The Relationship Between Anxiety and Decision Preference in the Ratio Bias Paradigm

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Abstract: In the ratio bias paradigm, people make different choices depending on whether information is presented in terms of probability or absolute value. The current research intended to investigate the relationship between anxiety and decision preference in the ratio bias paradigm. In Studies 1 and 2, we analyzed the mediating role of ego depletion in the relationship between anxiety and decision preference, using a relevant-event recall task to manipulate anxiety and a ratio bias paradigm to measure decision preference. The results showed that anxiety promotes ego depletion, thus increasing decision preference based on absolute value. In Study 3, we further examined the moderating role of self-control in the mediation model, with a movie clip used to manipulate anxiety and a decision-making task used to measure decision preference. The results showed that ego depletion was significantly associated with decision preference based on absolute value only when self-control was low.

Keywords: Anxiety, Decision preference, Ego depletion, Self-control.

1. INTRODUCTION

Anxiety is an important factor that affects decision-making. However, research findings on the relationship between anxiety and decision preferences vary considerably. Some studies have indicated that anxious individuals pay more attention to ratio information and prefer the option with a higher success rate (Gu & Luo, 2008), while other studies have suggested that anxiety drives decision-makers to ignore objective, factual statistical information and to place greater emphasis on subjective, heuristic anecdotal information (Jiang & Sun, 2022; Yang *et al*., 2015). Therefore, the present study focuses on the association between anxiety and decision preference, as well as how and under what circumstances anxiety is associated with decision preference. The results could help us identify effective interventions to mitigate the negative impact of anxiety on decision-making.

1.1. Decision Preference in the Ratio Bias Paradigm

Decision preference refers to individuals' stable and directional choice tendencies when confronted with multiple alternative options characterized by distinct benefits, risks, or attributes. The dual-process model indicates that two systems influence the judgment and decision-making of individuals (De Neys & Glumici, 2008). System 1 refers to quick, effortless, and heuristic processing, which generates fast and intuitive answers. System 2 refers to slow, deliberate, and analytic processing (Bago & De Neys, 2019; Pennycook *et al*., 2015; Pennycook *et al*., 2018). System 2 monitors the quality of these intuitive proposals, if System 2 detects an error, it will correct the intuitive judgments (Bago & De Neys, 2017; Risen, 2016, 2017).

The ratio bias paradigm is an experimental paradigm to explore people's decision-making preferences (Walco & Rise, 2017). A classic experimental task usually involves setting up a situation where participants are asked to make a choice between two options. Option A is to draw one red ball from ten balls (with a success probability of 1/10), and option B is to draw nine red balls from one hundred balls (with a success probability of 9/100). From the perspective of the absolute number of winning balls, nine red balls compared to one red ball gives people an intuitive feeling of "more opportunities", suggesting that option B should be preferred. However, from the perspective of success probability, 1/10 (0.1) is greater than 9/100 (0.09), which indicates that option A should be chosen.

In the ratio bias paradigm, people may overlook probability information and make decisions based on absolute value information (Longe *et al*., 2001). This might be due to the fact that the numerator is more salient, which thus leads to the occurrence of ratio bias (Price & Matthews, 2009). However, it has been demonstrated that people tend to make decisions based on probabilities when a substantial reward is introduced (Longe *et al*., 2001).

1.2. The Relationship between Anxiety and Decision Preference

Emotions function as informational cues and can influence information selection and processing,

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cognitive strategies and styles, as well as judgment and decision-making. When individuals are in a pleasant emotional state, they tend to remember more positive aspects about themselves. They are likely to adopt a heuristic processing strategy, employing a top-down processing mode, relying on pre-formed knowledge structures, paying less attention to the details of current stimuli, and expending less cognitive effort. They also tend to make optimistic judgments and show a greater preference for long-term options (Jiang & Sun, 2019). Conversely, individuals in a negative emotional state are prone to recalling sad events related to themselves. They typically adopt a systematic processing strategy, using a bottom-up processing mode, relying less on preexisting knowledge structures, and concentrating on the details of current stimuli. They tend to make pessimistic judgments, are more risk-averse (Tian *et al*., 2019), and have a stronger preference for short-term options (Jiang & Sun, 2019; Lempert *et al*., 2016). They are more inclined towards rational and analytical thinking (King *et al*., 2007; Remmers & Zander, 2018).

