Computable and Experimental Economics Laboratory

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The Role of Experienced Regret on Intertemporal Choice: An Experiment

Daniela Raeva · Luigi Mittone · Jens Schwarzbach

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Abstract Theoretical and empirical body of research have exposed the powerful role of experiencing regret in guiding choice behavior. In this paper, we examined the impact of experienced regret and rejoicing induced by feedback provided on a risk decision prior to a two-period intertemporal choice. To our knowledge, this is the first attempt to bring together experienced regret and choice over time. We used the two-component discounted utility model approach as a framework. We applied previous research findings on the effect of experienced regret on utility, and we performed an experiment to test whether experienced regret and rejoicing have an impact on the discount factor. We found that both experienced regret and rejoicing have an impact on the way people discount future: when regret is experienced the discount factor decreases, whereas when rejoicing is experienced the discount factor increases.

Keywords intertemporal choice · regret theory
JEL classification A12, C91, D91

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1 Introduction

Most of the decisions we make entail consequences that extend across time: we make trade offs between costs and benefits that occur at different points in time (i.e, *intertemporal choices*). The consequences of these decisions (e.g., education, marriage, health-relevant behavior, savings, investments, etc.), often have important ramifications to our life, therefore we believe that it is important to better understand what factors exert influence on intertemporal decision making. Loewenstein (1996, 1999, 2000) argued that negative emotions play an important role in intertemporal choice[1]. In this paper, we focus on experienced regret as a negative emotion.

Regret is a common everyday experienced negative emotion after making a wrong choice. We experience regret when we discover that an outcome would have been better if only we had chosen differently. Bell (1982) and Loomes and Sugden (1982) integrated experiencing regret into a decision theory called *regret theory*. Regret theory quantifies experienced regret by the unfavorable difference between the obtained outcome and the outcome that would have been obtained and when the difference is favorable then the positive emotion rejoicing is experienced. Therefore, to experience regret one should receive feedback both on the chosen and on a foregone alternative (*complete feedback*). If there is feedback only on the chosen alternative (*partial feedback*), no regret can be experienced. Regret has attracted much attention in research on individual decision making over the past few decades due to its serious day-to-day behavioral implications (for review, see Zeelenberg and Pieters (2007)). Here, our goal is to examine whether experienced regret has an impact on subsequent intertemporal choice. To our knowledge, in this paper, we make the first attempt to interconnect the findings on experienced regret with intertemporal choice.

The analysis of intertemporal choice, in economics and other social sciences has been normatively dominated by the discounted utility model (Samuelson, 1937; Koopmans, 1960). The common perception that a present outcome is worth more than a deferred one delineates the construct of discounted utility model. The model has two underlying components. The first component is the *instantaneous utility*. This is the present utility[2] of the option at hand, which is assumed to be stable over time. The second component is the *discount function*. This is a function of time delay (how far the outcomes of the option are removed from the present), which is assumed to be independent from the instantaneous utility. One can express the utility of an option whose consequences are intertemporal simply by multiplying the instantaneous utility associated to it by the discount function.

Over the last three decades, a large body of empirical research on intertemporal choice, in psychology and behavioral economics has documented various inadequacies in the assumptions about the properties of these two components. Many alternative models have emerged introducing modifications to the discounted utility model, while still maintaining the two-component construct (see

[1] More precisely, Loewenstein (1996, 1999, 2000) argued that a wide range of negative emotions (e.g., anger, fear), drive states (e.g., hunger, thirst, and sexual desire) and feelings states (e.g., pain) influence intertemporal choice.

[2] Utility of an option is a numerical value that refers to the satisfaction, or decision-maker's preferences, however derived. Options with higher utilities are preferred over options with lower utility.

Frederick et al (2002) for an extended overview). We use the two-component discounted utility model approach as a framework to examine the role of experienced regret on intertemporal choice.

As a first step, we outline the findings from previous research on the influence of experienced regret on post-choice utility evaluation. We extend these findings to the context of intertemporal choice by applying them to the instantaneous utility evaluation. Next, in an experimental study, we examine the role of experienced regret on the second component of the discounted utility model. In the experiment, we induce the emotion of regret by providing feedback on risk decision prior to a two-period intertemporal choice. We present and interpret the results through a qualitative analysis, which suggests that the time discount function is influenced as well by the regret experienced prior to making the intertemporal choice and that this influence is in the same direction as it is for the instantaneous utility.

