clearer isolation of the specific effects of reward and emotion processing by providing a baseline for comparison. Adding more conditions in the reward and emotion valence tasks helps to capture a wider range of responses. Increasing the sample size enhances the generalisability of the findings, making it more likely that the results can be applied to broader populations beyond the study sample.

In line with past research, it is hypothesised that participants will respond to reward stimuli faster and with higher accuracy compared to neutral stimuli, indicating a reward prioritisation effect. Emotional stimuli, particularly those with positive valence, are expected to be responded to faster and with higher accuracy compared to neutral stimuli, reflecting an emotional valence prioritisation effect. Additionally, no significant effects are anticipated for the control stimuli, as they serve to establish a baseline against which the reward and emotional valence conditions can be compared. This study also posits that individual differences in anxiety and reward sensitivity will modulate the prioritisation effects observed in reward and emotion processing tasks.

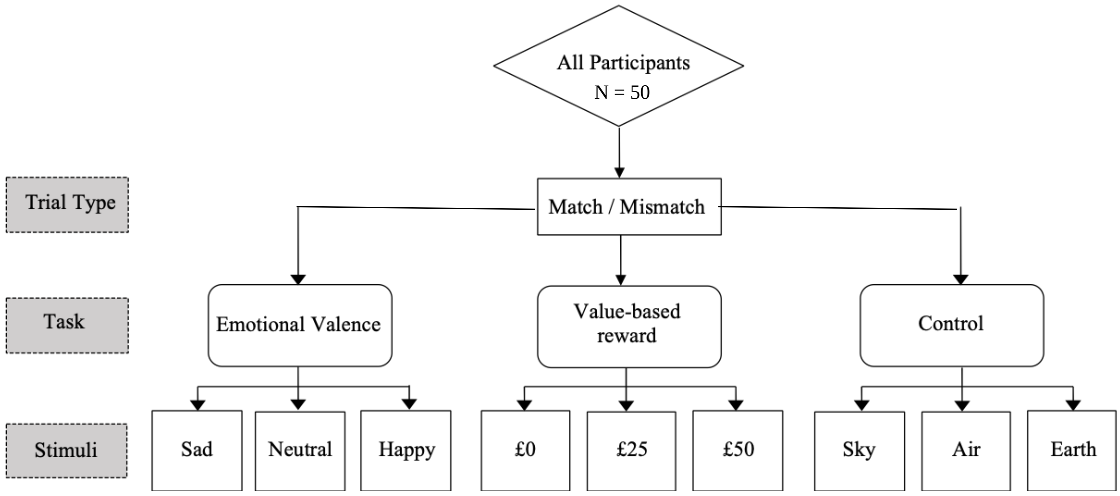
Chapter 2. Method

2.1. Design

A within-subjects design was employed for each of the three tasks: emotional valence, value-based reward, and control task. The experimental design was hierarchical where each task had a 2x3 design, with two factors: trial type (*match, mismatch*) and task-specific stimuli (three levels for each task: *happy*, *sad*, and *neutral* for emotional valence; *£0*, *£25*, and *£50* for value-based reward; *sky*, *air*, and *earth* for control task). The dependent measures were mean *accuracy* and response time (RT), as shown in figure 1. Additionally, participants completed self-reported questionnaires including the State-Trait Anxiety Inventory (STAI) and the Sensitivity to Reward (SR) scale to assess individual differences in anxiety and reward sensitivity.

Figure 1

Illustration of Experimental Design



Note. N = number of participants. In the emotional valence task, the stimuli are described in writing. However, during the experiment participants were presented with illustrations depicting happy, sad, and neutral valence. All other stimuli were presented as shown in the figure.

2.2. Participants

The study involved 56 students from Bournemouth University, comprising of 7 male and 49 females, aged between 18 and 28 years (*M* = 20.95; *SD* = 4.49). These participants were selected through opportunity sampling, which facilitated the recruitment of a large number of participants in a relatively short period, enhancing the efficiency of the data collection process compared to other more time-intensive sampling methods (Stratton, 2021). Eligibility criteria included fluency in English, normal or corrected-to-normal vision, and the absence of any mental health diagnoses or current use of psychiatric medication. Participant recruitment and the advertisement for the study were facilitated via the online research management system, SONA, which was exclusively accessible to students at Bournemouth University. In return for their participation, individuals were compensated with one SONA credit and an Amazon gift voucher each, the latter being an incentive for the value-based reward component of the study.

Sample size was performed using G*Power (Version 3.1.9.6). The power analysis was based on detecting a medium effect size (f = .25) with an alpha level of .05 and a power of .80. The analysis indicated that a minimum of 28 participants were adequate to detect significant effects within the data. To enhance the robustness and reliability of the results, sample size was increased to 50 participants. This larger sample size ensures more precise estimation of fixed and random effects, reduces the likelihood of Type II errors, and provides a solid foundation for hypothesis testing.

2.4. Materials

2.4.1. Computer-based Task

The study involved participants completing an emotional valence, value-based reward, and a control AMT. The fundamental concept of these tasks is to link a basic stimulus, like a simple geometric shape, with an associated emotion, value-based reward, or neutral information. This associative mechanism aims to enhance perceptual responses to stimuli associated with higher rewards or emotional laden content, as suggested by prior research (Stolte et al., 2021; Sui et al., 2012). The task design effectively controlled potential confounding variables such as complexity and familiarity of stimuli. To reduce the impact of stimuli and experimental sequence on the outcome measures, two randomisation strategies were implemented. These included limiting consecutive trials from the same condition to prevent predictable patterns and ensuring a balanced randomisation within each block. Such measures were essential to safeguard the integrity and impartiality of the experiment's results, thereby mitigating extraneous variables and experimenter bias and bolstering the validity of the findings.

Before the testing phase, participants underwent a learning phase designed to familiarise them with the associations between geometric shapes and their corresponding labels. This learning phase lasted approximately two minutes and was crucial for ensuring that participants could accurately remember and recognise the associations during the subsequent test phase. After learning phase, participants were required to indicate whether a displayed pairing matched or mismatched the associations previously learnt. For the emotional valence task, the learning involved associating geometric shapes with specific emotional labels (e.g., rectangle with happy, oval with sad, diamond with neutral). In the value-based task, different shapes were linked with monetary values (e.g., oval with £0, pentagon with £25, diamond with £50). The control task involved pairing shapes with arbitrary word labels (e.g., triangle with sky, star with earth, diamond with air). Each of these tasks adhered to a uniform experimental protocol.

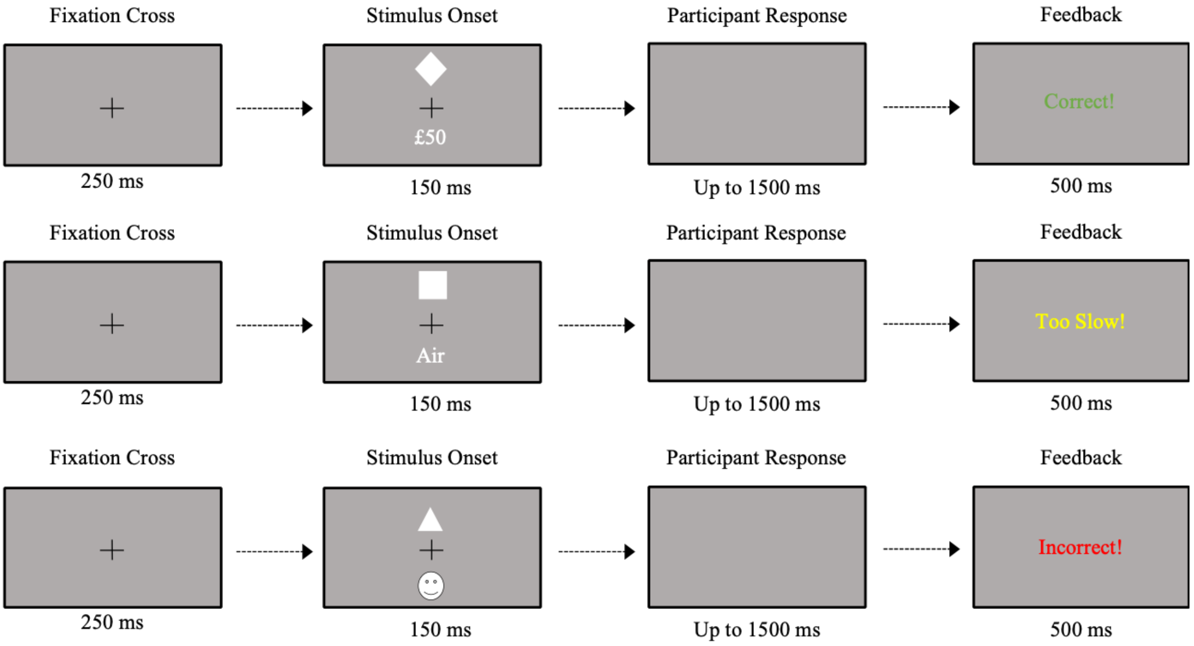
For the stimuli, a variety of geometric shapes (e.g., rectangle, oval, triangle, star, pentagon, and diamond) were randomly assigned across conditions in each task. The visual display setup included a fixation cross at the centre, flanked above and below by the shape and its corresponding label (Figure 2). The presentation order of shapes and labels was counterbalanced throughout the trials. Each trial commenced with a 250 ms fixation cross, followed by a 150 ms stimulus display, a response interval of up to 1500 ms, followed by a 500 ms feedback message regarding the participant's performance. A short practice session with 12 trials per task was conducted initially. Real-time feedback was provided post-trial, indicating the accuracy outcome (e.g., *Correct!* or *Incorrect!*) and RT (e.g., *Too Slow!*).