Anxiety is a kind of negative emotional state that individuals experience in uncertain situations, in which they feel subjectively nervous, worried, and fearful (Gu & Luo, 2008; Bekker *et al*., 2003). Prior research has demonstrated that anxiety is associated with decision-making processes. However, there have been contradictory assumptions and conclusions. Some research demonstrated that anxiety drives decision-makers to ignore statistical information which was objective and factual, and to place greater emphasis on anecdotal information which was subjective and heuristic (Yang *et al*., 2015). Anxiety leads individuals to be concerned about potential threat-related stimuli and negative future outcomes, stimulates pessimistic evaluations of decision-making events, and impairs the emotion regulation process (Hartley & Phelps, 2012; Yang *et al*., 2015). Furthermore, anxiety could evoke high levels of autonomic arousal, impair working memory capacity and executive function (Darke, 1988; Yang *et al*., 2015), and impair efficient functioning of the goal-directed attentional system (Eysenck *et al*., 2005; Eysenck *et al*., 2007). The combined effects of impaired emotion regulation and depleted cognitive resources may reduce attention to complex probability data, making individuals more susceptible to obvious absolute value data (Gao & Huang, 2008; Hartley & Phelps, 2012; Roberts *et al*., 2021).

An alternative perspective posits that anxiety fosters decision preferences based on probability. It has been demonstrated that anxious individuals pay more attention to ratio information and prefer the option with a higher success rate, even though the reward may not be as substantial, rather than the option with a lower success rate but a larger reward (Gu & Luo, 2008). The positive relationship between anxiety and decision preferences based on probability can also be elucidated through the following mechanisms: Firstly, anxiety might enhance physiological arousal, which facilitates memory (Hamann, 2001), augments rational response, and enhances performance on simple cognitive tasks (Paulus & Yu, 2012). Secondly, anxiety promotes probabilistic pessimism bias, which refers to the phenomenon that individuals believe that negative outcomes are more likely to happen, making them more sensitive to negative information and more inclined to choose the conservative, reality-based rational option (Gu & Luo, 2008; Lauriola & Levin, 2001; Raghunathan & Pham, 1999). Thirdly, individuals in an anxious state have a strong motivation to avoid failure and reduce uncertainty (Remmers & Zander, 2018). This motivation leads them to urgently need reasonable justifications to explain their decisions, promoting a preference for bottom-up processing during information processing (Wegbreit *et al*., 2015), and in turn leading individuals to focus more on local, central, and critical information in decision tasks (Feldman *et al*., 2010; Tiedens & Linton, 2001; Ye *et al*., 2023). Research has also revealed that individuals with a strong need for justification place greater emphasis on considering the evaluations and approvals of others regarding their decisions (Jiang *et al*., 2022; Xiao, 2017), feel heightened pressure to demonstrate the reasonableness and correctness of their decisions, and thus tend to adopt more rational processing strategies in decision-making to reduce uncertainty and others' negative evaluations (Buzzell *et al*., 2016; Tetlock & Boettger, 1994).

We hypothesized that the contradictory results may be attributed to several factors. Firstly, the manipulation methods of anxiety varied in previous studies. This may have led to differences in the arousal levels of anxiety, and subsequently resulted in contradictory results. Secondly, the decision-making tasks employed in previous studies varied greatly, which made it impossible to directly compare the research findings. Thirdly, there exist important conditional variables influencing the association between anxiety and decision preference. Based on the review above, the present study focused on the relationship between state anxiety and decision preference in the ratio bias paradigm, and further explored the boundary conditions and influence path of this association.

1.3. The Relationship between Anxiety, Decision Preference and Ego Depletion

Ego depletion is the state of diminished self-control capacity caused by substantial consumption of limited

resources (Wang *et al*., 2022). Some situations and behaviors, such as thought inhibition, emotional regulation, and impulse control, will consume the self-control resources, resulting in ego depletion (Baumeister *et al*., 2007; Wang *et al*., 2022). According to previous research, anxiety is positively associated with ego depletion (Prem *et al*., 2016; Shmueli & Prochaska, 2012). During the stage of anxiety emotion regulation, the use of emotion regulation strategies and the suppression of negative emotional expressions also deplete an individual's self-control resources, thereby contributing to ego depletion. Previous research indicated that anxiety leads to ego depletion, which in turn causes individuals to spend more time and achieve worse performance on reasoning and memory tasks (Harris & Cumming, 2003; Robinson & Demaree, 2007).