2 The Role of Experienced Regret on Utility

Regret theory assumes that experienced regret leads to reducing the psychological experience of satisfaction from the obtained outcome (Bell, 1982; Loomes and Sugden, 1982). Several empirical studies have provided support to this assumption. In Inman et al (1997) participants were asked to make choices between lottery pairs. After making their choices, the participants were provided with outcome feedback on the chosen lottery as well as on the foregone lottery and their subjective evaluation of the choices were assessed. The analysis of the results revealed that the information about the forgone alternative had a significant influence on the participants' evaluation of their choices. Regret feedback resulted in a decrease, and rejoicing feedback in an increase, of the satisfaction level. Similar results were reported in Mellers et al (1999, Experiment 1). In this study, participants were presented with series of choices between two gambles. Participants always learned the outcome of the chosen gamble. In some of the trials, they also observed the outcome of the foregone gamble. After each choice, their subjective emotion evaluation of the choice was assessed. The results revealed that the availability of feedback on the foregone alternative had significant effect on how participants felt about the outcome of the chosen gamble. Participants felt better for their own outcome when the outcome of the other gamble was worse, and they felt worse for their own outcome when the other gamble resulted in a better outcome.

Inspired by the experimental paradigm used in Mellers et al (1999), Camille et al (2004) provided confirmation of the subjective emotion evaluation ratings of the outcomes with the physiological index of emotional reactivity collected using skin conductance response (SCR). The authors compared the emotional reactions of normal participants with the emotional reactions of patients with orbitofrontal cortex (OFC) lesions. The authors found that the SCR was enhanced in normal participants while viewing both the outcome of the chosen gamble and outcome of the foregone gamble compared to viewing only the outcome of the chosen gamble. By contrast, the SCR in the patients were not modulated by the outcome of the foregone alternative. These results suggested the specificity of the OFC

in mediating regret. Previous neuroimaging studies have implicated that the OFC plays an important role in reward processing (coding stimulus value) from variety of sensory modalities (for a review, see O'Doherty, 2004). Coricelli et al (2005) were the first to provide neuroimaging evidences of the role of OFC in experiencing of regret. The authors measured brain activity using functional magnetic resonance imaging (fMRI) while participants were presented with a series of choices between two gambles. The results showed that the neural activity in response to experiencing regret is distinct from the activity detected during only the chosen outcome evaluation. The authors found that the activity in medial OFC was correlated with the degree of regret (i.e., the difference between the chosen outcome and the foregone outcome): greater activity for the negative outcomes and greater deactivation for the positive outcomes when feedback on the foregone gamble was provided. In addition to the activity in the OFC, the authors found similar response in dorsal anterior cingulate cortex and anterior hippocampus. These areas discriminated between better and worse outcome on the foregone gamble. These findings suggested that when experiencing regret there are distinctive neural substrates involved in the reward processing (Coricelli et al, 2007). The findings reported in the studies described above provide strong psychological, physiological and neurophysiological evidences of the influence of experienced regret on utility evaluation.

In this paper, we apply these findings to the study of the role of experienced regret on intertemporal choice. We first outline the model of the impact of experienced regret to the instantaneous utility evaluation. In the aforementioned studies, the effect of regret on utility is evaluated immediately after the decisions are made. Under the discounted utility framework, we interpret these results as observations about the instantaneous utility of an outcome. In this study, we induce regret and rejoicing prior to making an intertemporal choice. We assume that this emotion manipulation produces the same effect on instantaneous utility as the one observed by assessing post-choice level of satisfaction. That is, we follow the model of Inman et al (1997)[3] for regret effects on post-choice valuation, and we assume that the instantaneous utility $u_E(x)$ depends on emotion E as

$$u_E(x) = u_P(x) + r_E, \tag{1}$$

where $u_P(.)$ is a monotonically increasing value function, x is the outcome from the chosen option, r_E is an offset depending on whether regret or rejoicing was experienced prior to the intertemporal decision. The offset due to the discrepancy between the obtained outcome and the outcome that could have been obtained had an alternative option been chosen: r_E is negative when regret is experienced, and positive when rejoicing is experienced. The offset is created at the time when the payoffs are revealed. The subscript E, discriminating the role of the experienced emotion, can be R for regret or J for rejoicing. We set the no emotion situation corresponding to partial feedback as a reference. The instantaneous utility at partial feedback is denoted as $u_P(x)$. Extending the equation with allowing E to take the value P, we include the partial feedback condition as an identity (due to $r_P = 0$).