Participants were rewarded with Amazon gift vouchers, scaled to 0.01% of the monetary value associated with a correct shape (e.g., £0, £25, £50). For example, responding correctly to a shape associated with a £50 value would result in a reward of 0.01% of £50, a strategy employed to ensure participant motivation and engagement in the task. The monetary incentive was not displayed on screen but rather distributed post-experiment by email to participants. In total, 1080 trials were administered, equally divided among the three tasks (360 trials each).

The tasks were designed and executed using PsychoPy (Version 2023.2.2). Participants completed tasks in a secluded booth at Bournemouth University's laboratory, using a Lenovo ThinkStation P330, equipped with Windows 10, 64-bit, and 32GB RAM. The experiments were displayed on a BenQ XL 2411 monitor, a 24-inch widescreen with a 1920 x 1080 resolution.

Figure 2

Examples of Experimental Task Design



Note. The first row is an example of the value-based reward task, the second row is an example of the control task, and the third row is an example of the emotional valence task.

2.4.2. Questionnaires

The study employed two standardised psychometric questionnaires to assess individual differences in anxiety and reward sensitivity: the State-Trait Anxiety Inventory (STAI) and the Sensitivity to Reward (SR) scale from the Sensitivity to Punishment and Reward Questionnaire (SPSRQ).

The STAI is a widely used tool for measuring anxiety in adults (Spielberger et al., 1983). It comprises two scales with 20 items each. The State Anxiety Scale (S-Anxiety) assesses the current state of anxiety, asking how respondents feel *right now*, using items that measure subjective feelings of apprehension, tension, nervousness, and worry. For Example, *I feel calm*. The Trait Anxiety Scale (T-Anxiety) evaluates relatively stable aspects of anxiety proneness, including *general* states of calmness, confidence, and security. For Example, *I lack self-confidence*. Each item is rated on a 4-point Likert scale, ranging from *Not At All* to *Very Much So* for S-Anxiety and from *Almost Never* to *Almost Always* for T-Anxiety, with higher scores indicating greater self-reported anxiety for both sub-scales. Possible scores range from 20 indicating the least possible anxiety to 80 indicating the most possible anxiety. The scale demonstrated high internal consistency, with Cronbach's α ranging from .88 to .94 for the state and trait subscales, indicating reliability of the items within the subscales. Test-retest reliability over a 30- to 60-day interval ranged from r = .36 to r = .86, indicating stability over time (Spielberger et al., 1983; Groth-Marnat, 2003).

The SR scale is designed to assess individual differences in sensitivity to reward (Torrubia et al., 2001). This scale consists of 24 items that measure responses to rewarding stimuli, particularly in terms of approach behaviour. Participants receive 1 point for a *yes* response and 0 points for a *no* response, with a higher total score indicating greater sensitivity to reward. For example, *Does the good prospect of obtaining money motivate you strongly to do some things?* The SR scale has demonstrated good psychometric properties in assessing reward sensitivity, with Cronbach's α ranges between .78 and .75 indicating internal consistency. Test-retest reliability over three months was reported at .87 for the SR scale (Dufey et al., 2011).

2.5. Procedure

This study received approval from the Ethical Board of Bournemouth University on December 5th, 2023, in line with the university's Research Ethics Code of Practice. It rigorously adhered to the ethical standards outlined in the Code of Ethics and Conduct (2021) and the Code of Human Research Ethics (2021) as established by the British Psychological Society. To distribute the gift vouchers post-experiment, participants' email addresses were collected. All participant data was anonymised and kept in a password-protected computer only accessible by the Researcher, additionally, any personally identifying information was securely disposed of upon the study's completion.

Participants were briefed on the expected duration of the study, approximately 60 minutes, and were provided with a detailed study information sheet (Appendix 1). They were also required to sign a consent form (Appendix 2) to confirm their understanding and voluntary participation. The process for completing initial questionnaires (aimed at collecting reward sensitivity and anxiety levels) and subsequent computer-based tasks (aimed at collecting accuracy and RT data) was detailed by the experimenter. Participants were informed that their performance in the value-based reward task would influence their Amazon gift voucher amount. Breaks were permitted between tasks, with the experimenter present to ensure smooth conduct.

Upon completing questionnaires and computer-based tasks, participants were debriefed. They were notified about the email delivery of their Amazon gift voucher within two weeks post-study and were asked to confirm receipt by responding to the email.

2.6. Data Analysis

Jamovi version 2.5 (The Jamovi Project, 2024) statistical software was used to analyse the data. Data from six participants were excluded from the analysis due to low accuracy on at least one of the tasks. Further data cleaning involved the removal of fast guesses (< 150 ms) and slow responses (> 1500 ms) to ensure data quality. Specifically, 3.38% of all trials were removed as slow responses, with task-specific removals of .94% for Control, 1.32% for Valence, and 1.12% for Rewards tasks. Additionally, fast guesses, which comprised 3.19% of all trials, were also excluded, with 1.70% from Valence, .93% from Reward, and .56% from Control tasks.

Descriptive statistics were calculated for each task and condition. This included calculating the mean (*M*) and standard deviation (*SD*) for accuracy and RT across different conditions in the Control, Valence, and Rewards tasks. Regarding questionnaire data, the total mean scores and standard deviations for both the SR and the STAI scales were calculated.

For accuracy data, which was binary (correct or incorrect responses), a Generalised Linear Mixed Modelling (GLMM) analysis was used. GLMMs extend the standard GLM model to include both fixed and random effects, making it well-suited for data that involves non-Gaussian correlated data for correlations within groups or participants, such as repeated measures on the same participants. This approach uses a logistic regression framework, incorporating a binary distribution and a logit link function. This allows for the probability of a correct response as a function of the experimental conditions while accounting for the random variability among participants, making it suitable to analyse accuracy. The advantage of GLMM over traditional logistic regression is its ability to handle unbalanced data and missing values without a significant loss of power (Bates et al., 2018).

For RT data, which was continuous, a Linear Mixed Modelling (LMM) analytical approach was used. The contribution of the random effect of participants was estimated using the Likelihood Ratio Test (LRT), which compares the fit of a model with and without the random effect (Judd et al., 2012). Similar to the GLMM, LMMs can include both fixed and random effects, making it suitable for analysing RT data within groups or individual participants. Compared to traditional Analysis of Variance (ANOVA), LMMs offer robust handling of missing data, are less susceptible to outliers, and account for individual differences among participants. Additionally, LMMs are robust to violations of normality assumptions.

To control for multiple comparisons, the Bonferroni correction was applied. This correction was calculated by dividing the alpha level (0.05) by the number of comparisons being made. This stringent correction reduces the likelihood of Type I errors by adjusting the significance threshold based on the number of tests conducted.