In addition, ego depletion might influence decision-making processes. The self-control resource model indicates that, when an individual engages in purposeful and conscious self-control, their self-control resources will be depleted, and the quality of subsequent purposeful and conscious self-control behaviors will decline (Baumeister *et al*., 1998). The effects of ego depletion on the decision-making process are manifested in the following aspects: Firstly, individuals experiencing ego depletion exhibit diminished motivation to solve problems. Cognitive processing consumption and self-control resource depletion lead to psychological fatigue, thereby reducing their motivation to complete the task (Li, 2013; Park & Moghaddam, 2017) and impairing subsequent cognitive processing performance (Schmeichel *et al*., 2003). Secondly, ego depletion may enhance the intensity of intuitive feelings. Consequently, individuals may become more susceptible to heuristic information (Pennycook *et al*., 2015). Thirdly, ego depletion weakens an individual's ability to effectively discriminate information quality, impairs the filtering capacity of visual working memory, diminishes an individual's ability to inhibit and resist distractors (Song *et al*., 2021), impairs cognitive flexibility (Park & Moghaddam, 2017), inhibits analytical thinking processes, impedes individuals from thoroughly processing persuasive arguments, and increases risk-taking and impulsive behaviors (Dou *et al*., 2014; Zhong *et al*., 2018).

1.4. The Relationship between Self-Control and Decision Preference

Self-control refers to the process in which an individual actively masters and regulates their own psychological state and behavior in order to achieve specific goals, or satisfy internal needs. It involves multiple aspects such as suppressing impulses, delaying gratification, regulating emotions, and rationally allocating cognitive resources. The self-control resource model indicates that self-control resources are closely related to an individual's self-control behaviors. The more abundant the self-control resources are, the better the performance in self-control tasks will be. Self-control can influence people's decision-making preferences. Individuals with high self-control have a stronger motivation to complete tasks, possess greater executive ability to mobilize their cognitive resources and overcome unfavorable factors, and thus ensure that they make optimal choices (Fan *et al*., 2016). On the other hand, individuals with low self-control find it difficult to concentrate their attention and engage in in-depth thinking for a long time, and are more likely to make decisions based on intuition (Yu *et al*., 2013).

Moreover, when individuals with low self-control experience ego depletion due to a certain task, their self-control ability further decreases, and they lack the motivation and ability to mobilize additional cognitive resources for in-depth analysis and decision-making. Thus, this further reduces their preference for probability-based decision-making and increases their preference for absolute value-based decision-making. However, for individuals with high self-control, even if they are experiencing negative emotions and ego depletion, their high level of self-control can mitigate the adverse effects of these factors. They still have the possibility to try their best to mobilize cognitive resources to solve problems and make reasonable decisions (Li, 2016).

1.5. Current Study

Previous studies have the following deficiencies: (1) Previous studies on the relationship between anxiety and decision preferences have yielded conflicting results. (2) To our knowledge, there has been no study focusing on the relationship between anxiety and decision-making preferences within the ratio bias paradigm. In the ratio bias paradigm, decision preferences are divided into those based on probability and those based on absolute values. (3) The conditions and pathways under which anxiety is associated with decision preferences have received little attention. Based on the review above, the present study focused on the effect of anxiety on decision preference in the ratio bias paradigm. In addition, we further explored the internal mechanisms linking anxiety to decision preference. We hypothesized that anxious individuals experience high ego depletion (H1a), and thus, are more likely to make decisions based on absolute value in the ratio bias paradigm, compared to non-anxious individuals (H1b). Moreover, for individuals with low self-control, the association between ego depletion and

decisions based on absolute value was stronger, compared with individuals with high self-control (H2).

In order to verify our hypotheses, three studies were conducted. The purpose of Studies 1 and 2 was to explore the relationship between anxiety and decision preference using a relevant-event recall task and the ratio bias paradigm, and to analyze the mediating role of ego depletion. The purpose of Study 3 was to analyze the moderating role of self-control in the mediation model, with a movie clip used to induce anxiety, and a decision-making task used to measure decision preference.