[3] This model itself is motivated by the regret theory model of Bell (1982) and Loomes and Sugden (1982).

While we have a formulation for the effect of experienced regret on the instantaneous utility, we are not aware of any results concerning the other component of the discounted utility model, the discount function. In this paper, we present our experiment designed to bring insight into whether experienced regret has an effect on the discount function. In our study we use a choice between two outcomes that can occur respectively at two different points in time, i.e., two-period intertemporal choice. Note that this type of intertemporal choice does not allow for capturing the shape of the discount function, as the discount function is effectively reduced to a single discount factor. As our main goal is to measure how emotions influence the way people relate to future, and not to measure how discounting depends on the size of the time delay, such a two-period intertemporal choice is sufficient for us.

3 The Experiment

We conducted an experiment combining the experimental paradigm used in Coricelli et al (2005) with a two-period intertemporal choice. We presented participants with a sequence of trials involving making two different decisions. The first decision was between two risky gambles with equivalent probabilities associated to the outcomes. Both gambles had zero expected payoffs. The difference between the gambles was the size of the monetary gain or loss. On this decision, two different types of feedback were provided. In the partial feedback condition, only the outcome of the chosen gamble was shown, whereas in the complete feedback condition, the outcomes of both gambles were revealed. The second decision was the two-period intertemporal choice. On this second decision no feedback was provided. We tested whether the type of feedback on the risky gambles affects the way people make the trade off between the two periods. We hypothesized that emotions triggered in the first decision would influence the decision processes about the future in the second.

In this paper, we make the distinction between experienced decision-related and -unrelated regret. Previous empirical studies have demonstrated that experienced regret exert influence on subsequent choice (for review, see Zeelenberg et al (2001)). This influence has been shown for repeating decision in the same domain. We call this decision-related experienced regret, i.e., previously experienced regret in a certain decision domain is taken into account when making subsequent decisions in the same domain. In our experiment we apply a novel approach to the study of the consequences of experienced regret by introducing the decision-unrelated regret, i.e., regret is experienced on a choice prior to making a subsequent choice in a different domain. In the context of making two different decisions after each other, decision-unrelated regret can be treated as an incidental emotion. Although regret is experienced at the moment of making a decision, it arises from sources objectively unrelated to the decision at hand (cf. Rick and Loewenstein (2006)). Following the appraisal-tendency theory assumptions[4] (Lerner and Keltner, 2000), we assume that decision-unrelated experienced regret, although provoked in one decision situation, is carried over to the next decision.

[4] Lerner and her colleagues (Lerner and Keltner, 2000; Lerner and Tiedens, 2006; Han et al, 2007) have provided a framework to study the underlying appraisal patterns of incidental emotions. According to the Appraisal-Tendency Framework decision-unrelated emotional appraisals, which although provoked in a prior situation, are carried on beyond the eliciting situation by coloring the content as well as the process of people's thoughts.

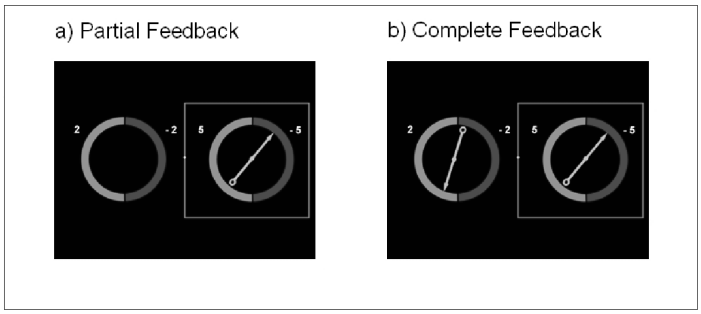

Fig. 1 The regret gambling task analogous to the one used in Coricelli et al (2005). The colored sectors on both wheels represent the probability associated with the monetary gain (blue) and loss (red). A green square highlights the selected wheel. (a) represents the partial feedback condition where feedback was provided only on the selected wheel (the stopping position of the arrow (in yellow) indicates the obtained outcome). (b) represents the complete feedback condition where the outcomes on both wheels were revealed.

