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When Choosing is Painful: A Psychological Opportunity Cost Model

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Quand le choix est douloureux : un modèle de coût d'opportunité psychologique

Résumé

Ce papier est une contribution à la théorie du regret, que nous généralisons de deux façons. Etant donné que le sentiment de regret dépend de l'information que le décideur a sur le résultat des choix qu'il n'a pas adoptés, nous proposons un modèle qui englobe toutes les situations informationnelles. Nous montrons aussi que le point de référence dans la fonction d'utilité de Quiggin (1994) ne correspond pas toujours à un sentiment de regret mais à un concept plus large que nous appelons « coût d'opportunité psychologique » ; le regret n'étant qu'une des expressions de ce concept. Le modèle prédit des déviations de comportement par rapport au modèle classique de l'espérance d'utilité. Nous mettons en évidence un goût pour la corrélation positive, une plus grande réticence à prendre du risque, ainsi que des effets négatifs de l'information sur le bien-être du décideur. Notre modèle offre aussi un cadre théorique au phénomène d'inertie face à la décision (inaction inertia) mis en évidence dans les études empiriques.

Mots-clés: choix, goût pour la corrélation, émotion, inertie face à la décision, information, regret.

When Choosing is Painful: A Psychological Opportunity Cost Model

Abstract

This paper is a contribution to regret theory, which we generalize in two ways. Since the intensity of regret depends on the information the decision-maker has about the results of the foregone strategies, we build a model of choice which accommodates any feedback structure. We also show that the reference point, which characterizes the regret utility function introduced by Quiggin (1994), does not always represent a feeling of regret. It corresponds to a broader concept, which we call psychological opportunity cost (POC), of which regret is no more than a specific expression. We find behavioral deviations from the predictions of the Expected Utility Theory. We obtain correlation loving, greater reluctance to take on risk and we highlight some harmful effects of information. Our model equally offers a theoretical framework for experimental studies about inaction inertia.

Keywords: choice, correlation loving, emotion, inaction inertia, information, regret.

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1 Introduction

The foundations of regret theory were essentially laid down by Bell (1982, 1983), Loomes and Sugden (1982, 1987), Sugden (1993) and Quiggin (1994). More recently, Bleichrodt and Wakker (2015) give a state-of-the art overview of the theory while Krähmer and Stone (2008) and Strack and Viefers (2014) address the issue of regret agents' decision process in a dynamic context.

As Zeelenberg and Pieters (2007) observe, 'all other negative emotions can be experienced without choice, but regret cannot'. The feeling of regret is based on a comparison between the chosen action payoff and what the decision-maker (DM) could have obtained making another choice. Regret is felt after the choice has been made but can be anticipated at the time of the decision making. Regret theory is concerned with the effects of the anticipation of regret on decision making. A regret utility function is choice set-dependent since utility is affected by the comparison between the chosen action payoff and the foregone action payoffs. Regret has been axiomatized by Loomes and Sugden (1987) and Sugden (1993) who put forward the utility function $u\left(x,\{y_1,..,y_N\}\right)$ where x is the chosen action payoff, and $y_1,...,y_N$ are the forgone alternative payoffs. Quiggin (1994) proposes the utility function $u\left(x,r\right)$, where the reference point r represents the impact of anticipated regret on utility and is defined as the best possible outcome that could have been attained : $r = \max\{x,y_1,...,y_N\}$.

The comparison between the chosen action payoff and the best payoff a DM could have obtained can only be achieved, however, when the forgone actions payoffs $y_1,...,y_N$ are perfectly observable. Apart from a few exceptions that we are going to discuss, regret theory assumes that the payoffs of the foregone options are perfectly observable. In this paper, we refer to that assumption as perfect feedback.

