Regret now, take it now: On the role of experienced regret on intertemporal choice

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Abstract

We present an experiment designed to test whether experienced regret and rejoicing evoked in a risk choice have an impact on subsequent intertemporal choice. We found that regret and rejoicing experienced prior to an intertemporal choice influenced considerably the way people relate to future: when regret was experienced participants preferred not to wait, whereas when rejoicing was experienced, participants were willing to wait longer. We show that in the framework of the discounted utility model experienced regret lowered and experienced rejoicing increased the discount factor.

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). Decisions about spending, investments, savings, mortgages, relationships and education all contain intertemporal trade-offs. Despite the important ramifications of these decisions on our life, people often make choices “in the heat of the moment” that they would not have intended to make. Previous research has shown that emotions experienced at the moment of choice (i.e., immediate emotions) play an important role in intertemporal choice (Loewenstein, 1996, 1999, 2000).

In this paper, the immediate emotions we focus on are experienced regret and rejoicing. We experience regret when we discover that the outcome we could have obtained if chosen differently would have been better. When we discover that we
have obtained a better outcome compared to a foregone one, we experience rejoicing (Bell, 1982; Loomes & Sugden, 1982). Bell (1982) and Loomes and Sugden (1982) integrated these emotions into a decision theory called regret theory. Regret theory quantifies experienced regret and rejoicing by the difference between the obtained outcome and the outcome that could have been obtained, had we chosen differently: when the difference is unfavorable regret is experienced, whereas when the difference is favorable then rejoicing is experienced. The experience of regret and of rejoicing, therefore, are on large part conditional on the knowledge of the outcome of the foregone option: one should receive feedback both on the chosen and on a foregone alternative (complete feedback) in order to experience either regret or rejoicing. If there is feedback only on the chosen alternative (partial feedback) it is unlikely to experience these emotions: when we are uncertain about the outcome of a foregone alternative, we are less likely to think about what could have been if chosen differently, and therefore less likely to feel regret (Van Dijk & Zeelenberg, 2005).

Regret has attracted much attention in research on individual decision-making over the past few decades. Previous research has shown that regret is a common human experience with powerful influence on decision behavior and with over-reaching implications to subsequent decision behavior (for a review, see Zeelenberg & Pieters (2007)). An extreme example of the implication of experienced regret is the man who in April 1995 decided to end his life after discovering that the set of numbers he always played were drawn to win £2 million in the national lottery, but he forgotten to renew his ticket for this drawing. His experience of regret was so intense that it impacted eminently his perception of value of life.

In this paper, our goal is to examine whether in experimental settings we could find that the prior experienced regret and rejoicing have an impact on subsequent intertemporal choice. To our knowledge, this would be the first attempt to interconnect the findings on experienced regret and rejoicing with the field of intertemporal choice.

The analysis of intertemporal choice 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 the discounted utility model. The model has two underlying components. The first component is the instantaneous utility. This is the present utility 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 we feel about the outcomes removed to later points in time), which is assumed to be independent from the instantaneous utility. We use this two-component discounted utility model approach as a framework to examine the role of experienced regret and rejoicing on subsequent 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 regret and rejoicing 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, and experienced rejoicing to increasing, the psychological experience of satisfaction from the obtained outcome (Bell, 1982; Loomes & Sugden, 1982). Several empirical studies have provided support to these assumptions. In Inman, Dyer, and Jia (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, Schwartz, and Ritov (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 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 results revealed enhanced SCR during viewing both the outcome of the chosen gamble and outcome of the foregone gamble compared to viewing only the outcome of the chosen gamble. Following the same experimental paradigm, Coricelli et al. (2005) measured brain activity using functional magnetic resonance imaging while participants were presented with a series of choices between two gambles. The results showed that the neural activity in response to experiencing regret and rejoicing is distinct from the activity detected during only the chosen outcome evaluation. The neural activity in the OFC, dorsal anterior cingulate cortex and anterior hippocampus discriminated between better and worse outcome on the foregone gamble (i.e., greater activity for the negative outcomes and greater deactivation for the positive outcomes when feedback on the foregone gamble was provided). The findings reported in the studies described above provided strong psychological, physiological and neurophysiological evidences of the influence of experienced regret and rejoicing on utility evaluation.
In this paper, we apply these findings to the study of the role of experienced regret and rejoicing on intertemporal choice. We first outline the model of the impact of experienced regret and rejoicing to the instantaneous utility evaluation. In the aforementioned studies, the effect of regret and rejoicing 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) for regret effects on post-choice valuation, and we assume that the instantaneous utility $u_E(x)$ depends on emotion $E$ as