Prioritisation effects were calculated for each task by determining the differences between shapes associated with higher and lower social value for both accuracy and RT. For the control task, shapes were associated with abstract words with no obvious social value, so differences were calculated between all pairs of stimuli. For the current investigation, only partial measurements were used, while a more detailed analysis of all relative measurements of prioritisation effects will be conducted elsewhere. In line with previous studies (e.g., Yankouskaya et al., 2022a), Prioritisation effects were calculated for each task by determining the differences between shapes associated with higher and lower social value for both accuracy and RT. For the control task, shapes were associated with abstract words with no obvious social value. Differences in accuracy and RT were calculated between all pairs of stimuli to assess any potential prioritisation effects. For the reward task, shapes were associated with different monetary values and were calculated by comparing the differences in accuracy and RT between shapes associated with higher values and lower values. For the valence task, shapes were associated with different emotional labels and were calculated by comparing the differences in accuracy and RT between shapes associated with happy and neutral stimuli, as well as between sad and neutral stimuli. The analysis was limited to prioritisation effects in match trials, as mismatched trials contain conflicting information (e.g., a shape associated with a wrong label or vice versa).

The magnitude of the prioritisation effect in each task was assessed using one-sample t-tests to examine whether the prioritisation effect was significantly different to zero (i.e., positive). To investigate the magnitude of the difference between the prioritisation effects of emotional valence and value-based reward, a paired-sample t-test was employed. Lastly, a Pearson's correlation analysis was conducted to investigate the relationship between the prioritisation effects observed in the value-based reward and emotional valence tasks with participants' scores from the STAI and SR scales.

Chapter 3. Results

3.1. Descriptive Statistics

3.1.1. Accuracy

Table 1 presents accuracy descriptive data across the conditions within the control, reward, and valence tasks. Overall, participants demonstrated higher accuracy in match trials across all tasks compared to mismatch trials. In the control task, accuracy was consistently higher for match conditions (Earth, Sky, Air) than mismatch conditions, though the differences between specific conditions were minimal. For the reward task, participants showed the highest accuracy in the medium reward condition, followed by high reward and no reward conditions. In the valence task, accuracy was highest for happy stimuli, followed by neutral and sad stimuli.

These observations suggest some influences of reward magnitude and emotional valence on participant accuracy, particularly in matched conditions but with no consistent trend observed for mismatched conditions.

Table 1

Descriptive Statistics for Accuracy Data

Conditions	***n***	***M***	***SD***
Control Match			
Earth	50	79.93	12.27
Sky	50	80.07	18.63
Air	50	80.57	17.08
Control Mismatch			
Earth	50	78.23	15.90
Sky	50	78.43	16.49
Air	50	77.23	17.72
Reward Match			
Low reward	50	72.77	17.64
Medium reward	50	81.13	19.87
High reward	50	76.67	21.38
Reward Mismatch			
Low reward	50	71.87	19.93
Medium reward	50	73.60	19.26
High reward	50	71.60	17.88
Valence Match			
Happy	50	83.93	20.29
Neutral	50	76.93	19.09
Sad	50	72.80	18.73
Valence Mismatch			
Happy	50	77.03	18.64
Neutral	50	77.83	18.61
Sad	50	73.13	16.56

Note. *n* = number of participants, *M* = mean, and *SD* = Standard Deviation.

3.1.2. Response Time

Table 2 presents RT descriptive data across the three conditions as a function of matched and mismatched trials. In the control task, RTs for matched conditions were generally faster compared to mismatched conditions. This pattern of faster RTs in matched conditions suggest quicker decision-making when stimuli are congruent.

RT varied across levels of reward. The Medium Reward matched condition demonstrated a relatively faster mean RT compared to the High Reward and Low Reward conditions. In mismatched conditions, RTs were generally slower for Medium reward, High reward, and Low reward, displaying no clear trend across different reward levels.

For the valence task, the fastest responses occurred with Happy stimuli in the matched condition, followed by Neutral stimuli, and Sad stimuli. Mismatched conditions showed slower RT for Sad, Neutral, and Happy.

Across all tasks, matched conditions consistently showed faster RTs than mismatched conditions, indicating that participants responded quicker to congruent stimuli. The standard deviations indicated much variability in individual response speeds.

Table 2

Descriptive Statistics for Response Time Data

Conditions	***n***	***M***	***SD***
Control Match			
Earth	50	730.45	81.64
Sky	50	738.47	99.37
Air	50	738.03	94.03
Control Mismatch			
Earth	50	800.90	107.80
Sky	50	798.60	107.17
Air	50	803.40	106.50
Reward Match			
Low reward	50	785.57	131.64
Medium reward	50	771.35	112.99
High reward	50	777.61	112.43
Reward Mismatch			
Low reward	50	839.93	136.62
Medium reward	50	833.32	122.86
High reward	50	830.11	129.42
Valence Match			
Happy	50	747.44	114.06
Neutral	50	818.59	125.36
Sad	50	843.05	109.56
Valence Mismatch			
Happy	50	850.02	129.07
Neutral	50	863.43	122.85
Sad	50	871.48	107.95

Note. *n* = number of participants, *M* = mean, and *SD* = Standard Deviation.

3.1.3. Questionnaire

Table 3 presents descriptive data for both SR and STAI questionnaires. The average SR scale total score was 10.86 (*SD* = 3.37), aligning with normative data collected from university student populations where SR mean scores ranged between 10 and 12 (Dufey et al., 2011; Torrubia et al., 2001). For the STAI, the mean score on the S-Anxiety subscale was 37.92. This average suggests a low level of state anxiety among participants, although it was just below the moderate threshold (typically defined as 40). While many scores were clustered around the average, there was considerable variation, as indicated by the standard deviations, with some participants reporting higher or lower levels of anxiety. The mean score on the T-Anxiety subscale was higher, at 47.74, suggesting participants, on average, perceive themselves as having higher levels of anxiety as a personal trait, than as a temporary state. The standard deviation for this sub-scale also indicated noticeable variability among participants in trait anxiety.

Table 3

Descriptive Statistics for SR and STAI Questionnaire Data

Questionnaire	***n***	***M***	***SD***
SR Scale	50	10.86	3.37
STAI Scale			
State Anxiety	50	37.92	9.86
Trait Anxiety	50	47.74	9.58

Note. *n* = number of participants, *M* = mean, and *SD* = Standard Deviation. These values provide the central tendency and variability with the participant responses for both the SR scale and STAI. For specific item names, see appendix 3 and 4.

3.2. Accuracy Analysis

In the analyses of accuracy data, a generalised linear mixed model (GLMM) was employed using a logistic regression framework suitable for the binary nature of the data (1 = correct, 0 = incorrect). The model assessed the impact of the three conditions across the three tasks (Control: Earth, Air, Sky; Reward: No Reward, Medium Reward, High Reward; Valence: Happy, Neutral, Sad) on the probability of correct responses.

3.2.1. Control Task

The conditional R^2 was reported at 0.15, indicating 15% of the variance in accuracy was explained by both fixed and random effects, while the marginal R^2 was 0.00, suggesting fixed effects alone did not account for significant variance in accuracy. The omnibus test for the effect of condition on accuracy did not reach statistical significance, $\chi^2(2) = 2.56$, $p = .277$, indicating no differences in accuracy across the conditions.

The random effects analysis revealed an intercept variance of 0.57 with a standard deviation of 0.76, indicating moderate variability in accuracy across individuals (Coolican, 2018). The total variance in accuracy that could be attributed to differences between individuals was 15% (ICC = 0.15), which is generally considered a moderate level of variability.

Fixed effects analysis showed no significant differences between the control conditions. Specifically, the comparison between Earth and Air ($B = -0.10$, $SE = 0.07$, 95% CI [0.78, 1.05], $p = .190$) and Sky and Air ($B = 0.01$, $SE = 0.08$, 95% CI [0.87, 1.17], $p = .895$) revealed non-significant results. Post hoc comparisons also indicated no significant differences between any of the control conditions ($p > .05$).

Findings suggest the manipulated conditions within the control task did not significantly influence the accuracy of responses, with individual differences among participants representing a significant component of the data.

3.2.2. Reward Task

The conditional R^2 for the model was 0.24, indicating that 24% of the variance in accuracy was explained by both fixed and random effects, whilst the marginal R^2 was 0.02, indicating that fixed effects alone explained a small portion of the variance in accuracy. The omnibus test for the effect of condition on accuracy was significant, $\chi^2(2) = 70.10$, $p < .001$, indicating differences in accuracy across the reward conditions.