Foregone actions payoffs, however, are not always perfectly observable. A firm manager observes the revenues generated from his past corporate investment decisions but not those from alternative investment opportunities which have not been implemented. A hiring manager, who has selected a person for a particular position, does not have any feedback on what would have been the performance and the level of involvement of non retained candidates. Challenging life decisions such as career choices, marriage, or even the choice, before a surgery, between two different surgeons, are other examples in which the DM receives poor feedback about how things would have gone as a different option would have been adopted. Bell (1983) has been the first and virtually the only author (see also Humphrey *et al.* 2005) to stress the relevance, in regret modeling, of information about forgone outcomes[1]. In the case of a choice between two independent lotteries, Bell (1983) studies, under which condition on an additive regret-utility function, a DM would prefer having the forgone lottery resolved or unresolved. This approach consists in a comparison between two extreme feedback structures: a perfect feedback structure, under which the foregone lottery payoffs are perfectly observable, and the opposite situation, under which a DM does no get any feedback about the foregone alternative. We refer to the latter situation as a non-informative feedback structure. In this paper, we try to go deeper in the study of regret and information with a model which encompasses all possible feedback structures. For that purpose, we consider a DM who has to choose between different lottery-like options, subsequently designated as 'actions', and who anticipates to receive, after her choice, some information about the payoffs of the foregone actions. Information can have any level of precision and can be of any type, like a signal or a message on the foregone actions' outcomes. At the feedback stage, after the choice has been made, the DM learns both the result of the chosen action and the information. We also consider a general choice set, which can contain more than two lotteries, statistically independent or not. We also propose a generalization of Quiggin's utility function in order to obtain preferences which accommodate any type of feedback structure.

This generalization attempt has first led us to better understand the reference point in Quiggin's utility function. More precisely, we establish that the reference point does not always represent a feeling of regret. Although this finding can be identified under the usual assumption of perfect feedback, we show that it takes on its full meaning when the feedback structure is not perfect.

In order to introduce that point, let us consider two actions X and Y and, for the moment, a perfect feedback structure. Assume that the payoffs of Y are systematically higher than the

[1]Although the paper does not focuss on information, the idea of imperfect information is also to be found in the dynamic model of Krähmer and Stone (2008) , in which the DM does not perfectly observe the results of past forgone alternatives.

payoffs of X. The expected regret-utility of action X is given by $E[u(x,y)]$ since, according to Quiggin's definition, the reference point is the best available payoff. In this example, we claim that the reference point cannot represent an anticipated feeling of regret. A DM who considers action X (even if, in this simple example, it is not optimal to choose action X) cannot anticipate to feel regret after his choice. He knows, from the outset, that action X is dominated by action Y. It is not something that he learns after his choice and there is thus no reason to feel regret after the choice has been made. This example reveals that Quiggin's utility function embodies another phenomenon, which is different from regret. In this example, the reference point, which affects the expected utility of action X, has a particular signification: it represents the psychological cost of knowing that choosing action X prevents from benefiting from action Y, which is more valuable. This psychological cost is borne at the very moment of choosing, before the realization of the lotteries payoffs. We refer to it as an *ex ante* psychological opportunity cost (POC). Regret, on the other hand, is felt after the choice, once the DM learns that the chosen action payoff is lower than one of the foregone action payoffs. We thus refer to it as an *ex post* POC. Regret is an opportunity cost, because the particular choice that has been made deprives the DM from taking advantage of what, finally, proves to be the most valuable action. Although these two phenomena (*ex ante* and *ex post* POC) are different, they share common features: they both represents negative feelings related to the act of choosing. They both occur when an unchosen alternative *is (ex ante* POC*) or turns out to be* (*ex post* POC) more rewarding. They are also both represented, in the DM utility function $u(x,r)$, by the same unique variable: the reference point r.

As it clearly appears in the above example, a DM cannot find optimal to choose action X, which involves an *ex ante* POC. In our example, action X is dominated by action Y. Action Y systematically offers a better payoff than action X and, therefore, also protects the DM from any feeling of regret. This result is not limited to our example: under a perfect feedback structure, an action involving an *ex ante* POC is always payoff dominated by another action and cannot represent a DM's optimal choice. This is certainly the reason why the theoretical literature on regret, which generally considers a perfect feedback structure, has focussed on the feeling of regret without identifying, to our knowledge, the existence of this alternative psychological cost. The generalization to any feedback structures, however, allows us to show that, as soon as we depart from the perfect feedback structure assumption, the *ex ante* POC is as relevant as regret in decision making.

First, we show that, under an imperfect feedback structure (any feedback structure, except the perfect one), the occurrence of an *ex ante* POC corresponds to a larger set of possibilities, compared to the perfect feedback case, since it does not require that the payoffs of action Y are systematically higher than the payoffs of X. Secondly, we show that action X, which involves an *ex ante* POC, can represent a DM's optimal choice. This can be the case when the more valuable action, that is action Y, does not offer a protection against regret. When action Y exposes a DM to the risk of experiencing some regret, the latter can thus choose to forgo action Y in favour of action X, thereby undergoing an *ex ante* POC. The DM, in that case, chooses to support an *ex ante* POC in order to avoid the possibility of having to experience an *ex post* POC.