2. STUDY1

2.1. Participants

One hundred and fifty-three college students from a university in central China voluntarily participated in this study. We deleted three participants whose responses were not valid, and a total of 150 valid data points were retained. There were 85 males (56.7%) and 65 females (43.3%); 46 participants (30.7 %) majored in humanities, and 104 (69.3%) majored in STEM field. Their ages ranged from 17 to 21 years old (M_{age}=18.07, *SD* = 0.65). There were 70 (46.7%) participants who came from urban areas and 80 (53.3%) who came from rural areas; 58 (38.7%) were the only child in their family, 92 (61.3%) were not the only child in their family. The G*Power method was used to calculate the minimum effect size, with *N*=150, α=0.05, power (1-β)=0.80, and *Z* tests logistic regression, the minimum detectable effect size was Exp = 0.80.

All participants were randomly assigned to the high anxiety group (*N*=72) or the low anxiety group (*N*=78). The chi-square test showed that there was no significant difference between the two groups in terms of whether they were the only one child in their family (χ^2 =0.38，*df*=1, *p*=0.33, Phi = 0.05), residential origin (χ^2 =0.73, *df*=1, p=0.25, Phi=0.07), and academic major (χ^2 =2.09，*df*=1, p=0.15, Phi =0.12). But there was a significant difference between the two groups in terms of gender (χ^2 =4.18，*df*=1, p= 0.03, Phi = -0.17).

2.2. Materials

Manipulation of anxiety: The relevant-event recall task was used to induce anxiety (Labouvie-Vief *et al*., 2003). Participants in the experimental condition were asked to recall and describe one event that made them anxious, while those in the control condition were asked to recall and describe one event that made them calm (at least 100 words). After a short emotional incubation period, participants in the experimental condition were asked to recall and describe another event that made them anxious, while those in the control condition were asked to recall and describe another event that made them calm (Liu & Li, 2022).

Short State Anxiety Inventory (SSAI): Participants completed the Short State Anxiety Inventory (SSAI) to check the effectiveness of anxiety manipulation (Tian *et al*., 2018). This scale consists of six items, which assess two dimensions: anxiety presence and anxiety deficiency. For instance, one item assesses the subjective experience of anxiety by asking participants to rate their agreement with the statement “I feel anxious”. Each item was rated on a 4-point Likert scale, ranging from 1 (strongly disagree) to 4 (strongly agree). Three items related to anxiety deficiency were reverse-scored, and the total score was calculated by summing all items. A higher score indicated a higher level of state anxiety. This scale’s internal consistency was good in the current sample (Cronbach’s alpha = 0.87).

Ratio bias paradigm: The ratio bias paradigm was employed to measure decision preference. In this task, participants were presented with two bottles (A and B) and asked to select one to participate in a lottery activity, where the goal was to draw a black ball from the chosen bottle to win a prize. Bottles A and B contained different ratios and quantities of white and black balls: specifically, Bottle A contained ten black balls and 90 white balls (10% winning rate), while Bottle B contained one black ball and eight white balls (11% winning rate). Participants might opt for Bottle A based on absolute number of black balls or choose Bottle B based on probability of winning. They were then required to answer three questions: (1) Which bottle do you intuitively think is more likely to yield a black ball (based on the number of black balls)? (2) Which bottle do you rationally think is more likely to yield a black ball (based on the ratio of black balls)? (3) Which bottle do you choose based on your own willingness?

Ego depletion: The short-form ego depletion scale developed by Lanaj *et al*. (2014) was used to measure ego depletion. This scale comprises five items; a sample item is “I feel exhausted”. Participants rated their agreement with each item on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), with higher scores indicating higher levels of ego depletion (Lanaj *et al*., 2014; Fehr *et al*., 2017; Ding *et al*., 2020; Zhang *et al*., 2017). The scale demonstrated good internal consistency in the current sample (Cronbach’s alpha = 0.81).

2.3. Procedures

Permission for this study was obtained from the ethics committee of the first author's institution. The

experiment was conducted offline. Participants were first required to complete an informed consent form. Next, they answered the questions measuring trait anxiety, self-control, and self-construal. Then, we induced state anxiety, and participants completed the SSAI items, as well as measures of the need to justify decisions and ego depletion. Lastly, they completed the ratio bias paradigm task. The participants received five yuan as a reward. We reported all measures, manipulations, and exclusions in the present paper.

2.4. Results

2.4.1. Manipulation Checks

A one-way ANOVA was conducted with SSAI scores as the dependent variable. The results showed a significant difference in anxiety scores between the two groups: participants in the high anxiety group ($M_{anxiety}$ =14.53, *SD*=3.84) reported higher anxiety levels than those in the low anxiety group (M_{calm}=11.28, *SD* =3.26), *F* (1,148) =31.29, $p < .001$, partialη^2=0.17. This indicated that the anxiety manipulation was effective in the current study.

