The Effect of Emotion on Intertemporal Choice: An Explanation from the Unidimensional Dominance Model

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Date: 2021-08-23T00:00:00+00:00

Abstract

Research on intertemporal decision-making indicates that there are significant differences in intertemporal decision-making behaviors under positive and negative emotional states. This study reveals the process mechanism by which emotions influence intertemporal decision-making from the perspective of the single-dimension dominance model. Experiment 1 induced positive and negative emotions in participants and found that participants under positive emotion exhibited lower temporal discount rates and a stronger tendency to choose delayed options. Experiment 2 employed a "simulated balance task" to measure inter-dimensional difference comparisons in intertemporal decision-making, testing the explanatory power of the single-dimension dominance model regarding the influence of emotion on intertemporal decision-making. The results revealed that inter-dimensional difference comparison plays a mediating role in the effect of emotion on intertemporal decision-making. Experiments 3a and 3b manipulated the inter-dimensional difference comparison process using time and money priming strategies, respectively, to further verify the explanatory role of the single-dimension dominance model. The results demonstrated that the effect of emotion on intertemporal decision-making disappeared with time and money priming, further supporting the mediating role of inter-dimensional difference comparison. This study reveals the psychological mechanism by which emotion influences intertemporal decision-making from the perspective of decision processes, and further provides supportive evidence for the explanatory power of the single-dimension dominance model on intertemporal decision-making behavior.

Full Text

The Effect of Emotion on Intertemporal Decision-Making: Evidence from the Single-Dimension Priority Model

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Abstract

Research on intertemporal decision-making has demonstrated significant differences in choice behavior between positive and negative emotional states. The present study elucidates the process mechanisms through which emotion influences intertemporal decisions from the perspective of the single-dimension priority model. In Experiment 1, inducing positive and negative emotions in participants revealed that those in a positive emotional state exhibited lower temporal discounting rates and a stronger tendency to choose delayed options. Experiment 2 employed the "intuitive analog scale" task to measure inter-dimensional difference comparisons during intertemporal decision-making, testing whether the single-dimension priority model could explain the effect of emotion on intertemporal choice. The results indicated that inter-dimensional difference comparison mediates the influence of emotion on intertemporal decisions. Experiments 3a and 3b further manipulated the inter-dimensional difference comparison process through time and money priming strategies, respectively, providing additional validation of the model' s explanatory power. The findings demonstrated that the effect of emotion on intertemporal choice disappeared under time and money priming, further supporting the mediating role of inter-dimensional difference comparison. This study reveals the psychological mechanisms underlying emotion' s influence on intertemporal decision-making from a process perspective and provides additional supportive evidence for the single-dimension priority model' s explanation of intertemporal choice behavior.

Keywords: intertemporal choice, positive emotion, negative emotion, inter-dimensional difference comparison

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Intertemporal choice refers to the process by which individuals weigh gains and losses occurring at different time points [?, ?]. Mainstream intertemporal decision models [?, ?, ?] posit that intertemporal decisions involve a temporal discounting process, whereby people discount the utility of future gains or losses according to their delay, resulting in discounted utility lower than the original utility. However, discount-based models cannot explain emerging anomalies such as subadditivity and superadditivity [?]. Consequently, some researchers have abandoned the discounting assumption and proposed alternative theories to explain intertemporal choice, with the single-dimension priority model being representative, including the tradeoff model and the equate-to-differentiate model [?].

The single-dimension priority model proposes that in intertemporal decisions, decision-makers must compare options across both delay and outcome dimensions, then base their choice on the dominant dimension. If the difference in outcomes exceeds the difference in delays, decision-makers will focus solely on the outcome dimension, choosing the option with the larger outcome. Conversely, if the difference in delays exceeds the difference in outcomes, decision-makers will focus solely on the delay dimension, choosing the option that yields results sooner. The explanatory power of the single-dimension priority model for intertemporal choice behavior has been supported by numerous studies. Jiang et al. [?] termed the process of comparing outcome differences and delay differences during intertemporal choice "inter-dimensional difference comparison." They pioneered the "intuitive analog scale" task to measure the magnitude of inter-dimensional difference comparison, providing supportive evidence for the single-dimension priority model. Liu et al. [?] employed a process dissociation procedure paradigm to support the explanatory role of the single-dimension priority model in intertemporal choice, demonstrating that people compare differences between dimensions and use the dimension with the larger difference as the basis for decision-making. Arieli et al. [?] used eye-tracking technology to explore information search processes during intertemporal choice, finding that two-thirds of participants' eye movements were dimension-based (i.e., moving between outcomes and between delays) rather than alternative-based (i.e., moving between outcomes and delays). This also provides support for the single-dimension priority model's guidance in intertemporal choice research.

Emotion represents a pervasive, effective, and predictable influence factor in intertemporal decision-making [?]. Substantial evidence indicates significant differences in intertemporal choice across different emotional states. Positive emotions can reduce individuals' temporal discounting rates, making them prefer long-term options, whereas negative emotions can increase temporal discounting rates, making them prefer short-term options [?, ?, ?, ?, ?, ?, ?, ?]. For example, Pyone and Isen [?] induced positive emotions through pictures and words, finding that participants in positive emotions chose delayed options with larger rewards compared to those in neutral emotions. Liu et al. [?] showed that participants who imagined positive emotional events were more inclined to choose delayed rewards, while those who imagined negative emotional events preferred immediate rewards. Muraven et al. [?] found that when individuals experienced low mood, they tended to eat more delicious food or smoke more cigarettes in the present moment. Other studies have similarly found that positive affect reduces temporal discounting rates, promoting farsightedness. For instance, individuals experiencing gratitude, high subjective well-being, or high hope or power become more patient in intertemporal choice and more willing to select delayed options [?, ?, ?].