In this paper, we also investigate the impact of POC sensitivity on risk preferences. When a DM has the choice between a riskless action and a risky action, we show that a POC-sensitive DM is more likely to choose the riskless action than a classical expected utility maximizer. This result is obtained under a non-informative feedback structure, when the DM just observes the result of the chosen action and does not receive any information on the foregone actions. Under a non-informative feedback structure, the riskless choice offers a protection against anticipated regret. The attractiveness of a riskless choice is thus stronger for a POC-sensitive DM than for a classical expected utility maximizer. We also show that, whatever the feedback structure, a POC-sensitive DM is a correlation lover. Correlation between the risky alternatives in the choice set is desirable because anticipated regret decreases with the level of correlation.

As information is a key player in regret theory, we also focus on information at the decision stage, when the choice is made. In the expected utility model, information value is always positive, which means that information cannot be harmful. In our model, we show that additional information at the decision stage can be detrimental to a DM's well-being, even if this information is optimally processed. Additional information can be a source of additional anticipated regret and, despite the fact that the DM will be better informed, her expected utility can be negatively affected when additional information is anticipated to be received.

Lastly, we would like to stress that we do not make any assumption about the second order derivatives of the utility function $u(x, r)$ and, therefore, the results presented in this paper are compatible with a large set of utility functions.

The paper is organized as follows. Next Section is dedicated to the presentation of empirical studies in psychology which are consistent with our theoretical findings. In Section 3, we introduce the basic framework and preferences. The definitions of an *ex ante* and an *ex post* POC are given in Section 4. Section 5 is devoted to the behavioral implications of POC sensitivity.

2 Related literature in psychology

We present here a summary of works in psychology which are related to our findings.

Our concept of *ex ante* POC proves particularly useful in explaining the choices observed in Tykocinski and Pittman (1998)'s experimental study about inaction inertia. Inaction inertia is observed when the fact of foregoing an initial attractive opportunity increases the likelihood of not seizing a second attractive, albeit lesser, opportunity. For example, for one reason or other, a DM fails to take the opportunity to rent a very nice apartment which is located at only two minutes' walking distance from her workplace. The DM then has the opportunity of renting another very nice apartment, but one that is at twelve minutes' walking distance. Inaction inertia consists in foregoing that second opportunity, even though it is attractive.

Tykocinski and Pittman explain inaction inertia by anticipated regret[2]. They show that people decline the second opportunity (even though it is attractive) because they try 'to prevent or to put an end to the unpleasant psychological experience of regret' (the regret of having missed out on the initial, superior opportunity). Seizing the second opportunity would activate conterfactual

[2] Other experimental studies (Arkes *et al.* 2002; Sevdalis *et al.* 2006) show that regret is the main determinant of inaction inertia.

thinking, the unpleasant comparison between obtainable outcomes and the superior outcomes that could have been obtained from the initial and forgone opportunity. In our model, as in the inaction inertia phenomenon, a DM voluntarily declines a valuable opportunity in order to avoid experiencing regret[3]. She passes up on the valuable opportunity in favour of a less valuable action, in the same way as people, in Tykocinski and Pittman's experiment, adopt inaction rather than renting the second apartment.

Tykocinski and Pittman refer to the cost of inaction as *avoidance cost*, which represents what a DM loses by choosing inaction. In the previous example, missing out on the opportunity to rent the second apartment represents an avoidance cost. In our model, the concept of *ex ante* POC measures the psychological impact of avoidance cost. More precisely, it measures to what extend the utility of the decision which is made is affected by avoidance cost.

Our *ex ante* POC has also in common with the idea of 'postchoice discomfort' introduced by Carmon *et al.* (2003). In their experimental study, the authors show that, when people choose one option, they can experience a feeling of discomfort because the forgone options are no longer feasible. In that case, 'choosing feels like losing'; loosing the 'prefactual ownership of the forgone options'. The *ex ante* POC is very close to the feeling of postchoice discomfort studied by Carmon *et al.*. A difference however exists. Postchoice discomfort occurs when people have to choose between two equally attractive alternatives. In our model, the DM experiences an *ex ante* POC when she deliberately forgives a more valuable alternative.