$$u_E(x) = u_P(x) + r_E,$$

where $u_P(\cdot)$ 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; $r_E$ 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, is $E = R$ for regret and $E = J$ for rejoicing. It is important to note that by experienced emotion we always refer to regret and rejoicing only, since these emotions are the main focus of our work. This is not to say that there can be no emotions experienced in the partial feedback condition. In fact, this type of feedback has been associated with the experience of disappointment or elation. However, these emotions are also potentially present in the complete feedback conditions, since partial feedback is an always present component of the complete feedback conditions. Here, we concentrate on the emotional influences due to complete feedback conditions, which distinguish them from the partial feedback condition. Thus, we compare the regret and rejoicing feedback conditions to the partial feedback condition $E = P$ ($r_P = 0$), i.e., partial feedback condition is our reference, or control condition.

While we have a formulation for the effect of experienced regret and rejoicing 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 and rejoicing have 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 equal 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 design of this first decision was adopted from Coricelli et al. (2005). Using this design for emotion manipulation, we ensure that the experience of regret and of rejoicing arose from the complete feedback condition: as discussed in Section 2, this has been thoroughly tested through psychological methods, physiological measurements and brain imaging techniques.

The second decision was the two-period intertemporal choice. 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 the different emotions triggered by the different complete feedback conditions in the first decision would influence the decision processes about the future in the subsequent decision differently than the partial feedback condition.

In this paper, we make the distinction between experienced decision-related and -unrelated regret.\(^1\) Previous empirical studies have demonstrated that experienced regret exerts influence on subsequent choice (for review, see Zeelenberg, Inman, & Pieters (2001)). This influence has been shown for a repeating decision in the same domain (Camille et al., 2004; Coricelli et al., 2005; Zeelenberg & Beattie, 1997; Zeelenberg & Pieters, 1999). 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. Regret is experienced at the moment of making a decision, but it arises from sources objectively unrelated to the decision at hand (cf. Rick & Loewenstein (2006)), similar to the effect of an affect produced watching movies, the music playing in the background, enjoying sunny weather, observing loss of the country’s soccer team, etc. Previous studies have shown that emotions often persist beyond the eliciting situation, becoming an implicit lens for interpreting subse-

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1. For simplicity, we take $r_P$ to be a constant, i.e., independent from the degree of experienced regret and rejoicing. We believe this is sufficient to account for the qualitative aspects of the way experienced regret and rejoicing affect how people discount future.

2. Since rejoicing is the opposite to regret, similar categorization holds for this emotion as well.
quent unrelated situations (for overview, see Lerner & Keltner (2000)). Following the appraisal-tendency theory (Lerner & Keltner, 2000), we assume that decision-unrelated experienced regret, although provoked in one decision situation, would be carried over to the next unrelated decision. According to this theory, the particular form of the carryover depends on the underlying appraisal patterns of the specific emotions (Lerner & Keltner, 2000).

Since regret arises from discovering that the outcome we could have obtained if chosen differently would have been better, we expect that experienced regret would evoke implicit tendency to contemplate more on the possibility of obtaining the worse from the potential outcomes of a given option (e.g., forgetting to come collect the money in case of choosing the future option). We therefore expect that relative to the partial feedback condition, experimentally induced decision-unrelated experienced regret would lead to overestimating the chance of negative factors to occur in each of the options. Since there are more such factors for an option in the future, we expect that experienced regret would lead to preferring present more.

4. Method

4.1. 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. Before starting the experiment, there was a training session consisting of six trials identical to the experimental trials. The experiment lasted 45 min. There were short breaks every 15 min. All responses were given anonymously.

A within-subjects experimental design with one factor was used to test whether experienced regret and rejoicing on a prior choice influence 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. The emotional manipulation in complete feedback was attested by the difference between the outcome of the selected wheel and the outcome of the unselected one: a negative difference defined experienced regret and a positive difference defined experienced rejoicing. 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 in Section 4.2).

In the beginning of each trial, participants were informed that they had 10 Euro as an initial amount to start with on the trial. Next, participants were presented with a choice between two gambles, depicted as two wheels of fortune (Fig. 1). In the experiment all numbers corresponded to payoffs in real money (in Euro). 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.