Empirical research on the mechanisms underlying emotion' s influence on intertemporal choice remains scarce, with most researchers relying on theoretical speculation. Construal Level Theory (CLT) proposes that people process information about the same object at both high and low levels. High-level construal tends to process general, primary, essential, relatively simple, and decontextualized features of objects—features whose change leads to fundamental changes in the event' s meaning. Low-level construal tends to process concrete, secondary, contextual, and incidental features—features whose change produces relatively minor changes in meaning. A crucial distinction between high and low construal levels concerns the consideration of desirability versus feasibility. Desirability refers to the ultimate goal value of an action, while feasibility refers to the difficulty of achieving that goal. For any activity, the goal value is typically the primary consideration, while the specific process is secondary. According to CLT, desirability is associated with goal value and belongs to high-level construal, whereas feasibility is associated with specific methods for achieving goals and belongs to low-level construal [?]. In risky decision-making, the money that can be won represents the outcome or goal, associated with desirability and thus a primary consideration in preference judgments, making the monetary amount a high-level construal feature. The probability of winning resembles the method or means for obtaining the outcome, associated with feasibility and thus a secondary consideration, making probability a low-level construal feature [?, ?]. Similarly, in intertemporal choice, the delay time represents a secondary low-level construal feature, while the value of the outcome itself represents a primary high-level construal feature [?, ?]. Researchers have found that information processing styles under different emotional states exhibit characteristics of different construal levels. Fredrickson [?] argued that positive emotions enhance cognitive flexibility, broaden attention and cognitive scope, and facilitate holistic processing, whereas negative emotions narrow consciousness, restrict attention and cognitive scope, and bias processing toward local features. Forgas and East [?] found that people in positive emotional states tend to adopt holistic information processing, while those in negative emotional states tend to adopt concrete processing. Based on their findings, Wang and Liu [?] speculated that positive emotions activate high-level construal thinking, leading people to focus more on the holistic meaning of objects—i.e., the outcome dimension—and thus prefer delayed options. Conversely, negative emotions make people focus more on concrete, flexible attributes—i.e., the delay dimension—leading them to prefer immediate options. Pyone and Isen [?] measured and found that participants in positive emotions engaged in higher-level thinking and showed stronger future orientation compared to those in neutral emotions. Therefore, we hypothesize that in positive emotional states, the outcome dimension with high-level construal features has greater influence on decisions, whereas in negative emotional states, the delay dimension with low-level construal features has greater influence.

Based on the single-dimension priority model, this study employs the "intuitive analog scale" task to directly measure inter-dimensional difference comparisons between outcome and delay dimensions across different emotional states, thereby uncovering the process mechanism through which emotion influences intertemporal decision-making. We hypothesize that individuals in positive emotions focus more on the "outcome" dimension, perceiving the difference in the outcome dimension as larger than that in the delay dimension, and consequently make decisions based on the outcome dimension, showing a tendency to choose delayed options with larger outcomes. In contrast, individuals in negative emotions focus more on the "delay" dimension, perceiving the difference in the delay dimension as larger than that in the outcome dimension, and consequently make decisions based on the delay dimension, showing a tendency to choose immediate options that arrive sooner. In other words, inter-dimensional difference comparison mediates the effect of emotion on intertemporal choice preferences. This study comprises four experiments: Experiment 1 induces positive and negative emotions to examine the effect of emotional valence on intertemporal choice behavior; Experiment 2 uses the "intuitive analog scale" task to measure inter-dimensional difference comparisons during intertemporal decision-making under different emotional states, examining the mediating role of inter-dimensional difference comparison and testing the explanatory power of the single-dimension priority model; Experiments 3a and 3b manipulate the inter-dimensional difference comparison process through time and money priming strategies, respectively, to further validate its role in the relationship between emotion and intertemporal choice and provide additional evidence for the single-dimension priority model.

Experiment 1: The Effect of Emotion on Intertemporal Choice Behavior

Participants

We used G*Power 3.1 software [?] to calculate the required sample size, setting the effect size to 0.25 (Cohen's f) and α to 0.05. The analysis indicated that 90 participants were needed to achieve statistical power of 0.8. We recruited 150 university students (mean age = 19.21 years, SD = 1.40) who were randomly assigned to positive, negative, and neutral emotion groups (n = 50 per group). All participants volunteered and had not previously participated in similar experiments. Each received 15 yuan as compensation.

Materials

Emotion Induction Materials. Video clips represent one of the most direct and effective methods for emotion induction [?]. We therefore used video viewing to induce emotions. To select appropriate clips, we conducted a pilot study using three films from the Chinese Emotional Film Database: *Flirting Scholar* (positive), *Mama, I Love You* (negative), and *IDE Interface Repair* (neutral), each 5–10 minutes long. Twenty-one participants not involved in the main experiment were randomly assigned to the three conditions. They completed the Positive and Negative Affect Schedule (PANAS) before and after viewing. A 2 (measurement time: pre-test, post-test) × 3 (emotion group: positive, neutral, negative) repeated measures ANOVA on positive affect scores revealed no significant main effect of emotion group, $F(2,18) = 2.44$, $p = 0.115$, no significant main effect of measurement time, $F(1,18) = 0.01$, $p = 0.921$, but a significant interaction, $F(2,18) = 4.97$, $p = 0.019$, $p^2 = 0.36$, 90% CI [0.04, 0.53]. Simple effects analysis showed that in the positive group, post-test positive affect scores ($M = 31.00$, $SD = 4.18$) were significantly higher than pre-test scores ($M = 25.63$, $SD = 6.52$), $p = 0.018$; no significant differences were found in the negative or neutral groups. For negative affect scores, the ANOVA revealed no significant main effect of emotion group, $F(2,18) = 2.60$, $p = 0.102$, no significant main effect of measurement time, $F(1,18) = 1.27$, $p = 0.275$, but a significant interaction, $F(2,18) = 11.21$, $p = 0.001$, $p^2 = 0.55$, 90% CI [0.22, 0.68]. Simple effects analysis indicated that in the negative group, post-test negative affect scores ($M = 24.83$, $SD = 7.68$) were significantly higher than pre-test scores ($M = 19.50$, $SD = 7.94$), $p = 0.001$; in the positive group, post-test scores ($M = 13.13$, $SD = 2.70$) were significantly lower than pre-test scores ($M = 16.50$, $SD = 3.78$), $p = 0.012$; no significant difference was found in the neutral group. These results confirm that the emotion induction materials effectively elicited the target emotions.

Emotion Self-Report Scale. We used the Chinese version of the Positive and Negative Affect Schedule (PANAS) [**?**, **?**] to assess emotion induction effectiveness. The scale comprises 20 emotion descriptors rated on a 5-point scale (1 = very slightly or not at all, 5 = extremely). The Chinese PANAS has an internal consistency coefficient of $\alpha = 0.87$.