2.4.2. Descriptive Statistics and Correlation Analyses of All Variables

Pearson product-moment correlation analysis revealed that anxiety was significantly associated with ego depletion, whereas ego depletion was marginally significantly associated with decision preference. See Table **1**.

2.4.3. Mediation Model Analysis

PROCESS macro in SPSS (Model 4) was used to test the mediating effect of ego depletion on the relationship between anxiety and decision preference, with gender, age, residential origin, and academic major included as control variables. First, in the regression model examining the association between anxiety and ego depletion, the results showed that the effect of anxiety on ego depletion was significant (β=0.60, *SE*=0.16, $p<0.001$). Second, in the regression model including both anxiety and ego depletion as predictors of decision preference, the results showed that the anxiety was not significantly associated with decision preference (β=0.54, *SE*=0.39, p=0.17), Whereas ego depletion was significantly associated with decision preference (β=-0.48, *SE*=0.20, p=0.01). Further analysis of the mediating effect revealed that the indirect effect of anxiety on decision preference via ego depletion was significant (β=-0.29, *SE*=0.18, LLCI=-0.72, ULCI=-0.03). These results indicated that anxiety induced ego depletion, which in turn increased individuals' preference for decisions based on absolute value. Thus, Hypotheses H1a and H1b were supported.

3. STUDY2

This study examined the relationship between anxiety and decision-making preferences among adolescents. Additionally, a continuous indicator of decision-making likelihood was used as the dependent variable.

3.1. Participants

Eighty-nine middle school students from a rural middle school in central China voluntarily participated in this study. There were 48 males (53.9%) and 41 females (46.1%), with ages ranging from 10 to 14 years old (M_{age}=12.52, *SD* = 0.88). All participants were randomly assigned to the high anxiety group (*N*=47) or the low anxiety group (*N*=42). The G*Power method was used to calculate the minimum effect size with the following parameters: *N*=44, number of groups =2, α=0.05, power (1-β)=0.80, and F tests. The minimum detectable effect size was η^2 = 0.43.

3.2. Materials

Manipulation of anxiety: The relevant-event recall task was used to induce anxiety (Labouvie-Vief *et al*., 2003). Participants in the experimental condition were asked to recall and describe one event that made them

Table 1: Description and Correlation Results Among All Variables in Study 1

	Anxiety	State Anxiety	Ego Depletion	Decision Making
Anxiety	-			
State anxiety	0.42***	-		
Ego depletion	0.27*	0.55***	-	
Decision making	0.04	0.04	-0.16	-
M	0.48	12.84	13.33	1.66
SD	0.50	3.90	4.59	0.47

Note: anxiety was a dummy variable, with anxiety group = 1, and calm group = 0. Decision making was a category variable, decisions based on probability = 2, and decisions based on absolute value= 1. * p < 0.5, ** p < 0.01, *** p < 0.001.

anxious, while those in the control condition were asked to recall and describe one event that made them calm (at least 100 words).

State Anxiety: State Anxiety was measured using the same method as in Study 1. This scale demonstrated good internal consistency in the current sample (Cronbach's alpha = 0.90).

Ratio bias paradigm: The ratio bias paradigm was implemented using the same method as in Study 1. However, one additional item was added to measure participants' decision preference: "What is the likelihood of you choosing Bottle A or B in your decision?" (1 = I definitely choose A; 7 = I definitely choose B). A higher score indicated a greater likelihood of making a probability-based decision.

Ego depletion: Ego depletion was measured using the same method as in Study 1. This scale demonstrated good internal consistency in the current sample (Cronbach's alpha = 0.83).

3.3. Procedures

Permission for this study was obtained from the ethics committee of the first author's institution. The experiment was conducted in class. Participants and their guardians were first required to complete an informed consent form. Next, they answered the questions measuring the need to justify decisions and trait anxiety. Then, anxiety was manipulated. After that, the SSAI and ego depletion were measured. Lastly, participants completed the ratio bias paradigm task. All measures, manipulations, and exclusions were reported in the present paper.