The parameter estimates revealed significant differences between reward conditions. Specifically, the comparison between High Reward and No Reward conditions showed a significant effect ($B = -0.25$, $SE = 0.07$, 95% CI [0.68, 0.90], $p < .001$), indicating lower accuracy for No Reward compared to high Reward. Similarly, Medium Reward compared to High Reward also showed a significant difference ($B = 0.38$, $SE = 0.08$, 95% CI [1.26, 1.71], $p < .001$), suggesting higher accuracy under the Medium Reward condition.

The random effects indicated variability in accuracy across individuals, with an intercept variance of 0.97 and a standard deviation of 0.98. Post hoc comparisons using the Bonferroni correction showed that the Medium Reward condition significantly enhanced performance compared to both the No Reward and High Reward conditions. Specifically, participants' Medium Reward trials were significantly more accurate than those in the No Reward condition ($OR = 1.88$, $SE = 0.14$, $z = 8.37$, $p < .001$). Similarly, accuracy was higher in the Medium Reward condition compared to the High Reward condition ($OR = 1.47$, $SE = 0.08$, $z = 4.99$, $p < .001$), and participants in the No Reward condition had a significantly lower probability of correct responses compared to those in the High Reward condition (*OR* = 0.68, *SE* = 0.05, *z* = -4.99, $p < .001$).

3.2.3. Valence Task

The conditional R^2 was 0.28, indicating that 28% of the variance in accuracy was explained by both fixed and random effects, whilst the marginal R^2 was 0.03, demonstrating that fixed effects alone explained a small portion of the variance in accuracy. The omnibus test for the effects of emotional valence on accuracy was highly significant, $\chi^2(2) = 136.65$, $p < .001$, indicating differences in accuracy across the valence condition.

The parameter estimates revealed significant differences among the levels of valence. The Neutral condition was associated with a lower probability of correct responses compared to Happy (*B* = 0.55, 95% CI [0.47, 0.64], $p < .001$) and the Sad condition showed an even lower probability compared to Happy (B) = 0.40, 95% CI [0.34, 0.46], $p < .001$).

The random effects analysis indicated variability in accuracy across individuals, with an intercept variance of 1.16 and a standard deviation of 1.08, highlighting the influence of individual differences on accuracy outcomes. The ICC for the model was 0.26, which is generally considered to reflect a moderate level of variability (Coolican, 2018).

Post hoc comparisons using the Bonferroni correction showed significant differences between all emotional conditions. Specifically, significantly higher odds of accuracy were found for Happy compared to Neutral (*OR* = 1.82, *SE* = 0.15, *z* = 7.37, $p < .001$) and Sad (*OR* = 2.53, *SE* = 0.20, *z* = 11.68, $p < .001$). Additionally, Neutral also demonstrated a higher odds of accuracy compared to Sad (*OR* = 1.39, SE = 0.10, *z* = 4.56, $p < .001$). These findings highlight the significant influence of emotional valence on accuracy, with Happy stimuli leading to the highest likelihood of correct responses, followed by Neutral, and least effectively by Sad stimuli.

3.3. Response Time Analysis

In the analysis of RT data, a linear mixed model (LMM) was employed to assess the impact of different conditions across the three tasks (Control: Earth, Air, Sky; Reward: No Reward, Medium, High Reward; Valence: Happy, Neutral, Sad) on RTs.

3.3.1. Control Task

The conditional R^2 was reported as 0.18, indicating that 18% of the variance in RT was explained by both fixed and random effects, whilst the marginal R^2 was a minimal 0.00, suggesting that the fixed effects alone did not account for a substantial portion of the variance in RT. The omnibus test for the effect of condition on RT was not statistically significant, $F(2, 14182.10) = 1.41$, $p = .245$, indicating no differences in RT across the conditions.

The random effects analysis revealed an intercept variance of 7553.74 with a standard deviation of 86.91, reflecting large variability in RT across individuals. The total variability in RT that could be attributed to differences between individuals was 18% (ICC = 0.18). These findings suggest that the conditions within the control task did not significantly influence the RT of participants, with individual differences among participants representing a significant component of the data.

3.3.2. Reward Task

The conditional R^2 of the model was reported at 0.26, suggesting that 26% of the variance in RT was explained both fixed and random effects, whilst the marginal R^2 was 0.00, indicating that the fixed effects alone did not explain a significant portion of the variance in RT. The omnibus test for the effect of condition on RT was significant, $F(2, 6874.79) = 14.16$, $p < .001$, demonstrating substantial differences in RT across the reward conditions.

The random effects analysis revealed an intercept variance of 12,094.43 with a standard deviation of 109.97, reflecting considerable variability in RT across individuals. The total variability in RT that could be attributed to differences between individuals was 26% (ICC = 0.26).

Post hoc comparisons of the conditions indicated significant differences in RT. Specifically, participants in the No Reward condition showed longer RTs compared to those in the Medium Reward condition (*MD* = -25.79, *SE* = 5.46, *t*(6874.99) = -4.73, $p < .001$). Similarly, RTs were longer in the No Reward compared to the High Reward condition (*MD* = -25.19, *SE* = 5.54, *t*(6875.43) = -4.55, $p < .001$), and there was no significant difference between the High Reward and Medium Reward conditions(*MD* = 0.60, *SE* = 5.38, *t*(6873.99) = 0.11, $p = 1$). These findings suggest absence of reward significantly impacts RTs, with No Reward conditions leading to slower RTs compared to both Medium and High Reward conditions.

3.3.3. Valence Task

The conditional R^2 of the model was 0.28, indicating 28% of the variance in RT was explained by both fixed and random effects. The marginal R^2 was 0.05, showing that the fixed effects alone explained 5% of the variance in RT. The omnibus test for the effect of condition on RT was significant, $F(2, 6970.21) = 218.08$, $p < .001$, indicating differences in RT across emotional valence.

The parameter estimates indicated significant effects of emotional valence on RT. the Neutral condition had significantly slower RTs compared to the Happy condition, (*MD* = 81.68, *SE* = 5.29, *t*(6970.72) = 15.45, 95% CI [71.32, 92.04], $p < .001$). Similarly, slower RTs were observed in Sad relative to Happy trials, (*MD* = 105.69, *SE* = 5.37, *t*(6970.87) = 19.69, 95% CI [95.17, 116.21], $p < .001$).

The random effects analysis revealed an intercept variance of 10,810.83 with a standard deviation of 103.98, indicating large variability in RT across individuals. The Intraclass Correlation Coefficient (ICC) for the model was 0.24, suggesting that 24% of the total variability in RT could be attributed to differences between individuals.

Post hoc comparisons indicated that participants RT for Happy was significantly faster than Neutral (*MD* = -81.68, *SE* = 5.29, *t*(6970.72) = -15.45, *p* < .001), and Sad trials (*MD* = -105.69, *SE* = 5.37, *t*(6970.87) = -19.69, *p* < .001). Finally, when comparing Neutral and Sad the RTs were faster in the Neutral condition (*MD* = -24.01, *SE* = 5.47, *t*(6968.97) = -4.39, *p* < .001). These findings indicate emotional valence significantly influences the RTs, with Happy stimuli associated with the fastest responses, followed by Neutral and then Sad stimuli.

3.4. Prioritisation Effects Analysis

The analysis revealed significant accuracy prioritisation effects for the Happy vs Neutral, High reward vs Low reward, and Medium reward vs Low reward conditions. These results suggest that participants' accuracy was significantly higher for Happy stimuli compared to Neutral stimuli, and significantly lower for Sad stimuli compared to Neutral stimuli, indicating that Neutral stimuli were processed more accurately than Sad stimuli. Additionally, accuracy was significantly higher for High reward and Medium reward stimuli compared to Low reward stimuli (Table 4). Comparisons for control conditions (Earth, Sky, Air) and certain reward conditions did not show significant prioritisation effects, indicating these conditions did not significantly impact accuracy in the tasks (*p* > .05).

The analysis showed significant RT prioritisation effects for the Neutral vs Happy, Neutral vs Sad, Low reward vs High reward, and Low reward vs Medium reward conditions. Participants' RTs were significantly faster for Happy stimuli compared to Neutral stimuli, and significantly slower for Sad stimuli compared to Neutral stimuli. Furthermore, RTs were significantly faster for High reward stimuli compared to Low reward stimuli, and for Medium reward stimuli compared to Low reward stimuli (Table 4). Comparisons for control conditions (Earth, Sky, Air) and certain reward conditions did not exhibit significant prioritisation effects, indicating these conditions did not significantly impact RT in the tasks ($p > .05$).