Intertemporal Choice Task. Participants completed the intertemporal choice task on computers using E-Prime 2.0. The delayed amounts were set at 100 yuan and 1000 yuan, with delay times of 10 days, 30 days (1 month), 90 days (3 months), 180 days (6 months), and 360 days (1 year). In each trial, the immediate amount initially equaled half the delayed amount (e.g., “500 yuan (now) vs. 1000 yuan (in 10 days)”). If participants chose the immediate option, the system decreased the immediate amount in the next trial (e.g., “400 yuan (now) vs. 1000 yuan (in 10 days)”); if they chose the delayed option, the immediate amount increased (e.g., “600 yuan (now) vs. 1000 yuan (in 10 days)”). This titration continued until preference reversal occurred—when a participant who initially chose the immediate option switched to the delayed option, or vice versa. The indifference point was calculated as the average of the immediate amounts before and after reversal. Each delay-by-amount condition yielded one indifference point. This method captures indifference points more effectively than matching procedures [**?**].

The procedure was as follows [Figure 1: see original paper]: First, a white fixation cross appeared at the center of a black screen for 500 ms. Then, a pair of intertemporal options appeared simultaneously on the left and right sides of the screen, and participants were instructed to make choices based on their true preferences as quickly as possible. Pressing "F" selected the left option, and pressing "J" selected the right option. If no response was made within 3000 ms, the trial automatically advanced. Task instructions read: "Imagine you have completed a short-term part-time job and will receive payment. You have two payment options: receive payment immediately today, or receive payment after a delay with a larger amount. Which would you choose? Please make your choice based on your true feelings at this moment."

Design and Procedure

We employed a 3 (emotion group: positive, neutral, negative) × 2 (delayed amount: 100 yuan, 1000 yuan) × 5 (delay time: 10, 30, 90, 180, 360 days) mixed design, with emotion group as a between-subjects factor and delayed amount and delay time as within-subjects factors. The dependent variable was the temporal discounting rate. After entering the laboratory, participants completed demographic questions (age, gender, grade) and were randomly assigned to emotion conditions for individual testing. They completed five tasks in sequence: keypress practice, pre-test emotion rating, emotion induction, post-test emotion rating, and the intertemporal choice task.

Results

After excluding invalid data from 40 participants whose discount rates fell beyond M ± 3SD or who failed the emotion induction, we obtained valid data from 110 participants (positive group: n = 37; negative group: n = 36; neutral group: n = 37).

Emotion Induction Effectiveness A repeated measures ANOVA on measurement time (pre-test, post-test) and emotion group (positive, neutral, negative) revealed a significant interaction for positive affect ratings, $F(2,107) = 77.59$, $p < 0.001$, $p^2 = 0.59$, 90% CI [0.49, 0.66]. Simple effects analysis showed that post-test positive affect scores in the positive group (M = 32.89, SD = 5.95) were significantly higher than in the negative group (M = 22.69, SD = 7.81) and neutral group (M = 23.24, SD = 6.37), both $ps < 0.001$, with no significant differences at pre-test. For negative affect ratings, the interaction was also significant, $F(2,107) = 67.75$, $p < 0.001$, $p^2 = 0.56$, 90% CI [0.45, 0.63]. Simple effects analysis indicated that post-test negative affect scores in the negative group (M = 20.89, SD = 6.88) were significantly higher than in the positive group (M = 11.81, SD = 2.66) and neutral group (M = 15.65, SD = 5.89), both $ps < 0.001$, with no significant differences at pre-test. These results confirm successful emotion manipulation.

Temporal Discounting Rates We calculated each participant' s indifference points across different delay times and amounts based on their choice turning points. Discount rates were computed using the classic hyperbolic model formula: $V = A/(1 + kD)$, where V represents the subjective value of the reward, A represents the reward amount, D represents the delay time, and k represents the temporal discounting rate. Higher discount rates indicate preference for immediate rewards, while lower rates indicate preference for delayed rewards [?]. The k values obtained in this experiment were skewed, so we applied a natural log transformation (Lnk) for statistical analysis. Descriptive statistics for discount rates across emotion groups, delayed amounts, and delay times are presented in Table 1 .

A 3 (emotion group: positive, neutral, negative) × 2 (delayed amount: 100 yuan, 1000 yuan) × 5 (delay time: 10, 30, 90, 180, 360 days) repeated measures ANOVA on Lnk revealed significant main effects of emotion group, $F(2,107) = 8.66$, $p < 0.001$, $p^2 = 0.14$, 90% CI [0.05, 0.23]; delayed amount, $F(1,107) = 4.16$, $p = 0.044$, $p^2 = 0.04$, 90% CI [0.0005, 0.1114]; and delay time, $F(4,428) = 295.23$, $p < 0.001$, $p^2 = 0.73$, 90% CI [0.70, 0.76]. Significant two-way interactions emerged between delayed amount and emotion group, $F(2,107) = 8.85$, $p < 0.001$, $p^2 = 0.14$, 90% CI [0.05, 0.23], and between delayed amount and delay time, $F(4,428) = 7.36$, $p < 0.001$, $p^2 = 0.06$, 90% CI [0.03, 0.10]. The three-way interaction among emotion group, delayed amount, and delay time was also significant, $F(8,428) = 1.99$, $p = 0.046$, $p^2 = 0.04$, 90% CI [0.0003, 0.0511].

Simple effects analysis revealed that for the 100 yuan delayed amount, when the delay was 360 days, the positive group' s discount rate was significantly lower than the negative group' s ($p = 0.001$) and the neutral group' s ($p = 0.029$), with no significant difference between negative and neutral groups ($p = 0.170$). For delays of 10, 30, 90, and 180 days, although the means showed a decreasing trend across positive, neutral, and negative groups (except at 90 days), no significant differences emerged between any pair of groups (all $ps > 0.139$). For the 1000 yuan delayed amount, across all delay times, the negative group' s discount rate was significantly higher than both the positive group (all $ps \leq 0.003$) and the neutral group (all $ps \leq 0.037$), while no significant differences appeared between positive and neutral groups (all $ps > 0.127$).

Overall, these results demonstrate significant differences in intertemporal choice behavior between positive and negative emotional states. Participants in positive emotions showed smaller temporal discounting rates and a stronger tendency to choose delayed options compared to those in negative emotions.

Experiment 2: The Mediating Role of Inter-Dimensional Difference Comparison

Experiment 1 confirmed that participants in positive emotions tend to choose delayed reward options, while those in negative emotions prefer immediate reward options. Experiment 2 further investigated the process mechanism underlying this emotion effect. Based on the single-dimension priority model, this experiment measured inter-dimensional difference comparisons during intertemporal decision-making under positive and negative emotional states to explore the process through which emotion influences intertemporal choice.