3 Basic framework

We consider a two-date model. We call *decision stage* the time of the choice, and *feedback stage* the time of complete or partial uncertainty resolution. At the decision stage, one action is chosen out of a set of alternatives. At the feedback stage, the result of the chosen action is observed, and certain feedback about the results of the forgone alternatives is received.

[3] In our model, however, regret is anticipated when two available options are compared. In Tykocinski and Pittman's experiment, regret concerns the fact of having missed out on a previous and superior opportunity.

Let $\Phi = \{Y_1, .., Y_{N+1}\}$ denote the set of decisions. This contains $N + 1$ actions, with a typical action Y_n, a positive random variable which takes its values y_n in the support $W_{Y_n} \subset \mathbb{R}^+$. The assumption of positive action payoffs is made for the sake of simplicity. It could be easily removed by assuming that the DM is endowed with an initial wealth. In all what follows, we use an uppercase to refer to a random variable and a lowercase to refer to a realization of a random variable.

3.1 Preferences

Following Quiggin (1994), we adopt a regret utility function (subsequently designated as the POC utility function), which depends on the payoff of the chosen action and on a reference point. If, without loss of generality, the chosen action is denoted by X, and the forgone alternatives by $Y_1, .., Y_N$, we can write Quiggin's expected regret utility as follows

$$E\left[u\left(X, R\right)\right] \tag{1}$$

with $R = \max\{X, Y_1, .., Y_N\}$.

Alternative payoffs $Y_1, .., Y_N$ serve as a reference by which the DM retrospectively evaluate her decision at the feedback stage. At the decision stage, a DM takes into account the regret that she anticipates she would experience as a result of this evaluation process. Variable R represents the impact of anticipated regret on the DM's utility. In states of nature in which $r > x$, a foregone action performs better than the chosen action and regret is anticipated to be felt.

The definition of the reference point given here assumes that the results of the forgone alternatives $Y_1, .., Y_N$ are anticipated to be perfectly observable. We refer to this feedback structure as the *perfect feedback structure.* The above reference point definition also implies that R cannot be lower than X, excluding the feeling of rejoicing when a DM learns that the chosen action turns out to be the best action[4]. Rejoicing has been investigated by Loomes and Sugden (1982, 1987). However, Quiggin (1994) shows that rejoicing is not compatible with the principle of irrelevance of statewise dominated alternatives (ISDA), a property of non-manipulability of preferences. Thus,

[4]Rejoicing can occur when the reference point satisfies the definition $r = \max\{y_1, .., y_N\}$.

we do not consider rejoicing in this paper in order to keep the ISDA property. Moreover, experimental studies show that, for most people, anticipated regret, and not anticipated rejoicing, has the greater impact on choices (Mellers *et al.* 1999; Mellers 2000). Psychology studies also find that people's conterfactual thinking is more oriented toward what could have been better than toward what could have been worse (Gilovich 1983; Roese 1997; Epstude and Roese 2008).

We will show in this paper that when $r > x$ that does not necessarily imply that regret is felt. A reference point greater than the chosen action payoff merely means that a POC is supported. Providing a precise definition of a POC necessitates to further develop the presentation of the model. In the meanwhile, a POC should be interpreted as a choice-related feeling, which can be regret, that decreases utility. However, when $r = x$, no POC is supported and the POC utility $u(x, r)$ coincides with the choiceless utility (c-utility) $u(x, x)$, which we define as follows:

Definition 1. *The c-utility function $v(x) = u(x, x)$ measures the satisfaction generated by the consumption of payoff x, independently of any choice-related feeling.*

The c-utility function represents preferences in which sensitivity to POCs has been removed. It can be assimilated to a von Neumann Morgenstern utility function, since the utility exclusively depends on the chosen action payoff.

When $u(x, r)$ is additive, our c-utility function coincides with the choiceless utility function identified by Loomes and Sugden (1982). The authors define the choiceless utility as 'the utility that a DM would derive from the consequence x without having chosen it'. Loomes and Sugden identified the choiceless utility in the following additive form:

$$u(x, r) = v(x) + \widehat{R}(v(x) - v(r)) \tag{2}$$

with $v'(.) > 0$, $\widehat{R}'(.) > 0$, $\widehat{R}(0) = 0$.

Function $\widehat{R}(.)$ represents the regret-rejoice function, and function $v(.)$ is the choiceless utility function. Regret (resp. rejoicing) is present when $v(r) > v(x)$ (resp. $v(r) < v(x)$).