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 probability 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 a wheel for a random interval of time and then stopped. Immediately after the first arrow stopped,
the second arrow started rotating. The stopping position of the arrow in the selected wheel indicated the obtained amount of money in the first choice.

The amount of money participants obtained from the selected wheel was accordingly subtracted or added to the initial amount. 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.

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 delay after the experiment instead of today to avoid the strong preference towards the present and to have equal cost for obtaining the rewards in both periods.

We determined the length of the larger time delay in the experiment through performing a pilot study. We tested independently choices between tomorrow and three larger time delays: one-week, two-week and two-month. Thirty students from University of Trento participated in an identical experimental procedure. 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 as the larger 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.

In order to obtain their time preferences, in this second choice participants were asked the following question:

*You will be paid x € in 2 months. Would you rather accept qx € tomorrow?*

Here \( q \) is a number smaller than unity, determining how much the amount payable tomorrow is reduced compared to \( x \) Euro (\( x \) is the total amount, i.e., the obtained outcome added or subtracted to the initial 10 Euro endowment in this trial).

Using the discounted utility model (Samuelson, 1937), this decision situation has the following mathematical form:

\[
\text{UtilityE}(qx) \leq d_x \text{UtilityE}(x),
\]

where \( \text{UtilityE}(x) \) is the instantaneous utility of receiving \( x \) Euro under experienced emotion in the experimental condition \( E \) and \( d_x \) is the corresponding discount factor.

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 a green square. The elapsed time between the presentation of the “yes” and “no” and the subsequent button press was recorded.

### 4.2. 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 under-weighting the utility of the outcome that is delayed further in time (Frederick, Loewenstein, & O’Donoghue, 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 decision between two options which 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 \( q_0^{(E)} \) is 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)

\[
\text{UtilityE}\left(q_0^{(E)} x\right) = d_x \text{UtilityE}(x).
\]

Note that, although at a certain moment and for a certain \( x \) a participant has a well defined \( q_0^{(E)} \), \( q_0^{(E)} \) can take a different value at a different moment or for a different \( x \). We assume that for a given individual the indifference value \( q_0^{(E)} \) fluctuates around a mean indifference value \( q_0^{(E)} \), which we use as our dependent variable to characterize the individual’s time preferences. To extract this mean indifference value for a given participant, we adopted a probabilistic approach (see below). The this way extracted mean indifference values of the participants will then form the group data, which can be analyzed via the usual statistical processing. 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 \( q_0^{(E)} \) can be only used to observe how the combination of these quantities behave, from the emotion dependence of \( q_0^{(E)} \) insights can be gained about the emotion dependence of the discount factor (Section 4.5). To estimate \( q_0^{(E)} \) we used four values: \( q = 0.6, 0.7, 0.8, \) and 0.9.

Each of these values was asked eight times for each condition, in order to average out the inconsistency (due to aforementioned fluctuation) in participants’ answer. The experiment thus had 96 trials, each consisting of a choice on the gambles followed by an intertemporal question. The conditions and the \( q \) values of the trials were randomized across the experiment.

We now briefly discuss how \( q_0^{(E)} \) 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 question was asked varied due to the number of outlier trials removed: for each participants, outlying responses with respect to the reaction time were excluded.\(^3\) We interpreted the answers probabilistically: if for a given \( q \) value in a given condition, the number of acceptances of a participant was \( Y_0^{(E)} q \), we obtained the probabilities \( P(q_0^{(E)} < q) = Y_0^{(E)}/n \). The quantity \( F(q) = P(q_0^{(E)} < q) \) is the cumulative probability distribution of \( q_0^{(E)} \), from which the average, \( q_0^{(E)} \), for the participant for the given condition can be taken straightforwardly. The probabilistic interpretation was the key ingredient in handling the aforementioned fluctuations in the individuals’ choices: 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\(^4\); these participants formed the group with inconsistent time preferences. For example, a participant with non-increasing \( F(q) \) could 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 having \( q_0^{(E)} \) fluctuating too much for its average to be measured by only eight repetitions of a question per each condition.

4.3. Participants

The participants were recruited through bulletin board advertising. Fifty-seven (30 males (53%) and 27 females (47%); \( M_{age} = 23.07 \) years) students at University of Trento participated in the experiment. Ten participants did not reveal consistent time preferences (they had non-increasing \( F(q) \)) and were excluded from the indifference values estimation. 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.