Participants

Using G*Power 3.1 [?] with effect size set to 0.6 (Cohen' s d) and $\alpha = 0.05$, we determined that 90 participants were needed to achieve 0.8 statistical power. We recruited 125 university students (mean age = 19.89 years, SD = 1.95), randomly assigned to positive (n = 60) and negative (n = 65) emotion groups. All participants volunteered and had no prior experience with similar experiments. Each received 15 yuan as compensation.

Materials

Emotion Induction Task. Identical to Experiment 1.

Intertemporal Choice Task. We used binary choice questions to measure intertemporal preferences. To select problems showing no baseline preference between immediate and delayed options in natural states, we conducted a pilot study combining titration and matching methods with 140 university students not participating in the main experiment. Accounting for magnitude and immediacy effects [?], we designed four intertemporal choice problems with different amounts and delays. Each condition included nine titration choice questions and one matching fill-in-the-blank question. If participants consistently chose Option A or B across all titration questions, they were asked to provide a value making the two options subjectively equivalent.

Indifference points were calculated for each condition. For participants who consistently chose one option, their provided equivalence value served as the indifference point. To ensure consistent difficulty across formal experiments, indifference points were rounded to integers, yielding the four intertemporal choice problems shown in Table 2 .

In the formal experiment, participants rated their preferences for these four problems on a 6-point scale, with lower scores indicating stronger preference for immediate options and higher scores indicating stronger preference for delayed options (1 = definitely choose immediate, 2 = probably choose immediate, 3 = slightly prefer immediate, 4 = slightly prefer delayed, 5 = probably choose delayed, 6 = definitely choose delayed).

Inter-Dimensional Difference Comparison Task. We adopted Jiang et al.' s [?] "intuitive analog scale" judgment task to measure inter-dimensional difference comparison. This task uses an analogy to represent the relative magnitude of delay dimension differences compared to outcome dimension differences in intertemporal options. If participants perceived the delay difference as larger than the monetary difference, they indicated a left-tilting scale; if they perceived the monetary difference as larger, they indicated a right-tilting scale; if differences were similar, they indicated a balanced scale. The degree of tilt represented the relative magnitude of differences between dimensions, rated on a 7-point scale where higher scores indicated larger monetary dimension differences relative to delay differences, and lower scores indicated larger delay differences relative to monetary differences (A = 1, B = 2, ···, G = 7). This is illustrated in Figure 2 [Figure 2: see original paper].

Design and Procedure

We used a single-factor between-subjects design (emotion group: positive, negative) with choice preference scores and inter-dimensional difference comparison scores as dependent variables. Participants completed five tasks in sequence: current emotion state pre-test, emotion induction, emotion state post-test, intertemporal choice preference task, and inter-dimensional difference comparison task. Procedures for all tasks except the latter two were identical to Experiment 1.

Results

After excluding 21 participants with discount rates beyond M $\pm$ 3SD or failed emotion induction, we obtained valid data from 104 participants (positive group: n = 49; negative group: n = 55).

Emotion Induction Effectiveness A repeated measures ANOVA on measurement time (pre-test, post-test) and emotion group (positive, negative) revealed a significant interaction for positive affect ratings, $F(1,102) = 111.65$, $p < 0.001$, $p^2 = 0.52$, 90% CI [0.41, 0.60]. Simple effects analysis showed that post-test positive affect scores in the positive group (M = 32.76, SD = 6.43) were significantly higher than in the negative group (M = 23.76, SD = 5.81), $p < 0.001$, with no pre-test difference. For negative affect ratings, the interaction was also significant, $F(1,102) = 121.14$, $p < 0.001$, $p^2 = 0.54$, 90% CI [0.43, 0.62]. Simple effects analysis indicated that post-test negative affect scores in the negative group (M = 20.93, SD = 6.01) were significantly higher than in the positive group (M = 12.88, SD = 3.89), $p < 0.001$, with no pre-test difference. These results confirm successful emotion manipulation.

Effects of Emotion on Intertemporal Choice Preference and Inter-Dimensional Difference Comparison Independent samples t-tests examined differences in "intertemporal choice preference" and "inter-dimensional difference comparison" between the two emotion groups across the four problems (see Figure 3 [Figure 3: see original paper]). Results showed:

For Problem 1, although the positive emotion group' s preference score was higher than the negative group' s, the difference was not significant, $t_1(102) = 1.90$, $p = 0.060$, Cohen' s d = 0.37, 95% CI [-0.02, 0.76]. However, the positive group' s inter-dimensional difference comparison score was significantly higher than the negative group' s, indicating that positive emotion participants were more likely to judge monetary differences as larger than delay differences, $t_1(102) = 2.06$, $p = 0.042$, Cohen' s $d = 0.40$, 95% CI [0.02, 0.79].

For Problems 2, 3, and 4, preference scores differed significantly between emotion groups, with the positive group scoring significantly higher—indicating stronger preference for delayed options: $t_2(101.2) = 2.60$, $p = 0.011$, Cohen' s $d = 0.51$, 95% CI [0.12, 0.90]; $t_3(102) = 4.20$, $p < 0.001$, Cohen' s $d = 0.83$, 95% CI [0.42, 1.23]; $t_4(102) = 2.76$, $p = 0.007$, Cohen' s $d = 0.54$, 95% CI [0.15, 0.93]. Additionally, inter-dimensional difference comparison scores differed significantly, with the positive group scoring higher—indicating greater tendency to judge monetary differences as larger than delay differences: $t_2(100.8) = 2.44$, $p = 0.016$, Cohen' s $d = 0.48$, 95% CI [0.09, 0.87]; $t_3(102) = 3.73$, $p < 0.001$, Cohen' s $d = 0.73$, 95% CI [0.34, 1.13]; $t_4(88.4) = 3.56$, $p = 0.001$, Cohen' s $d = 0.70$, 95% CI [0.30, 1.10].

Consistent with Experiment 1, emotion significantly affected intertemporal choice preferences, with positive emotion participants showing greater farsightedness and stronger preference for delayed options. Moreover, participants in different emotional states showed significant differences in inter-dimensional difference comparison processes: the positive group exhibited larger inter-dimensional difference comparison scores, indicating greater tendency to judge monetary differences as exceeding delay differences, while the negative group showed the opposite pattern.