Table 4

Prioritisation Effects for Accuracy and RT

Conditions	***t(49)***	***p***
Accuracy		
Happy vs Neutral	-17.23	< .001
Sad vs Neutral	-21.63	< .001
High Reward vs Low Reward	-18.13	< .001
Medium Reward vs Low Reward	-25.21	< .001
Response Time		
Neutral vs Happy	46.34	< .001
Neutral vs Sad	54.41	< .001
Low Reward vs High Reward	-13.37	< .001
Low Reward vs Medium Reward	-18.13	< .001

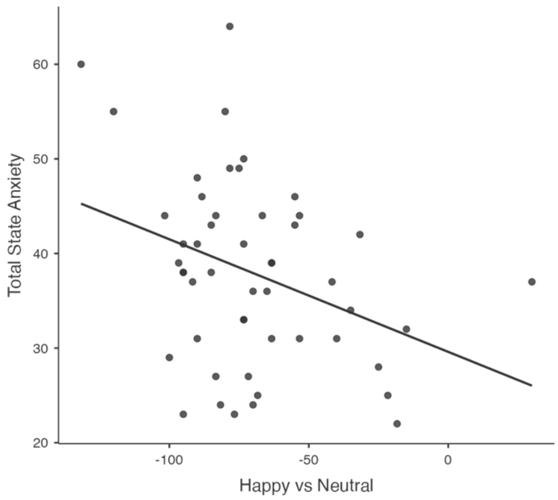
Note. The table includes the t-statistic and p-value comparisons that were significantly above zero.

3.5. Correlations Between Prioritisation Effects and Questionnaire Scores

A Pearson’s correlation analysis was conducted to examine the relationships between prioritisation effects that were significantly different from zero and questionnaire scores. In the accuracy task, there was a significant negative correlation between Total State Anxiety and Happy vs Neutral accuracy prioritisation effect, $r(48) = -.35$, $p = .014$ (Figure 3). In addition, total Trait Anxiety also showed a significant negative correlation with the Happy vs Neutral prioritisation effect, $r(48) = -.35$, $p = .012$ (Figure 4). However, no significant correlations were found between the SR total scores and any of the accuracy prioritisation effects. For the RT task, no significant correlations were found between any of the RT prioritisation effects and the questionnaire scores.

Figure 3

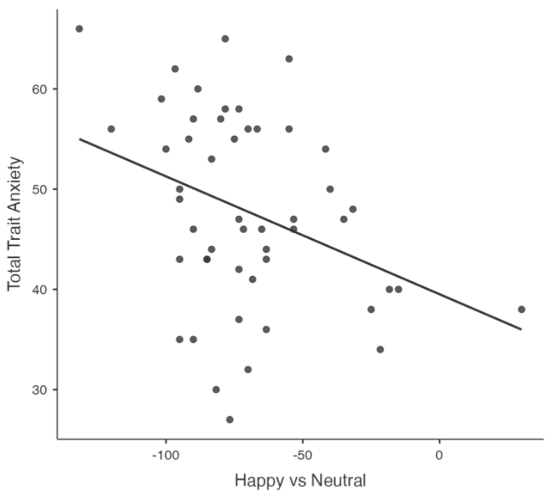
The Relationship Between Total State Anxiety and Happy vs Neutral Accuracy Prioritisation Effect



Note. The Happy vs Neutral accuracy prioritisation effect is plotted against Total State Anxiety scores.

Figure 4

The Relationship Between Total Trait Anxiety and Happy vs Neutral Accuracy Prioritisation Effect



Note. The Happy vs Neutral accuracy prioritisation effect is plotted against Total Trait Anxiety scores.

These findings suggest that higher levels of state and trait anxiety are associated with reduced prioritisation of happy stimuli over neutral stimuli in terms of accuracy. This indicates that individuals with higher anxiety may have difficulty prioritising positive emotional information. Additionally, the lack of significant correlations for the RT task and SR scores implies that reward sensitivity and anxiety do not have an impact on RT or the ability to prioritise based on reward and emotional valence.

Chapter 4. Discussion

The main objective of this study was to elucidate the interplay between emotion and reward processing and to determine how individual differences, specifically anxiety and reward sensitivity, influence these cognitive processes. The hypotheses proposed that participants would show higher accuracy and faster response times (RTs) for happy (positive) emotional stimuli compared to neutral and sad (negative) emotional stimuli, and for higher reward (£25 and £50) stimuli compared to lower reward (£0) stimuli. Additionally, it was hypothesised that individual differences in anxiety would negatively impact the prioritisation of happy emotional stimuli, while individual differences in reward sensitivity would modulate the processing of reward-related stimuli. These hypotheses were investigated using a robust experimental design that included emotional valence and value-based reward Associate Matching Tasks (AMT) to capture the nuances of cognitive processing related to both emotion and reward.

The results revealed significant prioritisation effects in both emotion and reward processing tasks. Participants demonstrated higher accuracy and faster RTs for happy (positive) emotional stimuli and higher reward (£25 and £50) stimuli. Specifically, shapes associated with happy emotions and higher monetary values (£25 and £50) were processed with greater accuracy and faster RTs compared to neutral or lower-value (£0) stimuli. In the reward task, the medium reward (£25) condition exhibited the highest accuracy, followed by the high reward (£50) and low reward (£0) conditions. This suggests a non-linear processing scale in reward evaluation, which may be explained by the optimal arousal theory. According to this theory, moderate levels of arousal, induced by medium reward, can lead to optimal cognitive performance, whereas very high or very low levels of arousal, induced by high or low rewards respectively, might impair performance due to overstimulation or lack of motivation. For the valence task, participants showed enhanced accuracy and faster RTs when interacting with the happy stimuli compared to the neutral and sad stimuli. These results indicate a bias towards more emotionally positive and higher rewarding stimuli. The control task, which included neutral stimuli with no emotional or reward associations, showed no significant differences in accuracy or RTs across the different conditions (Earth, Sky, Air). This indicates that the control stimuli did not elicit prioritisation effects, suggesting that the observed effects in the reward and emotion tasks were specifically due to the emotional valence and reward value of the stimuli.

Furthermore, individual differences played a significant role in modulating task performance. Participants with higher levels of state and trait anxiety showed reduced prioritisation for happy emotional stimuli, indicating that anxiety may interfere with the cognitive bias towards positive information. However, contrary to expectations, there was no evidence that anxiety enhanced processing of negative (sad) stimuli. In fact, sad stimuli were processed less accurately and more slowly than neutral stimuli, suggesting that anxiety may impair the processing of positive stimuli without enhancing the processing of negative stimuli. No significant correlations were found between reward sensitivity and prioritisation effects in either accuracy or RT, possibly because the SR scale used may not have been sensitive enough to capture the nuances of reward sensitivity or because the range of reward values was not wide enough to elicit differences.

4.1. Reward and Emotion Processing

Consistent with prior research, the study's results demonstrated a prioritisation effect for stimuli associated with positive emotions and higher rewards (Yankouskaya et al., 2022a). This suggests that both reward and emotion processing may engage common cognitive mechanisms, which could be attributed to the overlapping activities in brain regions such as the ventral striatum and prefrontal cortex, known for their roles in evaluating emotional and reward-related information (Hiser & Koenigs, 2018; McTeague et al., 2020).

Notably, the results provided new insights into the differential impact of emotional valence on cognitive processing. Participants showed enhanced accuracy and faster RTs when interacting with happy versus neutral stimuli, which supports the happy face advantage observed in previous emotional recognition studies (Leppänen & Hietanen, 2004). However, contrary to expectations, there was no prioritisation effect for sad versus neutral stimuli. In fact, sad stimuli were processed with lower accuracy and slower RTs compared to neutral stimuli. This finding suggests that negative emotions like sadness may not capture attention or enhance cognitive processing, which contrasts with some theories proposing that negative emotions universally enhance cognitive performance due to their evolutionary significance in signalling potential threats (Vuilleumier, 2005). These findings indicate that while positive emotions can enhance cognitive performance, negative emotions like sadness may not have the same effect. Positive emotions like happiness may foster social bonds and cooperation (Becker et al., 2011), whereas negative emotions like sadness may not enhance vigilance and problem-solving in response to adverse situations as previously thought.