\(^3\) For each participant the mean and the standard deviation of the reaction times in each trial per condition were calculated. We excluded all responses with ±2 SD of the participant’s mean reaction time. We consider these trials as misreported. We did not find significant difference between the mean reaction times in the different conditions.

\(^4\) If a participant gave answers that led to a non-increasing cumulative distribution, it means that her individual probability distribution is measured as having negative values. As probabilities cannot be negative, this precludes any further statistical analysis for this participant.
4.4. Results

A repeated measure ANOVA was performed to test whether the decision-unrelated experienced regret and rejoicing have an effect on the intertemporal choice in a statistically important way. 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.

Furthermore, a pairwise statistical comparison (with Bonferroni adjustment for multiple comparisons) 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. 2). The results also revealed a significant difference between regret and rejoicing in the complete 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 levels associated to the two gambles used in the experiment affected choice behavior in the second task, a statistical analysis of the proportion of choices of low and high risk gambles was performed. We found that there was no significant difference in the proportion of high risk gamble choices between the different conditions, in fact the proportion in which the high risk gamble was chosen was almost identical in all of the conditions. This result helped us to rule out the possible interference, due to the choice behavior in the first task, of the risk levels with the observed effect.

4.5. Discussion

The results showed that when making trade-offs between two time periods, participants were affected by the feedback in a prior choice. When participants received regret feedback 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 feedback 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). These effects supported our emotional–carryover hypothesis.

It is still left to examine whether the observed effect of experienced regret and rejoicing on subsequent intertemporal choice implies 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 perform a qualitative analysis, and 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 partial feedback condition,

$$u_p(q_0^{(p)} x) = du_p(x).$$

5 Our analysis is qualitative (as opposed to quantitative) in the sense that it discusses only the direction of changes, not their magnitude.
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

$$u_P(\theta_0^{(P)}x) + r_E < d(u_P(x) + r_E),$$

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

$$r_E > dr_E.$$

For regret, we have $r_E < d r_E$ 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 $\{q_0^{(R)} < q_0^{(P)}\}$ and greater than in rejoicing $\{q_0^{(R)} > q_0^{(P)}\}$. 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 $q_0^{(S)}$ 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 ingredients of the above qualitative reasoning graphically in Fig. 3. 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 $q_0^{(S)}$. 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 $r_E$, while the constant utility of the amount to be received after two months is shifted with a smaller amount, $dr_E$. 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 $r_E$. If the total decrease was precisely $r_E$, 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.

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: for regret, both the discount factor and the instantaneous utility decrease, for rejoicing the direction of change is the opposite.

5. 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 finds on regret have shown that experienced regret leads to a 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. This is our main result. This result confirms that intertemporal decision process can be influenced by factors unrelated to the decision task. To think of a real life manifestation of this finding, one can imagine a contractor who won a bid, but found out that he could have asked for a higher price for his service. Our result suggests that this experience of regret would subsequently influence him to pursue more aggressive short term profitable investments in other directions of his portfolio.

As outlined in the beginning of Section 3, our explanation for this emotional–carryover effect on the discount factor is based on the appraisal-tendency theory (Lerner & Keltner, 2000): experienced regret triggered pessimistic thoughts leading to overestimating the impact of negative forces in the future. This 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.

One could argue, however, for different alternative explanations. First, it would be possible to imagine that the negative emotion due to experienced regret increases the risk aversion of the participants. This would correspond to a different change in the instantaneous utility than the one we considered in Eq. (1), which in principle could explain the observed change in the mean indifference value $q_0^{(R)}$. However, based on the study of Coricelli et al. (2005), which found that experienced regret and risk aversion act independently, we believe that it is not likely for a change in risk aversion to be behind the observed change in $q_0^{(R)}$.

Another alternative explanation might be that in an attempt to regulate the unpleasant feelings due to experienced regret, participants tried to get a quick relief by opting for a smaller compensation immediately. On the other hand, rejoicing might
encourage people to postpone receiving compensations in two months in order to extend the experience of a positive feeling (Rottenstreich & Hsee, 2001). We believe that it would be an interesting direction for future research to design experiments in order to distinguish the explanation offered by our hypothesis from this also plausible interpretation for the processes behind our effect.

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