Mediating Role of Inter-Dimensional Difference Comparison To examine whether inter-dimensional difference comparison mediates the relationship between emotion and intertemporal choice preference, we used Hayes' [**?**] SPSS macro PROCESS with bootstrap methods to assess mediation effects [**?**, **?**]. The independent variable (X) was emotion group, the mediator (M) was inter-dimensional difference comparison, and the dependent variable (Y) was intertemporal choice preference. We set 5000 bootstrap samples and a 95% confidence interval.

Results showed that for all four intertemporal choice problems, the 95% confidence intervals for the indirect effect of inter-dimensional difference comparison did not include zero ($CI_1 = [-0.6916, -0.0069]$; $CI_2 = [-0.74, -0.08]$; $CI_3 = [-0.93, -0.29]$; $CI_4 = [-0.94, -0.29]$), indicating significant mediation (see Figure 4 [Figure 4: see original paper]). Specifically, participants in positive emotions were more likely than those in negative emotions to perceive monetary differences as larger than delay differences, leading to stronger preference for delayed options with larger monetary outcomes. Conversely, participants in negative emotions were more likely to perceive delay differences as larger than monetary differences, leading to stronger preference for immediate options.

Experiments 3a and 3b: Manipulating Inter-Dimensional Difference Comparison Through Priming

Experiments 3a and 3b used time and money priming strategies, respectively, to manipulate the inter-dimensional difference comparison process. We examined whether the effect of emotion on intertemporal choice preferences would diminish or disappear, thereby providing further validation of inter-dimensional difference comparison’ s role and additional evidence for the single-dimension priority model.

Anderson and Bower [?] proposed that knowledge and concepts are stored in structured networks in our brains, where activating one concept activates related concepts that subsequently influence cognition and behavior. Researchers suggest that money is more closely associated with value maximization, activating a utility mindset, whereas time activates an emotional mindset [?, ?, ?]. Mischel and Shoda [?] argued that under a utility mindset, individuals adopt a cognition-driven “cool system”for information processing, making decisions more rationally with utility maximization as their goal. Under an emotional mindset, individuals adopt an emotion-driven “hot system,” making decisions more emotionally based and seeking immediate gratification. We therefore hypothesized that money priming would increase perception of monetary dimension differences, leading to delayed option selection, while time priming would increase perception of delay dimension differences, leading to immediate option selection.

We used the scrambled-words task for time and money priming. This conceptual priming method is most common in time and money priming research. Vohs et al. [?] first successfully used this method to prime money concepts, and Mogilner [?] demonstrated its equal effectiveness for priming both time and money concepts.

Experiment 3a: Time Priming

Participants Using G*Power 3.1 [?] with effect size set to 0.25 (Cohen’ s f) and $\alpha = 0.05$, we determined that 128 participants were needed for 0.8 statistical power. We recruited 134 university students (mean age = 19.89 years, SD = 1.95), randomly assigned to four groups: positive emotion with time priming (n = 35), negative emotion with time priming (n = 35), positive emotion without priming (n = 32), and negative emotion without priming (n = 32). All participants volunteered and were compensated 13 yuan.

Materials **Scrambled-Words Task.** We adapted Mogilner’ s [?] method, requiring participants to complete a sentence construction task. The questionnaire had two parts: (1) a scrambled-words task with 10 sets of five scrambled words, from which participants selected four to form a sentence; and (2) a word completion task with five Chinese characters to which participants added characters to form meaningful words within one minute. In the time priming condition, each word set contained a time-related word (e.g., "is, most precious, in the world, everyone, time" → "Time is the most precious thing in the world"). In the no-priming condition, words had no time or money meaning (e.g., "is, most precious, in the world, everyone, life" → "Life is the most precious thing in the world"). The number of time- or money-related words generated served as a manipulation check.

Emotion induction, PANAS, intertemporal choice preference task, and inter-dimensional difference comparison task were identical to Experiment 2.

Design and Procedure We used a 2 (emotion group: positive, negative) × 2 (priming condition: time priming, no priming) between-subjects design with choice preference scores and inter-dimensional difference comparison scores as dependent variables. Participants completed five tasks: current emotion pre-test, emotion induction, emotion post-test, scrambled-words task, intertemporal choice preference task, and inter-dimensional difference comparison task.

Results After excluding 29 participants with discount rates beyond M ± 3SD or failed emotion induction, we obtained valid data from 105 participants (positive-time priming: n = 30; negative-time priming: n = 30; positive-no priming: n = 25; negative-no priming: n = 20).

Emotion Manipulation Check. A repeated measures ANOVA revealed a significant interaction for positive affect ratings, $F(1,103) = 216.62$, $p < 0.001$, $p^2 = 0.68$, 90% CI [0.59, 0.73]. Simple effects showed post-test positive affect scores were higher in the positive group (M = 31.62, SD = 5.25) than the negative group (M = 24.12, SD = 5.34), $p < 0.001$, with no pre-test difference. For negative affect ratings, the interaction was also significant, $F(1,103) = 163.24$, $p < 0.001$, $p^2 = 0.61$, 90% CI [0.51, 0.68], with post-test negative affect scores higher in the negative group (M = 21.56, SD = 5.94) than the positive group (M = 13.04, SD = 3.89), $p < 0.001$, and no pre-test difference. These results confirm successful emotion manipulation.

Time Priming Manipulation Check. An independent samples t-test on the number of time-related words generated in the word completion task showed that the time priming group produced significantly more time-related words (M = 3.32) than the no-priming group (M = 1.78), $t(103) = 8.50$, $p < 0.001$, Cohen' s $d = 1.68$, 95% CI [1.23, 2.12], confirming successful time concept priming.

Intertemporal Choice Preference and Inter-Dimensional Difference Comparison. Figures 5 [Figure 5: see original paper] and 6 [Figure 6: see original paper] display choice preference and inter-dimensional difference comparison scores across conditions. Separate 2 (emotion group) × 2 (priming condition) ANOVAs were conducted.