Furthermore, the distinction in processing between different reward magnitudes observed in this study further highlighted how individuals value different incentives. This aligns with the findings of Stolte et al. (2021), who noted that people exhibit faster RTs to cues associated with higher rewards. The prioritisation effect of medium over low and high rewards suggests a non-linear processing scale in reward evaluation. One possible explanation for this finding is the optimal arousal theory, which posits that moderate levels of arousal can lead to optimal cognitive performance (Ryan & Deci, 2000). In this context, medium rewards may induce a level of arousal that enhances cognitive processing without causing the overstimulation that high rewards might provoke or the lack of motivation associated with low rewards. This concept could be explored further in future research to understand the specific conditions under which medium rewards might be more effective than high rewards in enhancing performance.

4.2. Individual Differences

Participants with higher levels of state and trait anxiety showed reduced prioritisation for happy emotional stimuli, indicating that anxiety may interfere with the cognitive bias towards positive information. However, contrary to some previous research, our findings did not show that anxiety enhances processing of negative (sad) stimuli. Instead, sad stimuli were processed less accurately and more slowly than neutral stimuli, regardless of anxiety levels. This suggests that anxiety may impair the processing of positive information without a corresponding enhancement for negative information. These insights are particularly valuable as they provide empirical support for theories proposing that anxiety alters cognitive processing by impairing sensitivity to positive information (Eysenck et al., 2007). Interestingly, while anxiety affected how accurate people were, it didn't change how fast they responded. This difference might be because accuracy and RT measure different aspects of cognitive performance. Accuracy reflects the correctness of cognitive processing, which anxiety might reduce by impacting attention and decision-making processes related to positive stimuli. On the other hand, RT measures response speed, which might not be as affected by anxiety. Anxiety might not slow down the response speed but rather impact how correctly decisions are made.

In contrast, reward sensitivity did not show a significant correlation with any prioritisation effects, suggesting that within this sample, reward sensitivity may not play as crucial a role in cognitive processing as previously thought (Corr & Cooper, 2016). A possible reason for this lack of correlation could be that the SR scale was not sensitive enough to capture the nuances of reward sensitivity, or that the range of reward values was not wide enough to elicit differences based on individual reward sensitivity. This indicates the need for more refined measures of reward sensitivity in future research to fully understand its role in cognitive processing.

4.3. Theoretical Applications

The findings from this study both challenge and support existing research. For instance, while the happy face advantage observed supports evolutionary theories that suggest the importance of positive emotional recognition in social interactions (Becker et al., 2011), the nuanced responses to reward magnitude challenge the simple linear models of reward processing proposed in classical conditioning theories. Instead, they support more complex theories of motivation and decision-making that incorporate factors like arousal and satiation (Berridge & Kringelbach, 2013). According to these theories, the optimal level of arousal for cognitive performance is achieved with moderate rewards, which can enhance focus and effort without causing overstimulation or complacency. This helps explain the unexpected finding that medium rewards (£25) elicited higher accuracy than high rewards (£50), suggesting that the highest rewards might induce excessive arousal, leading to decreased performance.

Moreover, the role of individual differences in modulating these processes highlights the need to consider personality and mood factors. This is particularly true regarding the influence of anxiety on emotional processing. Affective neuroscience suggests that emotional and cognitive processes are shaped by individual neurobiological differences (Pessoa, 2018).

Additionally, the findings align with the theories of approach motivation discussed by Chiew and Braver (2011), which emphasise the role of reward sensitivity in driving motivational states and cognitive control. These theories suggest that individual differences in approach motivation can significantly influence how rewards and emotions are processed, further underscoring the importance of personalised approaches in both research and clinical settings.

Despite the significant findings regarding anxiety, the lack of significant correlations between the RS scale and prioritisation effects in both accuracy and RT is noteworthy. One possible explanation for this could be related to the nature of the RS scale itself. The scale may not be sensitive enough to detect subtle differences in reward processing within a relatively homogenous sample, such as university students. Another explanation could be that the sample used in this study differs from those in other studies where the RS scale has shown significant effects. This discrepancy suggests that more research is needed to refine our understanding of how reward sensitivity interacts with cognitive processes, potentially incorporating a wider range of participants and more nuanced measures of reward sensitivity.

4.4. Practical Applications

The findings from this study offer valuable insights for clinical practice, particularly in designing interventions for mental health issues such as anxiety and depression. Understanding the interplay between emotion and reward processing, as well as the modulating effects of individual differences like anxiety and reward sensitivity, provides a nuanced framework for assessing and treating these disorders.

Clinicians can incorporate assessments of reward sensitivity and anxiety into the diagnostic processes. By evaluating how individuals respond to rewards and emotional stimuli, mental health professionals can gain deeper insights into the underlying cognitive biases that may exacerbate or maintain psychiatric symptoms. Treatments can be tailored based on an individual's specific profile of anxiety and reward sensitivity. For example, therapeutic techniques might differ for a patient with high anxiety and low reward sensitivity compared to someone with moderate anxiety but high reward sensitivity. This personalised approach allows for more precise management of symptoms, potentially increasing the efficacy of psychological interventions. Therapies such as Cognitive Behavioural Therapy (CBT), can be adapted to specifically address the issues of reward sensitivity and emotional response biases. For instance, patients with high reward sensitivity might benefit from interventions that focus on managing expectations and reactions to rewards, potentially reducing behaviours linked to impulsivity and addiction. For individuals with anxiety, therapy could include exercises specifically designed to challenge the prioritisation of emotional stimuli, thereby reducing the over-evaluation of negative cues and enhancing the processing of positive stimuli. Equally important are the preventative opportunities that could curb the onset of more severe psychological challenges. For populations identified as high-risk based on reward sensitivity and anxiety characteristics, early intervention programs can strategically focus on resilience training, emotional regulation, and reward processing adjustments. For example, digital interventions such as apps or virtual reality programs could be designed to train patients in recognising and responding to emotional and reward stimuli in healthier ways. Such measures are designed to pre-emptively address and potentially avert the development of clinical disorders.

4.5. Limitations

One of the primary limitations of this study is the relatively small and homogenous sample size, comprising of university students. The use of opportunity sampling, while efficient, may introduce bias, as it is not entirely random and can lead to a sample that is not representative of the broader population. This lack of diversity in the sample limits the generalisability of the findings, as the observed effects might not extend to other demographic groups, such as males, older adults, or individuals from different cultural backgrounds. However, the homogeneity of the sample does allow for more controlled comparisons within a specific demographic, providing clearer insights within this group, and provides the opportunity for further research. Another limitation lies in the assessment of individual differences using self-reported questionnaires. While tools like the STAI and the SR scale have strong validity, self-report measures can be subject to biases such as social desirability and response bias. However, the use of these standardised measures allows for the comparison of results with a broad body of existing research, enhancing the study's relevance and connection to established literature. Additionally, the study used only one happy face, one sad face, and one neutral face, which could be seen as a limitation. This approach was chosen to control for potential variations in how each expression is expressed, thereby reducing variability that might have impacted performance. However, future research could benefit from including multiple expressions for each emotion to enhance ecological validity. The experimental design, while robust in controlling for various confounds, also presents some limitations. For instance, the use of a within-subjects design could introduce carryover effects, where participants' performance in one task influences their performance in subsequent tasks. Although measures were taken to mitigate this, such as randomising the order of tasks, the potential for these effects cannot be entirely ruled out. Despite these challenges, the study's robust methodological approach provides a strong foundation for understanding the interplay between emotion and reward processing, offering valuable insights that can inform future research.

4.6. Future Research Direction

This study opens several avenues for future research, particularly in further exploring the intricate relationship between emotion and reward processing, and how these processes are modulated by individual differences in anxiety. While this study examined low, medium, and high reward conditions, future research could benefit from incorporating a wider range of reward levels to better understand the nuances of reward sensitivity. Additionally, expanding the range of emotional stimuli to include other emotions such as anger, fear, and disgust could provide a more comprehensive understanding of how different emotional states influence cognitive performance and decision-making. Future research could also benefit from including multiple expressions for each emotion (e.g., different variations of happy, sad, and neutral faces) to enhance ecological validity and control for potential variations in emotional expression.