We assume that, at the feedback stage, outcomes of the $N+1$ alternatives are compared using the c-utility function. A choiceless evaluation criterion is appropriate, because the comparison made at the feedback stage is not a matter of choice. The different actions are evaluated according to pure preferences, unaffected by the idea of choice. This two-utility approach already exists in Loomes and Sugden (1982) (see Equation 2).

We are now able to give the definition of a reference point under a perfect feedback structure. We generalize our approach to any feedback structure in Section 3.2.

Definition 2. *Under a perfect feedback structure, the reference point* $R^{X,Y_1,\ldots,Y_n}$ *is the ex post realized payoff which maximizes the c-utility function:*

$$R^{X,Y_1,\ldots,Y_n} = Arg \max_{Z \in \{X,Y_1,\ldots,Y_n\}} v\left(Z\right)$$

The notation $R^{X,Y_1,\ldots,Y_n}$ indicates, in superscript, the variables that a DM observes at the feedback stage. It is noteworthy that, under a perfect feedback structure, the reference point is the same no matter which alternative is chosen.

The POC utility $u(x,r)$ is additively separable when $u(x,r) = g\left(x\right) + h\left(r\right)$. Under separability, the cross-derivative $\frac{\partial^2 u(x,r)}{\partial x \partial r}$ is equal to zero. In Equation 2 for example, separability occurs when $\widehat{R}\left(.\right)$ is linear. Generally, separability is not considered as being compatible with regret theory. In a two-choice model, Bell (1982) and Loomes and Sugden (1982) advocate properties for function $\widehat{R}\left(.\right)$ which rule out separability. In their approach, when $\widehat{R}\left(.\right)$ is linear, regret theory yields the same predictions as expected utility theory, since a DM behaves exactly as if he were maximizing an expected utility. In our approach, similarly, when the assumption of perfect feedback structure is considered, separability does not offer any generalization relative to expected utility theory. Decisions are, in the end, exclusively determined by function $g\left(x\right)$, since the reference point is independent of the chosen action (See Definition 2). When the assumption of perfect feedback structure is removed, however, we show that the reference point is choice-dependent, which entails violations of expected utility theory, even under separability. In what follows, we do not make any assumption about second order derivatives, which means that our results can be obtained with a wide range of utility functions, including the additively separable utility function. In order to introduce the assumptions that are required for our results, let $u_1(x,r)$ denote $\frac{\partial u(x,r)}{\partial x}$, $u_2(x,r)$ denote $\frac{\partial u(x,r)}{\partial r}$ and $v^{'}(x)$ denote $\frac{\partial v(x)}{\partial x}$. We make the following assumptions:

A0. The POC utility $u(x,r)$ is differentiable on $\mathbb{R}^{+2}$.

A1. $v^{'}(x) = u_1(x,x) + u_2(x,x) > 0$

A2. $u_1(x,r) > 0$

A3. $u_2(x,r) < 0$

Assumptions $A1$ and $A2$ simply state that the DM, whether POC-sensitive ($A2$) or not ($A1$), prefers to consume more rather than less. Under assumption $A1$, the reference point (see Definition 2) is also the highest payoff, as in Quiggin (1994) (see Equation 1).

Assumption $A3$ states that the POC utility decreases with the reference point. Given payoff x, as the reference point increases, the intensity of the POC increases, and utility decreases. Assumption $A3$ characterizes POC sensitivity and corresponds to the assumptions $v'(.) > 0$, $\widehat{R}'(.) > 0$ in Loomes and Sugden's additive approach (see Equation 2).

The following multiplicative POC utility functions $u(x,r) = -e^{-\gamma x + kr}$, $u(x,r) = x^{\gamma} r^{-k}$ and $u(x,r) = -x^{-\gamma} r^{k}$ satisfy assumptions $A0$ to $A3$ when $\gamma > k > 0$. The commonly-used additive regret utility function (see Equation 2) also satisfies assumptions $A0$ to $A3$, as does the linear and additively separable utility function $u(x,r) = x - kr$ with $0 < k < 1$.