3.4. Results

3.4.1. Manipulation Checks

A one-way ANOVA was conducted with SSAI scores as the dependent variable. The results showed a significant difference in the anxiety scores between the two groups: participants in the high anxiety group ($M_{anxiety}$ =14.11, *SD*=5.06) reported significantly higher anxiety levels than those in the low anxiety group (M_{calm}=10.14, *SD* =3.48), F (1, 87) =18.09, $p < .001$, partial η^2=0.17. This indicated that the anxiety manipulation was effective in the current study.

3.4.2. Descriptive Statistics and Correlation Analyses of All Variables

Pearson product-moment correlation analysis showed that anxiety was significantly associated with ego depletion. See Table **2**.

3.4.3. The Relationship between Anxiety and Decision Preference

PROCESS macro in SPSS (Model 4) was used to test the mediating effect of ego depletion on the relationship between anxiety and decision preference, with gender and age included as control variables. First, in the regression model examining the association between anxiety and ego depletion, the results showed that anxiety had a significant positive effect on ego depletion (β=0.42, *SE*=0.21, p=0.049). Second, in the regression model including both anxiety and ego depletion as predictors of decision preference, the results indicated that both anxiety and ego depletion were significantly associated with decision preference (β=0.43, *SE*=0.21, p=0.04; β=-0.23, *SE*=0.11, p=0.04). However, further analysis of the mediating effect revealed that the indirect effect of anxiety on decision preference via ego depletion was not significant (β=-0.09, *SE*=0.06, LLCI=-0.24, ULCI=0.01).

4. STUDY 3

The purpose of Study 3 was to replicate Studies 1 and 2 using a movie clip emotion induction task and a decision-making task.

4.1. Participants

One hundred and eighty-eight college students from a university in central China voluntarily participated in this study. Fifteen participants with missing responses were excluded, resulting in a total of 173 valid data

Table 2: Description and Correlation Results Among All Variables in Study 2

	Anxiety	State Anxiety	Ego Depletion	Decision Preference
Anxiety	-			
State anxiety	0.42***	-		
Ego depletion	0.22*	0.66***	-	
Decision preference	-0.17	-0.09	0.15	-
M	0.53	12.24	11.55	4.65
SD	0.50	4.79	4.98	2.03

Note: anxiety was a dummy variable, with anxiety group = 1, and calm group = 0.* p < 0.5, ** p < 0.01, *** p < 0.001.

points retained. There were 95 males (54.9%) and 78 females (45.1%), 37 participants (21.4 %) majored in humanities, and 136 (78.6%) majored in STEM fields. Their ages ranged from 17 to 24 years old (M_{age}=18.29, *SD* = 0.83). All participants were randomly assigned to the high anxiety group (*N*=81) or the low anxiety group(*N*=92). The G*Power method was used to calculate the minimum effect size with the following parameters: *N*=86, number of groups=2, α=0.05, power (1-β)=0.80, and F tests. The minimum detectable effect size was η^2 = 0.30.

4.2. Materials

Manipulation of anxiety: Participants watched a movie clip to induce different emotions: those in the anxiety group watched "Final Destination", while those in the calm group watched “Migratory bird migration”. Each movie clip lasts 10 minutes.

State Anxiety Inventory: Four items were used to measure participants’ state anxiety, including nervous, stressed, calm, and relaxed. Participants responded to these items on a 9-point scale. This scale demonstrated good internal consistency in the present sample (Cronbach’s alpha = 0.83, 0.89 for the pretest and post-test, respectively).

Decision-making task: Participants were instructed to imagine that they were looking for a job, and a company that matched their needs has invited them to an interview. There could choose between two departments, both of which met their expectations in terms of compensation, work environment, and work content. If they chose Department A, they would face 99 competitors, with 10 candidates being hired (success probability = 1/10). If they chose Department B, they would face 8 competitors, with only 1candidate being hired (success probability = 1/9). Participants were told that all competitors had equivalent abilities and external conditions to their own, and they were then required to choose between the two departments. Three questions were posed to them: (1) Based on intuition, which department would you choose? (2) Based on the success rate, which department would you choose? (3) What is your final choice? This question was rated on a 9-point scale, where 1 = I definitely choose A and 9 = I definitely choose B.

Ego depletion: Ego depletion was measured using the same method as in Study 1. This scale’s internal consistency was good in the current sample (Cronbach’s alpha = 0.85).

Self-control: The Self-Control Scale developed by Tangney (2004) was adopted to measure self-control. Tan and Guo (2008) translated and revised this scale into a Chinese version. This scale comprises 5 dimensions and 19 items in total, with responses rated on a 5-point scale (1 = Completely does not fit my situation; 5 = Completely fits my situation). Higher scores indicated stronger self-control ability. The scale demonstrated good internal consistency in the present sample (Cronbach’s alpha = 0.87).