Future studies should aim to include larger and more diverse samples to enhance the generalisability of the findings. This could involve recruiting participants from multiple institutions and varying demographic backgrounds, including different age groups, genders, and cultural contexts. Incorporating physiological measures such as heart rate and neuroimaging techniques (e.g., fMRI) could offer a more comprehensive view of the underlying mechanisms. These measures would complement behavioural data, providing a multi-faceted understanding of emotion and reward processing.

To improve ecological validity, future research could utilise more realistic and complex stimuli, such as dynamic social interactions or real-world reward scenarios. For example, instead of using abstract shapes and monetary rewards, researchers could simulate a work environment where participants receive different types of feedback and incentives for their performance on tasks. This approach would provide a more accurate representation of how reward and emotion processing occur in everyday life. Virtual and augmented reality technologies could be useful in creating environments that closely mimic real-life situations.

Considering the findings regarding reward sensitivity, future research could investigate the reliability and validity of the SR scale in different populations and settings. It would be beneficial to explore whether other measures of reward sensitivity or different methodological approaches might yield more significant results. Additionally, future research should consider the possibility of employing more sensitive and specific measures of reward sensitivity that could better capture individual differences and their impact on cognitive processing.

Moreover, future research should consider the role of anxiety in modulating cognitive processes more deeply. The finding that anxiety significantly impacted accuracy but not RT suggests that different aspects of cognitive performance might be differentially sensitive to emotional and motivational states. Investigating these differential effects could provide a more nuanced understanding of how anxiety affects cognition.

4.7. Conclusion

This study aimed to elucidate the interplay between emotion and reward processing and to determine how individual differences, specifically anxiety and reward sensitivity, influence these cognitive processes. The key findings revealed significant prioritisation effects in both emotion and reward processing tasks. Participants demonstrated higher accuracy and faster RTs for happy emotional stimuli, as well as for medium and high reward stimuli. However, contrary to expectations, sad emotional stimuli were processed less accurately and more slowly than neutral stimuli, indicating no prioritisation effect for sad stimuli over neutral stimuli. Additionally, no significant findings were observed in the control task, which suggests that the prioritisation effects were specifically due to the emotional valence and reward value of the stimuli. The study also highlighted the modulatory effects of anxiety, showing that anxiety negatively impacted the accuracy of processing positive emotional stimuli, while no significant effects were observed for reward sensitivity.

These results provide valuable insights into the cognitive mechanisms underlying emotion and reward processing and underscore the importance of considering individual differences in psychological research and practice. Specifically, the findings suggest that anxiety can alter cognitive processing by impairing the processing of positive information without enhancing sensitivity to negative information. This has important implications for understanding how emotional and reward-related stimuli are processed differently by individuals with varying levels of anxiety.

Future research should focus on addressing the limitations identified in this study. By expanding the range of reward levels and emotional stimuli, incorporating larger and more diverse samples, and utilising realistic and complex stimuli, future studies can enhance the ecological validity and generalisability of these findings. Additionally, exploring more sensitive measures of reward sensitivity will be crucial in furthering understanding of these processes.

By building on the current findings and addressing these limitations, future research can further elucidate the interplay of reward and emotion processing, contributing to the development of more targeted and effective interventions for mental health issues such as anxiety and depression.

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Appendix 1

Participant Information Sheet

Bournemouth University

Ref & Version: PIAMT1.0
Ethics ID: 52132
Date: 04/12/23

The title of the research project

Examining the Influence of Anxiety and Sensitivity to Punishment on Reward and Emotion Processing Using an Associative Matching Task

Invitation to take part

You are being invited to take part in a research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether you wish to take part.

What is the purpose of the project?

Emotion and reward processing are fundamental motivational factors that influence a broad spectrum of cognitive processes, including reasoning, knowledge acquisition, and attention (Kiely, 2014). Notably, these processes have been linked to mental health conditions, particularly anxiety. While both emotion and reward processing have been extensively researched, they are often studied in isolation. This leaves a significant gap in understanding their interactive effects, especially in the context of anxiety. Furthermore, existing studies that have delved into the interplay between emotion and reward processing often face methodological inconsistencies. This study aims to address this literature gap by measuring both emotion and reward processing in tandem using an associative matching task (AMT) and questionnaires to measure your State-Trait anxiety as well as sensitivity to punishment.

Why have I been chosen?

You have been chosen because you are a Bournemouth University student who is 18 years old or older, with no diagnosed mental health conditions and have normal to corrected vison. We aim to recruit 50 participants using the SONA online recruitment tool.

Do I have to take part?

It is up to you to decide whether to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a participant agreement form. We want you to understand what participation involves before you make a decision on whether to participate.

If you or any family member have an on-going relationship with BU or the research team, e.g., as a member of staff, as student or other service user, your decision on whether to take part (or continue to take part) will not affect this relationship in any way.

Can I change my mind about taking part?

Yes, you may stop participating in study activities at any time and without giving a reason. However, if you decide to stop after the experiment has started, any information already collected will be anonymous. This means we will not be able to identify and remove your specific data.

If I change my mind, what happens to my information?
After you decide to withdraw from the study, we will not collect any further information from or about you.

In regard to the information we have already collected before this point, your rights to access, change or move that information are limited. This is because we need to manage your information in specific ways in order for the research to be reliable and accurate. Further explanation about this is in the Personal Information section below.

Your data will be anonymised and therefore we may be unable to withdraw or delete any data collected after participation.

What would taking part involve?

You will be asked to complete two questionnaires before starting the computer-based task. One questionnaire will have questions regarding anxiety and the other about your sensitivity to punishment. The questionnaire phase will take approximately 15 minutes.

You will be asked to perform three short tasks using a computer. The stimuli used in the three short tasks will differ but consists of the same procedure. In each task you will be asked to learn associations between geometric shapes and different labels, depending on the task. For example, a control task (e.g., triangle – sky, circle – earth, square – air), a value-based task (e.g., oval - £0, pentagon - £25, and diamond - £50), and an emotion task (e.g., square – Happy, circle – sad, and triangle neutral). You will be required to decide on whether a displayed pairing matched or mismatched what you learnt during the learning phase. Each task will take approximately 15 minutes to complete. Upon completing the experimental task, you will receive an email containing the Amazon gift voucher. You will need to respond to that email to confirm you have received the voucher.

Will I be reimbursed for taking part?

This study will take one hour to complete and therefore you will be compensated with one SONA credit even if you decide to withdraw at any point during the experiment. You will receive an Amazon gift voucher worth a percentage of your performance on the tasks (e.g., you will be awarded 0.01% bonus of the sum displayed for each correct answer and this will be calculated automatically as you progress). The value of this voucher will range between £3-£5. This is only available to you upon completing the experiment.

What are the advantages and possible disadvantages or risks of taking part?

Whilst there are no immediate benefits to you for participating in the project, it is hoped that this work will improve our understanding of the relationship between emotion and reward processing by overcoming previous gaps, methodological challenges, and inconsistencies.

What type of information will be sought from me and why is the collection of this information relevant for achieving the research project's objectives?

Your age, gender, and name will be required from you. Also, your student email address will be collected to send the Amazon gift voucher for your participation in the study. For the questionnaires, your responses for each item will be recorded and for the experiment, your response time and accuracy on each trial will be recorded, but this data is anonymous.

How will my information be managed?

Bournemouth University (BU) is the organisation with overall responsibility for this study and the Data Controller of your personal information, which means that we are responsible for looking after your information and using it appropriately. Research is a task that we perform in the public interest, as part of our core function as a university.

Undertaking this research study involves collecting and/or generating information about you. We manage research data strictly in accordance with:

- Ethical requirements; and
- Current data protection laws. These control use of information about identifiable individuals, but do not apply to anonymous research data: "anonymous" means that we have either removed or not collected any pieces of data or links to other data which identify a specific person as the subject or source of a research result.

BU's Research Participant Privacy Notice sets out more information about how we fulfil our responsibilities as a data controller and about your rights as an individual under the data protection legislation. We ask you to read this Notice so that you can fully understand the basis on which we will process your personal information.

Research data will be used only for the purposes of the study or related uses identified in the Privacy Notice or this Information Sheet. To safeguard your rights in relation to your personal information, we will use the minimum personally identifiable information possible and control access to that data as described below.