3.2 Generalization to any feedback structure

Let us remember that, at the feedback stage, the result of the chosen action X is observed, and a certain feedback about the results of the forgone alternatives is received. More precisely, we assume that a DM not only observes the realization of the chosen action outcome, but also receives information about the realized payoffs of the foregone alternatives. Although information can be of any kind[5], for the sake of clarity, we develop here an example in which information I_X has a

[5] Information, however, is assumed to be anticipable. In other word, information must be consistent with the a priori distributions of $Y_1, .., Y_N$. It cannot correspond to an unanticipated event (for example, "Y_n takes a value outside W_{Y_n}").

particular structure:

$$I_X = (1 - \lambda_X) Y_X + \lambda_X \Lambda_X \tag{3}$$

where λ_X is a real parameter, $Y_X = \begin{pmatrix} Y_1 \\ \vdots \\ Y_N \end{pmatrix}$ is a random vector which contains the N random payoffs of the foregone actions (all actions except X), $\Lambda_X = \begin{pmatrix} \varepsilon_1^X \\ \vdots \\ \varepsilon_N^X \end{pmatrix}$ is a vector of N zero-mean random variables, with $\forall Y_n \in \Phi \backslash \{X\}$, $\forall y_n \in W_{Y_n}$, $E\left(\varepsilon_n^X \middle| y_n\right) = 0$. In this setting, I_X is a noisy multi-dimensional signal of Y_X. A similar idea can be found in the paper of Krähmer and Stone (2008), which extends regret to a dynamic context and in which a DM observes not only the realization of the chosen strategy outcome, but also the realization of a signal about the foregone strategies.

An alternative setting would be, for example, to consider that, for a foregone action Y_n, information I_X rules out some elements of W_{Y_n}. In other words, the DM learns, at the feedback stage, that the foregone action Y_n has taken its value in a sub-set of W_{Y_n}.

Whatever the nature of information, it is worthy of note that, at the feedback stage, the level of information about the forgone alternatives may depend on the action which has been chosen. Let F_X denote the *action X feedback structure*. F_X is made of both action X payoff and action X information: $F_X = (X, I_X)$. Action X feedback structure contains all information sources at the feedback stage when action X has been chosen. We denote by $f_x = (x, i_x)$ a realization of F_X at the feedback stage. For example, in the specification of Equation 3, i_x is a realization of the multi-dimensional signal I_X.

In the rest of the paper, either $\{X, Y_1, .., Y_N\}$ or $\{Y_1, .., Y_{N+1}\}$ will refer to the choice set Φ, depending on whether we need or not to distinguish the chosen action X from the other alternatives. We now define the feedback structure which characterizes a choice set $\Phi = \{Y_1, .., Y_{N+1}\}$.

Definition 3. *The feedback structure* F_Φ *is the set of all the action feedback structures:*

$$F_\Phi = \left\{F_{Y_1}, ..., F_{Y_{N+1}}\right\} = \left\{(Y_1, I_{Y_1}), ..., \left(Y_{N+1}, I_{Y_{N+1}}\right)\right\}$$

The feedback structure F_Φ represents the *ex post* informative context that a DM is faced with *before making her choice*. So, by choosing a particular action, a DM selects not only a random payoff but also a particular *ex pos*t feedback structure. F_Φ can therefore be considered as the relevant choice set.

We give, in what follows, the definitions of a perfectly informative, non-informative and imperfectly informative feedback structure. In the particular case in which each I_{Y_n} is perfectly informative, a DM, at the decision stage, faces with a perfect feedback structure. When some I_{Y_n} are not fully revealing, the feedback structure is imperfect, which corresponds to a partial resolution of uncertainty. When all I_{Y_n} are non-informative, a DM faces with a non-informative feedback structure. A non-informative feedback structure represents the exact opposite of the perfect feedback structure, which is generally considered in the regret literature.

Definition 4. *The feedback structure* $F_\Phi = \left\{F_{Y_1}, ..., F_{Y_{N+1}}\right\}$ *is perfectly informative when* $\forall Y_n \in \Phi$, I_{Y_n} *gives perfect information about the values taken by* $Y_1, .., Y_{n-1}, Y_{n+1}, .., Y_{N+1}$. *If we use the specification of Equation 3, the feedback structure is perfectly informative when* $\forall Y_n \in \Phi, \lambda_{Y_n} = 0$.

The feedback structure $F_\Phi = \left\{F_{Y_1}, ..., F_{Y_{N+1}}\right\}$ *is non-informative when* $\forall Y_n \in \Phi$, I_{Y_n} *gives no information about the values taken by* $Y_1, .., Y_{n-1}, Y_{n+1}, .., Y_{N+1}$. *If we use the specification of Equation 3, the feedback structure is non-informative when* $\forall Y_n \in \Phi, \lambda_{Y_n} = 1$.