Method

3.1 Experimental Procedure and Design

In the beginning of the experiment, each participant was seated in front of a computer screen and presented with instructions written on paper. An experimenter and one assistant were running the experiment. Before starting the experiment, there was a training session consisting of six trials identical to the experimental trials. The experiment lasted 45 minutes. There were short breaks every 15 minutes. All responses were given anonymously.

A within-subjects experimental design with one factor was used to test whether experienced regret on a prior choice influences the discounting decision processes. The independent variable was the type of feedback provided on the first decision: partial feedback and complete feedback. The complete feedback was subdivided into regret and rejoicing feedback. Participants were not informed in advance what type of feedback they will receive. The dependent variable was the mean indifference value (to be discussed in more detail later in this Section).

In the beginning of each trial, participants view two gambles, depicted as two wheels of fortune (Fig. 1). In the experiment all numbers corresponded to payoffs in real money (in Euro[5]). One of the wheels had win 2 on the left and loss 2 on the right side. This was the lower risk wheel. The other wheel had win 5 on the left and loss 5 on the right side. This was the higher risk wheel. These two wheels were used throughout the experiment. The position of the wheels on the screen was counterbalanced in a random order (i.e., half of the trials one of the wheels was on the left side of the screen and the other half on the right side).

In each gamble, the relative size of the colored sectors of the wheel represented the probability associated with the monetary gain (blue) and loss (red). During the experiment the depicted proba-

[5] At this time, the Euro (€) is the currency used in 16 of the 27 member states of the European Union.

bility level on both wheels was kept constant (50/50). The depicted and the actual probabilities were the same for obtaining gains or losses for both types of feedback provided.

Participants indicated their choice by left or right mouse press. The elapsed time between the wheels' appearance on the screen and the button press was recorded. Once selected, the chosen gamble was highlighted on the screen by a green square. Depending on the type of condition, an arrow appeared in the center either in the selected wheel only or in both wheels. In partial feedback, the arrow appeared always only in the chosen wheel. In complete feedback condition, the arrow appeared randomly in half of the trials first in the chosen wheel and in the other half of the trials first in the unchosen wheel. Each arrow rotated within the wheel for an interval of time randomly selected between 1s and 5s with 0.5s steps and then stopped. Immediately after the first arrow stopped, the second arrow started rotating. The stopping position of the arrow in the chosen wheel indicated the obtained amount of money in the first choice.

Prior to each trial, participants were informed that they had 10 Euro as initial amount to start with on a trial. The amount of money participants obtained from the selected wheel was accordingly subtracted or added to this initial 10 Euro. This gave the total amount in this trial that could be paid for the participation in the experiment. After each trial the obtained total amount was recorded. By default, this total amount was payable two months after the experiment.

Before conducting the experiment, we performed a pilot study to determine the length of time delay to be used in the experiment. 30 students from University of Trento participated in an identical experimental procedure. We tested independently three time delays: one-week, two-week and two-month. We found that the participants preferred tomorrow over the two-month delay 62% of the times on average, whereas in one-week and two-week delays, participants preferred tomorrow only 19% of the times on average. On the basis of these data, we selected the two-month time delay to measure how emotions influence the way people relate to tomorrow. This time delay allows for displaying an increase or a decrease of the time preferences due to the emotion manipulation, while in the other cases the preference towards the delayed payment was too strong, thus it would be difficult to induce variation due to the emotion manipulation.

After each round on the wheels, participants made a second decision. They had to decide whether to keep the total amount and receive it after two months or to exchange it for a smaller amount, but to receive it one day after the experiment. We used one day after the experiment instead of today to avoid the strong preference towards the present (today) and to have equivalent cost for obtaining the rewards in both periods.

In order to obtain their time preferences, participants were asked the following question:

You will be paid x € in 2 months.

Would you rather accept qx € tomorrow?

We define this decision situation in the following mathematical form:

$$u_E(qx) \gtreqless d_E u_E(x), \tag{2}$$

where q is a number smaller than unity, $u_E(x)$ is the instantaneous utility of receiving x Euro under experienced emotion in the experimental condition E and d_E is the discount factor under the emotion condition. The meaning of the number q is the proportion to which the amount to be received after two months is reduced if it was to be obtained after one day.

To give their answer, participants had to wait for "yes" and "no" to appear on either left or right side of the screen, which was counterbalanced in a random order. By left or right mouse press, their choice was highlighted by green square. The elapsed time between the presentation of the "yes" and "no" and the subsequent button press was recorded.