Publication

You will not be able to be identified in any external reports or publications about the research without your specific consent. Otherwise, your information will only be included in these materials in an anonymous form, i.e. you will not be identifiable.

Research results could be published.

Security and access controls

BU will hold the information we collect about you in hard copy in a secure location and on a BU password protected secure network where held electronically.

Personal information which has not been anonymised will be accessed and used only by appropriate, authorised individuals and when this is necessary for the purposes of the research or another purpose identified in the Privacy Notice. This may include giving access to BU staff or others responsible for monitoring and/or audit of the study, who need to ensure that the research is complying with applicable regulations.

Further use of your information
The information collected about you may be used in an anonymous form to support other research projects in the future and access to it in this form will not be restricted. It will not be possible for you to be identified from this data.

Keeping your information if you withdraw from the study
If you withdraw from active participation in the study we will keep information which we have already collected from or about you, if this has on-going relevance or value to the study. This may include your personal identifiable information. As explained above, your legal rights to access, change, delete or move this information are limited as we need to manage your information in specific ways in order for the research to be reliable and accurate. However, if you have concerns about how this will affect you personally, you can raise these with the research team when you withdraw from the study.

You can find out more about your rights in relation to your data and how to raise queries or complaints in our Privacy Notice.

Retention of research data
Project governance documentation, including copies of signed **participant agreements**: we keep this documentation for a long period after completion of the research, so that we have records of how we conducted the research and who took part. The only personal information in this documentation will be your name and signature, and we will not be able to link this to any anonymised research results.

Research results:

As described above, during the course of the study we will anonymise the information we have collected about you as an individual. This means that we will not hold your personal information in identifiable form after we have completed the research activities.

You can find more specific information about retention periods for personal information in our Privacy Notice.

We keep anonymised research data indefinitely, so that it can be used for other research as described above.

Contact for further information

If you have any questions or would like further information, please contact:
Sancho Nascimento Loreto (Master by Research Student) - [s5215752@bournemouth.ac.uk] or Dr Ala Yankouskaya (Project supervisor) - [ayankouskaya@bournemouth.ac.uk]

In case of complaints
Any concerns about the study should be directed to the Deputy Dean of Research by email - researchgovernance@bournemouth.ac.uk.

Finally

If you decide to take part, you will be given a copy of the information sheet and a signed participant agreement form to keep. Thank you for considering taking part in this research project.

Appendix 2

Participant Consent Form

Ref & Version: PAAMT1.0
Ethics ID number: 52132
Date: 28/09/23

Full title of project: Examining the Influence of Anxiety and Sensitivity to Punishment on Reward and Emotion Processing Using an Associative Matching Task

Researcher: Sancho Nascimento Loreto (Master by Research Student) - [s5215752@bournemouth.ac.uk]

Supervisor: Dr Ala Yankouskaya (Project supervisor) - [ayankouskaya@bournemouth.ac.uk]

To be completed prior to data collection activity

Section A: Agreement to participate in the study
You should only agree to participate in the study if you agree with all of the statements in this table and accept that participating will involve the listed activities.

I have read and understood the Participant Information Sheet (PIAMT1.0) and have been given access to the BU Research Participant Privacy Notice which sets out how we collect and use personal information (https://www1.bournemouth.ac.uk/about/governance/access-information/data-protection-privacy).	
I have had an opportunity to ask questions.	
I understand that my participation is voluntary. I can stop participating in research activities at any time without giving a reason and I am free to decline to answer any particular question(s).	
I understand that taking part in the research will include the following activity/activities as part of the research:	
• Completing the revised version of the Sensitivity to Punishment and Reward (SP) and the State-Trait Anxiety Inventory (STAI) questionnaires. • Completing three associative matching tasks relating to reward, emotion, and a control tasks.	
I understand that, if I withdraw from the study, I will also be able to withdraw my data from further use in the study **except** where my data has been anonymised (as I cannot be identified) or it will be harmful to the project to have my data removed.	
I understand that my student email address is needed to receive Amazon gift voucher after study completion. • I understand that I must reply to the email containing the voucher.	
I understand that my data may be used in an anonymised form by the research team to support other research projects in the future, including future publications, reports or presentations.	
	Initial box to agree
I consent to take part in the project on the basis set out above (Section A)	

Name of participant (BLOCK CAPITALS)	Date (dd/mm/yyyy)	Signature
Name of researcher (BLOCK CAPITALS)	Date (dd/mm/yyyy)	Signature

Appendix 3

Sensitivity to Punishment and Reward Questionnaire (SPSRQ) - Revised Sensitivity to Reward

1.	Does the good prospect of obtaining money motivate you strongly to do some things?	No	Yes
2.	Are you frequently encouraged to act by the possibility of being valued in your work, in your studies, with your friends or with your family?	No	Yes
3.	Do you often meet people that you find physically attractive?	No	Yes
4.	Do you like taking some drugs because of the pleasure you get from them?	No	Yes
5.	Do you often do things to be praised?	No	Yes
6.	Do you like being the center of attention at a party or a social meeting?	No	Yes
7.	Do you spend a lot of your time on obtaining a good image?	No	Yes
8.	Do you need people to show their affection for you all the time?	No	Yes
9.	When you are with a group, do you try to make your opinions the most intelligent or the funniest?	No	Yes
10.	Do you often take the opportunity to pick up people you find attractive?	No	Yes
11.	As a child, did you do a lot of things to get people's approval?	No	Yes
12.	Does the possibility of social advancement, move you to action, even if this involves not playing fair?	No	Yes
13.	Do you generally give preference to those activities that imply an immediate gain?	No	Yes
14.	Do you often have trouble resisting the temptation of doing forbidden things?	No	Yes
15.	Do you like to compete and do everything you can do to win?	No	Yes
16.	Is it easy for you to associate tastes and smells to very pleasant events?	No	Yes
17.	Are there a large number of objects or sensations that remind you of pleasant events?	No	Yes

18.	When you start to play with a slot machine, is it often difficult for you to stop?	No	Yes
19.	Do you sometimes do things for quick gains?	No	Yes
20.	Does your attention easily stray from your work in the presence of an attractive stranger?	No	Yes
21.	Are you interested in money to the point of being able to do risky jobs?	No	Yes
22.	Do you like to put competitive ingredients in all of your activities?	No	Yes
23.	Would you like to be a socially powerful person?	No	Yes
24.	Do you like displaying your physical abilities even though this may involve danger?	No	Yes

Appendix 4

The State-Trait Anxiety Inventory (STAI)

Self-Evaluation Questionnaire STAI Form Y-1

DIRECTIONS
A number of statements which people have used to describe themselves are given below. Read each statement and then highlight the appropriate number to the right of the statement to indicate how you feel *right now, that is, at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	Statement	**Not at all**	**Somewhat**	**Moderately so**	**Very much so**
		1	2	3	4
1	I feel calm				
2	I feel secure				
3	I am tense				
4	I feel strained				
5	I feel at ease				
6	I feel upset				
7	I am presently worrying over possible misfortunes				
8	I feel satisfied				
9	I feel frightened				
10	I feel comfortable				
11	I feel self-confident				
12	I feel nervous				
13	I am jittery				
14	I feel indecisive				
15	I am relaxed				
16	I feel content				
17	I am worried				
18	I feel confused				
19	I feel steady				
20	I feel pleasant				

Self-Evaluation Questionnaire STAI Form Y-2

DIRECTIONS
A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you *generally* feel.

	Statement	**Almost Never**	**Sometimes**	**Often**	**Almost Always**
		1	2	3	4
21	I feel pleasant				
22	I feel nervous and restless				
23	I feel satisfied with myself				
24	I wish I could be as happy as others seem to be				
25	I feel like a failure				
26	I feel rested				
27	I am “calm, cool, and collected”				
28	I feel that difficulties are piling up so that I cannot overcome them				
29	I worry too much over something that really doesn’t matter				
30	I am happy				
31	I have disturbing thoughts				
32	I lack self-confidence				
33	I feel secure				
34	I make decisions easily				
35	I feel inadequate				
36	I am content				
37	Some unimportant thought runs through my mind and bothers me				
38	I take disappointments so keenly that I can’t put them out of my mind				
39	I am a steady person				
40	I get in a state of tension or turmoil as I think over my recent concerns and interests				