The feedback structure $F_\Phi = \left\{F_{Y_1}, ..., F_{Y_{N+1}}\right\}$ *is imperfectly informative in all the other situations.*

Under a non-informative feedback structure, whatever her choice, a DM only observes the outcome of her choice and obtains no additional information about the other alternatives. In this paper, however, we do not rule out (unless we specify it) the possibility of statistical dependence between the alternatives in the choice set. Consequently, even under a non-informative feedback structure, the observation of the chosen action payoff can be a source of information about the foregone alternatives.

We assume that a DM improves her beliefs by revising them when new information becomes available. At the feedback stage, a forgone action Y_n is thus characterized by a *posterior* probability distribution after the information (a realization f_x of F_X) has been processed. When possible, the probability distribution revision is made using Bayes' rule.

Remember that, at the feedback stage, actions are compared with the c-utility function. The *posterior* probability distribution allows us to compute the *posterior* certainty equivalent of action Y_n, which satisfies

$$v\left(CE_{Y_n}^{v,f_x}\right) = E\left[v\left(Y_n\right) \middle| f_x\right] \tag{4}$$

where the operator $E\left[.\middle| f_x\right]$ represents the conditional expectation, given the realization f_x of F_X. The notation $CE_{Y_n}^{v,f_x}$ indicates, in superscript, that the certainty equivalent is computed with the c-utility function $v\left(.\right)$, given information f_x.

The *posterior* certainty equivalent of the chosen action is equal to the realization of the payoff itself.

$$CE_X^{v,f_X} = x \tag{5}$$

We are now able to give the definition of a reference point which accommodates any feedback structure.

Definition 5. *The reference point R^{F_X} is the highest ex post certainty equivalent:*
$R^{F_X} = Max\left\{X, CE_{Y_1}^{v,F_X}, ..., CE_{Y_N}^{v,F_X}\right\}$

Under assumption $A1$, the reference point is the certainty equivalent of the alternative which maximizes the expected c-utility, given available information at the feedback stage. Definition 5 is a generalization of Definition 2 to any feedback structures.

In the particular case of a perfect feedback structure, our reference point definition fully coincides with that of Quiggin (see Equation 1) since, at the feedback stage, a DM perfectly observes the payoff of each alternative: $\forall X, \forall Y_n, CE_{Y_n}^{v,F_X} = Y_n$. In this particular case, the reference point is independent of the choice which has been made whereas, in general, the reference point does depend on the chosen alternative. Lastly, this generalization to any feedback structure maintains the ISDA property of preferences[6].

4 Psychological opportunity costs

In the events where $R > X$, a POC is supported. A POC can be felt at the decision stage (*ex ante* POC) or at the feedback stage (*ex post* POC or regret). In what follows, we provide a series of definitions in order to clearly distinguish an *ex ante* POC from an *ex post* POC. Remember that, at the feedback stage, a DM compares the different actions according to the c-utility criterion.

Definition 6. *Action Y_n (which can be the chosen action X itself) is the ex post most valuable action when $r^{f_x} = CE_{Y_n}^{v,f_x}$.*

Definition 6 states that, given the realization of the chosen action feedback structure f_x, action Y_n is the *ex post* most valuable action when it maximizes, *ex post*, the expected c-utility function.

Definition 7. *If, at the decision stage, the ex post most valuable action is anticipated not to be the same action for all the values $f_x = (x, i_x)$ then, when choosing action X, it is anticipated that an ex post POC (which is regret) may have to be supported.*

Regret is anticipated as possible when the chosen action is expected not to be the most valuable, at least for one realization f_x of F_X. Regret is supported at the feedback stage when the action, which finally proves to be the most valuable one, was not known in advance with certainty, and when that action does not coincide with the action which has been previously chosen. Two situations, however, do not meet these conditions: when the chosen action is expected to systematically be the most valuable one (no regret can be anticipated) or when another action is expected to systematically be the most valuable one. The latter situation occurs when the same forgone action is anticipated to be, for all realizations of F_X, the *ex post* most valuable one. In that case, this action could be identified by the DM *as and from the decision stage.* This situation is particular and may even seem paradoxical, but we will see under which conditions it can happen. We claim that this situation involves a POC at the very time of the decision making.

[6] The introduction of a statewise dominated alternative (in our model, we would rather say a payoff dominated action) in the choice set does not modify the reference point and a DM's optimal choice.