4.3. Procedures

Permission for this study was obtained from the ethics committee of the first author's institution. The experiment was conducted in the laboratory. Participants were first required to complete an informed consent form. Next, they answered the questionnaires measuring the need for justification, trait anxiety, self-control, and intuitive thinking tendency. One week later, participants returned to the laboratory to complete the subsequent experiment. We first measured their baseline state anxiety. Then, anxiety was manipulated. After that, ego depletion and post-manipulation state anxiety were measured again. Furthermore, participants completed the decision-making task. Lastly, the need for justification was measured a second time. The participants received five yuan as a reward. All measures, manipulations, and exclusions were reported in the present paper.

4.4. Results

4.4.1. Manipulation Checks

A one-way ANOVA was conducted with the pretest-posttest anxiety scores difference as the dependent variable. The results showed a significant difference in the anxiety difference scores between the two groups: participants in the high anxiety group had a higher anxiety difference score ($M_{anxiety}$ =5.13, *SD*=8.77) than those in the low anxiety group (M_{calm}=3.92, *SD* =6.63), *F* (1,171) =59.53, *p* < 0.001, partial η^2 =0.26. This indicated that the anxiety manipulation was effective in the current study.

4.4.2. Descriptive Statistics and Correlation Analyses of All Variables

Pearson product-moment correlation analysis showed that pretest-posttest state anxiety difference was significantly associated with ego depletion, whereas state anxiety was marginally negatively associated with decision preference. See Table **3**.

4.4.3. The Relationship between Anxiety and Decision Preference

PROCESS macro in SPSS (model 14) was used to examine the relationship between anxiety and decision

Table 3: Description and Correlation Results Among All Variables in Study 3.

	Anxiety	State Anxiety Difference	Ego Depletion	Self-Control	Decision Making
Anxiety	-				
State anxiety difference	0.51***	-			
Ego depletion	0.09	0.24**	-		
self-control	-0.12	-0.04	0.21**	-	
Decision making	-0.13	-0.05	0.09	0.10	-
M	0.47	0.32	11.67	59.55	5.62
SD	0.50	8.92	4.54	10.08	2.31

Note: anxiety was a dummy variable, with anxiety group = 1, and calm group = 0. * p < 0.5, ** p < 0.01, *** p < 0.001.

preference, and further test the mediating role of ego depletion and the moderating role of self-control. First, in the regression model examining the association between anxiety and ego depletion, after controlling for gender, age, residential origin, and academic major, anxiety was positively associated with ego depletion (*β*=0.43, *SE*=0.07, *p*<0.001). Second, in the regression model including anxiety, self-control, ego depletion, and the interaction term of ego depletion × self-control as predictors of decision preference, none of anxiety, self-control, or ego depletion was significantly associated with decision preference (anxiety: *β*=0.09, *SE*=0.08, *p*=0.30; self-control: *β*=-0.12, *SE*=0.08, *p*=0.14; ego depletion: *β*=-0.16, *SE*=0.09, *p*=0.06). However, the interaction term of ego depletion × self-control was significantly associated with decision preference (*β*=0.15, *SE*=0.08, *p*=0.046).

Simple slope analysis of the moderating effect showed that when self-control was high, ego depletion was not significantly associated with decision preference (*β*=-0.006, *SE*=0.11, LLCI=-0.23, ULCI=0.22). When the self-control was low, ego depletion was significantly associated with decision preference (*β*=-0.32, *SE*=0.12, LLCI=-0.55, ULCI=-0.08).

Furthermore, we analyzed the moderating role of self-control in the mediating model. The results showed that when the self-control was low, the mediating role of ego depletion was significant (*β*=-0.14, *SE*=0.05, LLCI=-0.25, ULCI=-0.04). When the self-control was high, the mediating role of ego depletion was not significant (*β*=-0.003, *SE*=0.05, LLCI=-0.10, ULCI=0.08). Thus, Hypotheses H1a, H1b, and H2 were supported.

5. GENERAL DISCUSSION

The present study explored the relationship between anxiety and decision preference. The results of Study 1 showed that anxiety increased decisions based on absolute value through the mediating role of ego depletion; specifically, anxiety was positively associated with ego depletion, and ego depletion was positively associated with decision preference based on absolute value. Study 3 found that only for individuals with low self-control, ego depletion played a mediating role in the relationship between anxiety and decision preference.