3.2 Eliciting the Indifference Value

We asked our participants to make choices between receiving a larger reward x two months after the experiment and a smaller reward qx one day after the experiment. In the literature on intertemporal choice, when the choice is between outcomes only in two periods, the norm is to assume underweighting the utility of the outcome that is delayed further in time (Frederick et al, 2002). Therefore, we took implicitly our two-period sequence to be declining with the increasing of the time delay (i.e., the utility of an amount received after two months is lower than the utility of the same amount received tomorrow due to the larger time delay).

In the experiment, our goal was to elicit the participants' preferences between the two time delays and to evaluate whether their preferences for the time delays were altered by the regret and rejoicing experienced prior to the intertemporal decision. We elicited the participants' preferences through extracting their (mean) indifference value. For a general two choice options decision that depends on one parameter, the indifference value is the value of the parameter at which the two choice options are of equal subjective value to the individual. In our two-period intertemporal choice, finding the indifference value means finding how much the amount to be received after one day should be in order to make the participants indifferent between the two time periods. That is, in this decision situation the parameter is the proportionality factor q and its indifference value $q_0^{(E)}$, such that the amount receivable after two months and the amount receivable after one day are of equal subjective value. In terms of the decision relation Eq. (2)

$$u_E(q_0^{(E)}x) = d_E u_E(x). \tag{3}$$

Note that, although at a certain moment and for a certain x a participant has a well defined q_0, q_0 can take a different value at a different moment or for a different x. We assume that for a given individual the indifference value q_0 fluctuates around a mean indifference value $\bar{q}_0$, which we use as our dependent variable to characterize the individual's time preferences. To extract this mean indifference value we will have to adopt a statistical approach for each participant (preceding the usual statistical processing of the group data). Note also that in the context of intertemporal choice the indifference value defined in this way is a measurable quantity, in contrast to the discount factor

and the instantaneous utility, which are not accessible separately experimentally. While generally $\bar{q}_0^{(E)}$ can be only used to observe how the combination of these quantities behave, with the model Eq. (1) for the emotion dependence of the instantaneous utility at hand, from the emotion dependence of $\bar{q_0}^{(E)}$ insights can be gained about the emotion dependence of the discount factor (see the Discussion).

To estimate $\bar{q}_0^{(E)}$ we used four values $q = .6, .7, .8$, and $.9$. Each of these values was asked per condition, which formed 12 questions. Each of these questions was repeated eight times during the experiment in order to average out the inconsistency (due to aforementioned fluctuation) in participants' answer.

We now briefly discuss how $\bar{q}_0^{(E)}$ was obtained. We asked our question n times for a given q value, for a given condition. We use here n instead of eight, because the number of times a questions is asked varies due to the of outliers removal: for each subject, outlying responses with respect to the reaction times were excluded[6].

We interpreted the answers probabilistically: if for a given q value in a given condition, the number of acceptances of a participant was $Y_q^{(E)}$, we obtained the probabilities $P(q_0^{(E)} < q) = Y_q^{(E)}/n$. The quantity $F(q) = P(q_0^{(E)} < q)$ is the cumulative probability distribution of $q_0^{(E)}$, from which the average, $\bar{q_0}^{(E)}$, for the participant for the given condition can be taken straightforwardly. The probabilistic interpretation was the key ingredient in handling the possible choosing at random: it provided means for treating situations when from the eight questions for a condition a given q value was accepted some times and rejected some other times. This inconsistency was handled using the criterion of increasing $F(q)$, participants with non-increasing $F(q)$ were disregarded; these participants formed the group with inconsistent time preferences, see the next subsection. For example, a participant with non-increasing $F(q)$ would accept an offer with $q = 0.6$ more likely than one with $q = 0.8$, which seems unreasonable. This could be interpreted as the participant is having $q_0^{(E)}$ fluctuating too much for its average to be measured by only eight repetitions of a question per each condition.

3.3 Participants

The participants were recruited through bulletin board advertising. 57 students at University of Trento participated in the experiment. We had both male and female participants, in roughly equal proportions. Participants were paid for their participation. The amount they received was automatically selected by the software based on the choices made during the experiment, i.e., at the end of the experiment the reward obtained in one of the trials was selected at random. Participants were asked to return for the payment on the date indicated in the chosen trial - after one day or after two months, from the date of the experiment. All payments were made in cash and strictly only on the specified date.