For choice preference scores, significant main effects of emotion group emerged for all four problems: $F_1(1,101) = 4.24$, $p_1 = 0.042$, ${p_1}^2 = 0.04$, 90% CI [0.0008, 0.1182]; $F_2(1,101) = 8.48$, $p_2 = 0.004$, ${p_2}^2 = 0.08$, 90% CI [0.01, 0.17]; $F_3(1,101)$

= 22.08, $p_3 < 0.001$, $p_3{}^2 = 0.18$, 90% CI [0.08, 0.29]; $F_4(1,101) = 15.08$, $p_4 < 0.001$, $p_4{}^2 = 0.13$, 90% CI [0.04, 0.23]. Significant main effects of priming condition also emerged: $F_1(1,101) = 10.02$, $p_1 = 0.002$, $p_1{}^2 = 0.09$, 90% CI [0.02, 0.19]; $F_2(1,101) = 13.45$, $p_2 < 0.001$, $p_2{}^2 = 0.12$, 90% CI [0.04, 0.22]; $F_3(1,101) = 8.78$, $p_3 = 0.004$, $p_3{}^2 = 0.08$, 90% CI [0.02, 0.17]; $F_4(1,101) = 14.06$, $p_4 < 0.001$, $p_4{}^2 = 0.12$, 90% CI [0.04, 0.22]. Crucially, significant interactions between emotion group and priming condition appeared for all problems: $F_1(1,101) = 4.73$, $p_1 = 0.032$, $p_1{}^2 = 0.05$, 90% CI [0.0020, 0.1249]; $F_2(1,101) = 6.57$, $p_2 = 0.012$, $p_2{}^2 = 0.06$, 90% CI [0.0075, 0.1479]; $F_3(1,101) = 10.79$, $p_3 = 0.001$, $p_3{}^2 = 0.10$, 90% CI [0.02, 0.19]; $F_4(1,101) = 5.21$, $p_4 = 0.025$, $p_4{}^2 = 0.05$, 90% CI [0.0033, 0.1311].

Simple effects analysis revealed that without priming, the positive group had significantly higher choice preference scores than the negative group ($p_1 = 0.006$, $p_2 < 0.001$, $p_3 < 0.001$, $p_4 < 0.001$). However, under time priming, no significant differences emerged between emotion groups ($p_1 = 0.929$, $p_2 = 0.790$, $p_3 = 0.281$, $p_4 = 0.223$). Within the positive emotion group, time priming produced significantly lower choice preference scores than no priming (all ps < 0.001). Within the negative emotion group, no significant differences appeared between priming conditions (all ps > 0.317).

For inter-dimensional difference comparison scores, significant main effects of emotion group emerged for Problems 2, 3, and 4: $F_2(1,101) = 5.75$, $p_2 = 0.018$, $p_2{}^2 = 0.05$, 90% CI [0.0049, 0.1380]; $F_3(1,101) = 15.92$, $p_3 < 0.001$, $p_3{}^2 = 0.14$, 90% CI [0.05, 0.24]; $F_4(1,101) = 15.22$, $p_4 < 0.001$, $p_4{}^2 = 0.13$, 90% CI [0.04, 0.23]. Significant main effects of priming condition appeared for Problems 2, 3, and 4: $F_2(1,101) = 10.94$, $p_2 = 0.001$, $p_2{}^2 = 0.10$, 90% CI [0.02, 0.19]; $F_3(1,101) = 11.15$, $p_3 = 0.001$, $p_3{}^2 = 0.10$, 90% CI [0.03, 0.20]; $F_4(1,101) = 6.70$, $p_4 = 0.011$, $p_4{}^2 = 0.06$, 90% CI [0.0079, 0.1494]. Significant interactions between emotion group and priming condition emerged for all problems: $F_1(1,101) = 12.05$, $p_1 = 0.001$, $p_1{}^2 = 0.11$, 90% CI [0.03, 0.21]; $F_2(1,101) = 4.71$, $p_2 = 0.032$, $p_2{}^2 = 0.05$, 90% CI [0.0020, 0.1246]; $F_3(1,101) = 8.44$, $p_3 = 0.005$, $p_3{}^2 = 0.08$, 90% CI [0.01, 0.17]; $F_4(1,101) = 16.13$, $p_4 < 0.001$, $p_4{}^2 = 0.14$, 90% CI [0.05, 0.24].

Simple effects analysis showed that without priming, the positive group had significantly higher inter-dimensional difference comparison scores than the negative group ($p_1 = 0.001$, $p_2 = 0.003$, $p_3 < 0.001$, $p_4 < 0.001$). Under time priming, no significant differences emerged between emotion groups ($p_1 = 0.212$, $p_2 = 0.862$, $p_3 = 0.408$, $p_4 = 0.930$). Within the positive emotion group, no-priming conditions produced significantly higher scores than time priming (all ps < 0.001). Within the negative emotion group, no significant differences appeared between priming conditions (all ps > 0.297).

Moderated Mediation Model. We used PROCESS Model 7 to test a moderated mediation model, with continuous variables standardized (except age) and gender and age included as covariates [**?**].

Results (Table 3) showed that for Problems 2, 3, and 4, emotional valence significantly negatively predicted intertemporal choice, with significant total effects. After including the mediator and moderator, emotional valence' s direct effect on choice became non-significant, while its negative effect on inter-dimensional difference comparison and the latter' s positive effect on choice remained significant, indicating full mediation. Additionally, the interaction between emotional valence and time priming significantly predicted inter-dimensional difference comparison, demonstrating a moderating effect.

To clarify this interaction, we conducted simple slope analysis at high and low levels of time priming ($±1SD).Forthelow(nopriming)condition,emotionalvalencesignificantlynegativelypre
dimensionaldifferencecomparison(B_{1}$ = -0.91, t_1 = -3.21, p_1 = 0.002; B_2 = -0.88, t_2 = -3.17, p_2 = 0.002; B_3 = -1.13, t_3 = -4.27, $p_3 < 0.001$; B_4 = -1.33, t_4 = -5.03, $p_4 < 0.001$). For the high (time priming) condition, emotional valence did not significantly predict inter-dimensional difference comparison (all ps > 0.148).

Overall, emotional valence influenced intertemporal choice preference through inter-dimensional difference comparison, with this indirect effect moderated by time priming. The moderated indirect effects were significant (95% CIs: CI_1 = [0.42, 1.62]; CI_2 = [0.06, 1.23]; CI_3 = [0.19, 1.31]; CI_4 = [0.53, 1.52]). For participants without time priming, the indirect effect was significant ($index_1$ = -0.73, 95% CI [-1.25, -0.21]; $index_2$ = -0.71, 95% CI [-1.15, -0.28]; $index_3$ = -0.86, 95% CI [-1.32, -0.42]; $index_4$ = -1.00, 95% CI [-1.40, -0.58]). For participants with time priming, the indirect effect was non-significant (all 95% CIs included zero).