5.1. The relationship of Anxiety Associated with Decision Preference

Consistent with our hypothesis, the Study 1 found that anxiety was associated with decision-making through the mediating role of ego depletion. Anxiety induces ego depletion, and thus increases the preference for decisions based on absolute value. According to the bipolar valence-arousal model, emotions are jointly determined by valence and arousal (Haj-Ali *et al*., 2020; Lang *et al*., 1993; Russell, 1980; Ye *et al*., 2023; Zou *et al*., 2022). Anxiety is generally characterized as a negative emotion that is associated with high arousal. The state of high arousal can help individuals mobilize their internal resources and prepare themselves to respond to a given situation (Posner *et al*., 2009; Zou *et al*., 2022). Therefore, individuals experiencing anxiety would mobilize additional cognitive resources to control and regulate their negative emotions, which can result in ego depletion. Moreover, the decrease in cognitive resources and increased ego depletion can limit an individual's ability to discriminate and process information effectively, ultimately leading to an increased tendency to make decisions based on absolute value.

Consistent with previous research (Li, 2016), the present study confirmed the moderating role of self-control in the process linking anxiety to decision preference in the ratio bias paradigm. Specifically, when individuals' self-control was low, ego depletion increased decisions based on absolute value. However, when individuals' self-control was high, there was no significant association between ego depletion and

decisions based on absolute value. People with low self-control have poor emotional management abilities and behavior management abilities, and it is more difficult for them to suppress impulses and delay gratification. Ego depletion makes it even harder for them to concentrate their cognitive resources, making it difficult for them to invest sufficient energy and patience to accurately judge probabilities and conduct complex analyses and thinking. Instead, they are more likely to notice the more intuitive quantity of success opportunities, so they rely more on the quantity of opportunities rather than probabilities when making decisions. However, people with high self-control are able to better manage their emotions, cognitive resources, and behaviors. Even in a state of ego depletion, they can maintain a relatively stable psychological state and have a strong ability to allocate cognitive resources. Thus, they could mobilize sufficient resources to make rational decisions.

5.2. Limitations and Future Research

Our research has some limitations, which are expected to be improved in future studies. Firstly, in Studies 1 and 2, anxiety was measured after the emotion manipulation. The effectiveness of the anxiety manipulation was analyzed by comparing the differences in anxiety levels between the experimental group and the control group. In Study 3, anxiety was measured both before and after the emotion manipulation, and the effectiveness of the emotion manipulation was analyzed based on the pretest and post-test differences. However, our research overlooked the interfering effects of other emotions. Future research should measure a variety of emotions before and after the emotion manipulation, including happiness, pride, excitement, sadness, fear, anger, and other emotions. Only in this way can we clearly determine whether our emotion manipulation induced changes exclusively in anxiety. Secondly, the measurement methods for decision preference varied across the three studies, which resulted in a lack of comparability among the research findings. Thirdly, a notable limitation of the present research lies in its exclusive reliance on self-report measures to assess ego depletion. Incorporating complementary behavioral indicators in future investigations would substantially enhance the validity of ego depletion assessments.

Moreover, future studies should use rapid eye movement (REM) and electroencephalogram (EEG) to provide objective physiological evidence to explain the effect of anxiety on decision preference. In addition, we analyzed the mediating role of ego depletion in the relationship between anxiety and decision preference, but we did not conduct an experimental study to directly establish the causal relationship between ego depletion and decision-making. Finally, in this study, based on the self-control resource theory, we focused on the mediating role of ego depletion and the moderating role of self-control. We believe that there are other important mechanisms that can explain the relationship between anxiety and decision-making preferences, which deserve further exploration in future research.

DECLARATIONS

Ethics Approval and Consent to Participate

Research performed in accordance with the Declaration of Helsinki. Approval to conduct the study was obtained from the ethics committee of Institute of Applied Psychology, China University of Geosciences. Informed consent was obtained from all study participants.

Conflict of Interest

The author declares that they have no conflict of interest.

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Author Contributions

XQS complete the study conceptualization, data collection, data preparation, data analysis, and report writing. YTY complete the data preparation and data analysis. JJS complete the study conceptualization and report writing.

Available of Data

Data will be shared in a public repository before publication.

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