After the data collection was completed, participants' preferences were categorized in three groups based on the type of choices they made. In the context of our experiment, there were strict, non-strict

[6] For the purpose of outliers removal, we excluded all responses with +/- 2.00 SD above the mean. We consider these trials as misreported.

and inconsistent time preferences. In the strict time preferences group were included 10 participants exhibiting a strong preference towards one of the two available periods (they chose tomorrow or two months on every trial). The participants in the strong time preference group did not display sensitivity to our emotional manipulation. In the inconsistent time preferences group were included another 10 participants, who did not reveal consistent time preferences (as in the example discussed above, these participants were more likely to accept $q = .6$ while tending to reject $q = .9$). The data from the participants in the inconsistent group were excluded from the indifference values estimation.

3.4 Emotion Induction

Regret and rejoicing rise from the discrepancy between actual outcome and the foregone outcome, i.e., when the value of the foregone outcome is higher than the obtained outcome regret is experienced, whereas when the obtained outcome is higher than the foregone one rejoicing is experienced (see Tab. 1. In the experiment, the emotional manipulation was attested by the difference between the outcome of the selected wheel and the outcome of the unselected one. This difference is possible to be measured only in the complete feedback condition. The emotion induction in the experiment was counterbalanced in complete feedback.

Emotion	Total	Payoffs	Total	Emotion
R	12	(2, 5)	15	J
J	12	(2, -5)	5	R
R	8	(-2, 5)	15	J
J	8	(-2, -5)	5	R

Table 1 Emotion induction cases. The middle column refers to the combination of outcomes, paired in the form (a, b). The left side of the table refers to a as chosen and to b as unchosen, whereas the right side refers to b as chosen and a as unchosen.

3.5 Results

To test whether the decision-unrelated regret and rejoicing have an effect on the intertemporal choice in a statistically important way, a repeated measure ANOVA was performed. The results revealed a significant main effect of the manipulated emotions ($F(1.27, 58.28) = 7.89$, $p < .05$). The type of feedback provided on the gamble had a substantial influence on the subsequent intertemporal choice. Compared with partial feedback, complete feedback modified in a considerable way how people make trade offs between the two time periods (Fig. 2).

Furthermore, in a pairwise statistical comparison (with Bonferroni adjustment for multiple comparisons), the analysis indicated the relevance of the type of complete feedback. The mean indifference value obtained in the partial feedback ($M = .62$, $SD = .19$) was statistically different ($p < .05$) from the mean indifference value obtained in the regret condition ($M = .59$, $SD = .19$) as well as it was from the mean indifference value obtained in the rejoicing condition ($M = .64$, $SD = .19$) (see Fig. 3). The results also revealed a significant difference between regret and rejoicing in the complete

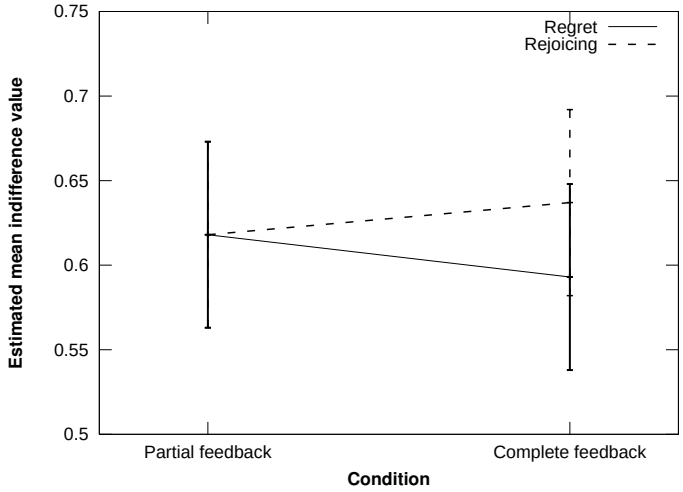

Fig. 2 Estimated mean indifference value per condition. (Error bar: 95% confidence interval) The solid line connects the mean indifference value for the partial feedback and the regret condition, the dashed line connects the mean indifference value in partial feedback condition with that in the rejoicing condition.