Experiment 3b: Money Priming

Participants Identical to Experiment 3a, we required 128 participants and recruited 138 university students. They were randomly assigned to positive emotion with money priming (n = 37), negative emotion with money priming (n = 36), positive emotion without priming (n = 32), and negative emotion without priming (n = 32).

Materials The scrambled-words task primed money concepts by replacing "time" with "money" in each word set, with other words and procedures identical to Experiment 3a. Emotion induction, PANAS, intertemporal choice preference task, and inter-dimensional difference comparison task were identical to Experiment 3a.

Procedure We used a 2 (emotion group: positive, negative) × 2 (priming condition: money priming, no priming) between-subjects design with choice preference and inter-dimensional difference comparison scores as dependent variables. All procedures matched Experiment 3a.

Results After excluding 33 participants with discount rates beyond M ± 3SD or failed emotion induction, we obtained valid data from 105 participants (positive-money priming: n = 30; negative-money priming: n = 30; positive-no priming: n = 25; negative-no priming: n = 20).

Emotion Manipulation Check. A repeated measures ANOVA revealed a significant interaction for positive affect ratings, $F(1,103) = 196.06$, $p < 0.001$, $p^2 = 0.66$, 90% CI [0.57, 0.72]. Simple effects showed post-test positive affect scores were higher in the positive group (M = 30.71, SD = 5.95) than the negative group (M = 23.56, SD = 5.45), $p < 0.001$, with no pre-test difference. For negative affect ratings, the interaction was also significant, $F(1,103) = 178.66$, $p < 0.001$, $p^2 = 0.63$, 90% CI [0.54, 0.70], with post-test negative affect scores higher in the negative group (M = 22.40, SD = 6.69) than the positive group (M = 13.40, SD = 4.36), $p < 0.001$, and no pre-test difference. These results confirm successful emotion manipulation.

Money Priming Manipulation Check. An independent samples t-test on money-related words generated showed the money priming group produced significantly more money-related words (M = 2.63) than the no-priming group (M = 1.49), $t(103) = 5.80$, $p < 0.001$, Cohen' s d = 1.14, 95% CI [0.73, 1.56], confirming successful money concept priming.

Intertemporal Choice Preference and Inter-Dimensional Difference Comparison. Figures 7 [Figure 7: see original paper] and 8 [Figure 8: see original paper] display scores across conditions. Separate 2 × 2 ANOVAs were conducted.

For choice preference scores, significant main effects of emotion group emerged for Problems 2 and 4: $F_2(1,101) = 4.02$, $p_2 = 0.048$, $p_2{}^2 = 0.04$, 90% CI [0.0002, 0.1152]; $F_4(1,101) = 4.34$, $p_4 = 0.040$, $p_4{}^2 = 0.04$, 90% CI [0.0010, 0.1196]. A significant main effect of priming condition appeared for Problem 1: $F_1(1,101) = 14.22$, $p_1 < 0.001$, $p_1{}^2 = 0.12$, 90% CI [0.04, 0.22]. Significant interactions between emotion group and priming condition emerged for Problems 2, 3, and 4: $F_2(1,101) = 5.04$, $p_2 = 0.027$, $p_2{}^2 = 0.05$, 90% CI [0.0029, 0.1289]; $F_3(1,101) = 10.92$, $p_3 = 0.001$, $p_3{}^2 = 0.10$, 90% CI [0.02, 0.19]; $F_4(1,101) = 9.50$, $p_4 = 0.003$, $p_4{}^2 = 0.09$, 90% CI [0.02, 0.18].

Simple effects analysis revealed that without priming, the positive group had significantly higher choice preference scores than the negative group ($p_2 = 0.006$, $p_3 = 0.003$, $p_4 = 0.001$). Under money priming, no significant differences emerged between emotion groups ($p_2 = 0.854$, $p_3 = 0.124$, $p_4 = 0.445$). Within the positive emotion group, no significant differences appeared between priming conditions for Problems 2 and 3 ($p_2 = 0.463$, $p_3 = 0.335$), but Problem 4 showed higher scores in the no-priming than money priming condition ($p_4 = 0.013$). Within the negative emotion group, money priming produced significantly higher scores than no priming for Problems 2 and 3 ($p_2 = 0.019$, $p_3 < 0.001$), with no difference for Problem 4 ($p_4 = 0.065$).

For inter-dimensional difference comparison scores, significant main effects of emotion group emerged for Problems 1 and 2: $F_1(1,101) = 4.37$, $p_1 = 0.039$, $p_1{}^2 = 0.04$, 90% CI [0.0011, 0.1200]; $F_2(1,101) = 5.47$, $p_2 = 0.021$, $p_2{}^2 = 0.05$, 90% CI [0.0041, 0.1345]. A significant main effect of priming condition appeared for Problem 1: $F_1(1,101) = 10.80$, $p_1 = 0.001$, $p_1{}^2 = 0.10$, 90% CI [0.02, 0.19]. Significant interactions between emotion group and priming condition emerged for Problems 3 and 4: $F_3(1,101) = 11.02$, $p_3 = 0.001$, ${}_3{}^2 = 0.10$, 90% CI [0.02, 0.20]; $F_4(1,101) = 4.16$, $p_4 = 0.044$, $p_4{}^2 = 0.04$, 90% CI [0.0006, 0.1171].

Simple effects analysis showed that without priming, the positive group had significantly higher inter-dimensional difference comparison scores than the negative group ($p_3 = 0.006$, $p_4 = 0.023$). Under money priming, no significant differences emerged between emotion groups ($p_3 = 0.073$, $p_4 = 0.663$). Within the positive emotion group, no significant differences appeared between priming conditions ($p_3 = 0.196$, $p_4 = 0.070$). Within the negative emotion group, money priming produced significantly higher scores than no priming for Problem 3 ($p_3 = 0.001$), with no difference for Problem 4 ($p_4 = 0.285$).