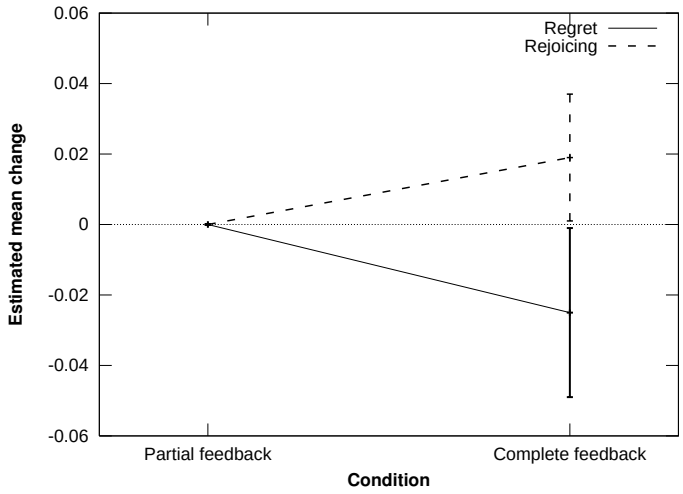

Fig. 3 Estimated mean changes for regret (solid line) and rejoicing (dashed line) conditions, based on a pairwise statistical comparison to the partial feedback condition (zero line). The error bars are the 95% confidence intervals for the mean differences.

feedback condition ($p < .05$). We found that regret and rejoicing displayed distinct directions of influences when induced prior to an intertemporal decision, compared to situation when no counterfactual comparison between obtained and foregone outcome can be made (partial feedback): when regret is experienced the indifference value decreases, when rejoicing is experienced the indifference value increases.

In addition, to check whether the different risk level associated to the two gambles used in the experiment affected choice behavior, a statistical analysis of the proportion of choices of low and high risk gambles was performed. We found that the proportion of high risk gambles did not show significant differences for different conditions, in fact, the proportions of risky gamble choices were

almost identical. This result helped us to rule out the possible interference of the risk level with the observed effect.

3.6 Discussion

The results showed that when making trade-offs between two time periods, participants were influenced by the emotions triggered by the type of feedback on a prior choice. When participants experienced regret they were willing to accept on average more offers to exchange a larger-later reward with a smaller-sooner reward, whereas when presented with rejoicing they were willing to reject on average more of these offers, both compared to the partial feedback condition (which served as a baseline since neither regret nor rejoicing were introduced). This effect supported our emotional-carryover hypothesis. We found evidence that decision-unrelated regret, although evoked by the prior irrelevant decision situation, applied different color lenses to the judging of the subsequent decision.

It is still left to examine whether the observed effect of experienced regret and rejoicing on subsequent intertemporal choice imply effect on the discount factor, or the effect can be attributed to the impact on the instantaneous utility (see Eq. (1)). To this end, let us first assume that the discount factor does not depend on the emotions, i.e., $d_E = d$ for all conditions. Let $q_0^{(P)}$ denote the indifference value of q in the absence of emotions (partial feedback),

$$u_P(q_0^{(P)}x) = du_P(x). \tag{4}$$

As we show below, if d does not depend on emotions, the emotion dependence of the instantaneous utility results in an increase of the indifference value for regret, and a decrease for rejoicing compared to its value in the partial feedback case. Indeed, substituting the regret theory model (1) in the decision situation (2) we have

$$u_P(q_0^{(P)}x) + r_E \gtreqless d\,(u_P(x) + r_E) \tag{5}$$

which amounts to (because of Eq. (4))

$$r_E \gtreqless dr_E. \tag{6}$$

For regret, we have $r_R < dr_R$ and for rejoicing $r_J > dr_J$, because $0 < d < 1$. This means that the indifference value $q_0^{(P)}$ in partial feedback is smaller than the indifference value in regret ($q_0^{(P)} < q_0^{(R)}$) and greater than in rejoicing ($q_0^{(P)} > q_0^{(J)}$). This clearly conflicts our behavioral results. We found that the indifference value depends on decision-unrelated emotions in the opposite way: when regret is experienced the indifferent value decreases and when rejoicing is experienced the indifference value increases.

The discrepancy between the above qualitative result and the behavioral responses tells us that assuming an emotion independent discount factor would be incorrect. If we want a qualitative model that describes the emotion dependence of $q_0^{(E)}$ observed in the experiment, we should use a discount factor that decreases for regret and increases for rejoicing. To illustrate this point, we depicted the

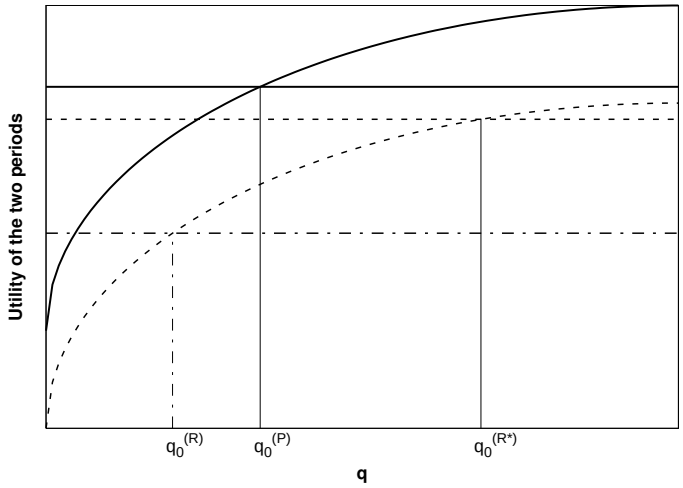

Fig. 4 Graphical representation of the decision situation. Solid lines: Partial feedback. Dashed lines: Regret condition, assuming emotion independent discount factor. Dashed-dotted line: the utility of the two month option for the regret condition, including the emotion dependence of the discount factor.

ingredients of the above qualitative reasoning graphically in Fig. 4. The solid lines represent the decision situation for partial feedback, with the monotonically increasing line being the utility of the option payable tomorrow as a function of the parameter q. The horizontal line is the utility of the option payable after two months. (Both utilities are represented for a fixed value of x.) The intersection of the two lines gives the indifference value $q_0^{(P)}$. The dashed lines are the analogous functions for the case of regret, assuming an emotion independent discount factor. The key point here is that the curve for the utility of the amount to be received tomorrow is shifted down with r_R, while the constant utility of the amount to be received after two months is shifted with a smaller amount, dr_R. The intersection of these lines gives the corresponding indifference value, which we denote $q_0^{(R^*)}$ on the figure. The dashed dotted line represents the utility of the option payable in two months for regret condition, if it is assumed that the discount factor decreases due to regret (resulting in a further downward shift of the constant utility curve). In order to have $q_0^{(R)} < q_0^{(P)}$, this decrease should be large enough to result in a total decrease (compared to the partial feedback case) of the utility of the option payable in two months that is larger than r_R. If the total decrease was precisely r_R, the constant utility line would be shifted down exactly as much as the line of the utility of the amount to be received tomorrow. The two curves would thus be shifted down without a change in their relative position, resulting in no change in q_0. A similar reasoning can be carried out for the case of rejoicing. To summarize, from our experiment we can conclude that decision-unrelated regret decreases, rejoicing increases the discount factor. This is our main result. This result confirms that intertemporal decision process can be influenced by factors unrelated to the decision task.

One possible explanation of this emotional carryover effect on the discount factor could be that experienced regret triggered more pessimistic thoughts about the future: overestimating the impact of negative forces in the future, which made the smaller-sooner option more attractive. On the opposite

side, experienced rejoicing triggered more optimistic thoughts: underestimating the role of future uncontrollable events due to the positive experience. Rejoicing acted as pink-colored glasses affecting participants' ability to judge. It is worthwhile to note, that the results from our behavioral study suggest that experienced decision-unrelated regret affects the discount factor in the same direction as it affects the instantaneous utility.

4 Conclusion

In this paper we brought together experienced regret and intertemporal choice. Regret and rejoicing are emotions based on juxtaposing the outcome of the choice we made with the outcome of the rejected alternative. We studied the impact of regret and rejoicing induced by the feedback on a risk decision prior to a two-period intertemporal choice. Previous research findings on regret have shown that experienced regret leads to decrease in the utility of the obtained outcome. We applied these findings to the instantaneous utility. We conducted an experiment to test whether experienced regret has also influence on the discount factor. We found that when regret is experienced the discount factor decreases, when rejoicing is experienced the discount factor increases. These results indicated that the discounting decision process is influenced by regret experienced on a prior different choice. We found that this influence is in the same direction as the one for the instantaneous utility. Our results led us to conclude that experienced regret evoked in one decision situation is carried over to a subsequent intertemporal choice. We interpret these results as suggesting that, apart from reducing the utility, experienced regret is affecting the ability to judge by eliciting more pessimistic believes about the future. We hope that our empirical findings will foster the creation of new interface between emotions and intertemporal choice by taking special consideration of the regret effects, which may lead to more informed and improved formal assumptions about intertemporal decision making.

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