Moderated Mediation Model. Results (Table 4) showed that inter-dimensional difference comparison fully mediated the effect of emotional valence on intertemporal choice for all problems. For Problem 3, money priming moderated this relationship. Simple slope analysis at high and low levels of money priming (\$$\pm 1 SD) revealed that for the low (no priming) condition, emotional valence significantly negatively pred... dimensional difference comparison (B_{3}$\$ = -0.69, t_3 = -2.45, p_3 = 0.016). For the high (money priming) condition, the prediction was marginally significant ($B_3 = 0.49$, $t_3 = 1.94$, $p_3 = 0.055$). The indirect effect was moderated, with a significant index for Problem 3 (95% CI: [0.44, 1.70]). For no-priming participants, the indirect effect was significant ($index_3 = -0.62$, 95% CI [-1.05, -0.18]), whereas for money-priming participants, it was non-significant ($index_3 = 0.44$, 95% CI [-0.01, 0.90]).

General Discussion

Experiments 3a and 3b collectively demonstrate that when time and money priming strategies manipulate the inter-dimensional difference comparison process, differences between positive and negative emotion groups in both inter-dimensional difference comparison and intertemporal choice preferences disappear. Time and money priming moderate the effect of emotional valence on intertemporal choice. These results provide further evidence for the critical role of inter-dimensional difference comparison in emotion' s influence on intertemporal decision-making and additional support for the single-dimension priority model.

Our findings align with previous research on emotion' s effect on intertemporal choice, which has consistently found that individuals in positive emotional states show greater farsightedness than those in negative states [?, ?, ?, ?, ?, ?, ?, ?]. Guan et al. [?] examined the role of time perception in this process, finding that negative emotional states produce longer time perception than positive states, with emotion influencing intertemporal choice through its effect on time perception. This partially supports our mechanism exploration, suggesting that negative emotion participants focus more on the delay dimension and perceive larger delay differences, leading to delay-based decision-making. Our results further confirm that different emotional states involve different information processing styles, supporting theoretical speculations based on construal level theory [?, ?, ?, ?]. Positive emotions induce high-level construal, enhancing self-control and cognitive flexibility, leading to evaluations that emphasize holistic, goal-relevant information and focus on outcome values, making people willing to wait for larger monetary rewards. Negative emotions induce low-level construal, reducing self-control and narrowing attention, leading to evaluations that emphasize concrete, local information and focus on time attributes, resulting in impulsive choices for immediate gratification.

Our use of time and money priming to manipulate inter-dimensional difference comparison processes successfully eliminated emotion group differences in choice preferences and inter-dimensional difference comparisons. This aligns with previous intertemporal choice research. Jiang [?] used similar priming strategies and found that time priming made individuals value time more, adopting a "money for time" strategy and preferring sooner options, while money priming made them value money more, adopting a "time for money" strategy and preferring delayed options. In consumer research, money priming leads individuals to prefer products or services that maximize economic utility, resulting in more utilitarian consumption [?, ?, ?, ?, ?, ?, ?, ?, ?], whereas time priming leads individuals to focus on emotional experiences [?]. Moreover, money priming activates analytic processing modes, while time priming activates holistic or affective processing modes, influencing behavioral decisions [?, ?]. These findings are consistent with our results and can be explained by hot/cool system theory [?]: money priming activates the cool, cognition-driven system associated with self-control, while time priming activates the hot, emotion-driven system associated with impulsive behavior. Intertemporal choice research shows that when the hot system dominates, individuals prefer immediate options; when the cool system dominates, they prefer delayed options [?]. Our study further reveals at the process level how money or time priming changes decision preferences by altering inter-dimensional difference comparison.

Theoretical and Practical Implications

Previous theoretical explanations for emotion' s effect on intertemporal choice include affect-as-information theory [?, ?], the motivational dimensional model of affect [?, ?], and the appraisal-tendency framework [?, ?]. These theories emphasize how different emotional valences, motivational dimensions, or appraisal dimensions affect cognitive evaluation and subsequently intertemporal choice. However, most research remains at the stage of mechanistic speculation due to the lack of appropriate measurement tools and experimental paradigms for empirical validation. Our study opens the "black box" of the psychological process through which emotion influences intertemporal choice from a decision-process perspective. Additionally, we employed easily manipulable time/money priming strategies to alter inter-dimensional difference comparison processes and change decision preferences. Particularly, money priming led participants to make more outcome-based decisions, mitigating the myopic behavior caused by negative emotions. These findings deepen understanding of the emotion-intertemporal choice relationship and provide methods for improving poor judgment and decision-making caused by negative emotions. Furthermore, as a competing theory to discounting models, the single-dimension priority model receives additional supportive evidence from this research.

Limitations and Future Directions

Our study focused primarily on emotional valence, examining general emotional states' effects on intertemporal choice and finding that negative emotions increase temporal discounting relative to positive emotions. However, research suggests that examining specific emotions is important [**?**]. Recent studies have explored relationships between specific emotions (e.g., sadness, fear, anger, disgust) and intertemporal choice [**?**, **?**, **?**, **?**, **?**], with some findings diverging from general negative emotion effects. For instance, research on anger consistently finds that angry participants show smaller discounting rates and greater preference for delayed options compared to neutral participants, explained through affect-as-information and appraisal-tendency frameworks [**?**, **?**]. While our study reveals one psychological process mechanism, it may not be the only one. Future research should continue examining mechanisms from different theoretical perspectives (affect-as-information, appraisal-tendency, motivational dimensional models) and test whether the single-dimension priority model can explain effects of specific negative emotions.

Although the single-dimension priority model effectively explains many intertemporal choice anomalies, intertemporal choice is a complex phenomenon that may involve additional mechanisms operating jointly or independently. Future research should continue exploring these mechanisms. While the intuitive analog scale provides a clever behavioral measure of inter-dimensional difference comparison, future studies should employ multiple methods (e.g., eye-tracking) and neuroimaging techniques to identify neural evidence for this process. Our video-based emotion induction resulted in relatively many failed inductions; future research should test our findings using more effective emotion induction methods.

Conclusion

Through four experiments examining decision processes, this study investigated emotion' s influence on intertemporal choice and its underlying mechanisms. We conclude: (1) Participants in positive emotions show smaller temporal discounting rates and stronger preference for delayed rewards than those in negative

emotions. (2) Inter-dimensional difference comparison mediates the relationship between emotion and intertemporal choice preference. (3) Manipulating inter-dimensional difference comparison through time and money priming eliminates differences in choice preferences and inter-dimensional difference comparisons across emotional states. Overall, these results support the single-dimension priority model's explanation of intertemporal behavior differences across emotional states and reveal the process mechanism through which emotion influences intertemporal decision-making.

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Note: Figure translations are in progress. See original paper for figures.