Definition 8. *Action Y_n is, ex ante, more valuable than the chosen action X if action Y_n is the ex post most valuable action for all possible realizations f_x ($\Leftrightarrow \forall f_x$, $r^{f_x} = CE_{Y_n}^{v,f_x}$ with a strict inequality $x < CE_{Y_n}^{v,f_x}$ for at least one f_x). In that case, choosing action X involves an ex ante POC.*

An *ex ante* POC represents the pain of knowing, from the outset, that the chosen action X will systematically be dominated by another action Y_n, whatever the state of nature f_x at the feedback stage. In other words, the choice which is made deprives the DM of an alternative which is, *ex ante*, more valuable. Under a perfect feedback structure, Definition 8 gives $\forall f_x = (x, y_1, ..., y_N)$, $r^{f_x} = y_n$ with a strict inequality $x < y_n$ for at least one f_x. This situation corresponds to a particular choice set in which action Y_n always offers the greatest payoff. In that case, action Y_n is the best choice and a DM never finds optimal to bear an *ex ante* POC. This result does not mean that the *ex ante* POC does not exist under a perfect feedback structure. The utility function incorporates this particular feeling, which negatively affects the utility of any action, except Y_n.

Under an imperfect feedback structure, Definition 8 embodies a larger set of situations and, as we will see in the next section, it can be optimal to choose an action which involves an *ex ante* POC.

In order to better understand the concept of *ex ante* POC, let us begin with a simple example taken under a non-informative feedback structure (the results of the foregone actions are not observable). Imagine that we receive \$100. Obviously, we are pleased about that. Now, imagine that we have the choice between receiving \$100, or playing in a lottery where we can win either \$1,000, or nothing. If we choose to receive \$100, we are pleased but, when the winning probability of the forgone lottery is high enough, our level of satisfaction is lower than in the previous case. The fact of knowing that we might have won \$1,000, if we had chosen the lottery, decreases our utility.

More precisely, when a DM receives \$100, her utility is measured with the c-utility function $v(100)$ since receiving \$100 is not the result of a choice (no POC can be felt).

Now, when a DM chooses \$100 instead of playing to the lottery, her utility is measured with the POC-utility function. If the lottery winning probability is sufficiently high, then the certainty equivalent of the lottery CE^v_L is higher than \$100. In that case, choosing to receive \$100 generates an *ex ante* POC. The POC utility of \$100 is $u(100, CE^v_L)$, which is, under $A3$, lower than $v(100) = u(100, 100)$. Choosing \$100 is painful (compared to receiving \$100) because it implies missing out on the opportunity of winning \$1,000 with a significant probability. In the next section, we explain in which circumstances a DM chooses to support an *ex ante* POC.

Now, let us generalize this idea with a choice set $\Phi = \{X, Y_1 ..., Y_N\}$ containing $N+1$ statistically independent alternatives. We still consider, for the moment, a non-informative feedback structure. We know that if there is an action Y_n which is, *ex ante*, more valuable than X, then there is an *ex ante* POC of choosing X. The reference point in $E\left[u\left(X, R^{F_X}\right)\right]$ is the certainty equivalent of action Y_n. This certainty equivalent satisfies $CE^{v,F_X}_{Y_n} = CE^{v,X}_{Y}$ because the feedback structure is non-informative, and it also satisfies $CE^{v,X}_{Y} = CE^v_Y$, because actions X and Y_n are independent. The reference point is constant, because nothing new about the forgone action Y_n is learned at the feedback stage.

Whatever the payoff to be obtained from action X, that payoff is lower than $CE^v_{Y_n}$. If action X were adopted, however, a DM could not feel regret. Nothing new about the forgone action Y_n would be learned at the feedback stage and, from the very outset, action X is known to generate a lower payoff than $CE^v_{Y_n}$. There would thus be no reason to feel any regret, whatever the result of the choice. We note, however, that

$$E\left[u\left(X, CE^v_{Y_n}\right)\right] < E\left[v\left(X\right)\right] \tag{6}$$

The expected POC utility of action X is lower than the expected c-utility of action X. While no regret can be anticipated, choosing X generates a lower level of utility than receiving X. The reference point represents, here, an *ex ante* POC[7].

If we now relax the assumptions of non-informative feedback structure and of statistical independence between the alternatives, we have an *ex ante* POC when $\forall f_x$, $r^{f_x} = CE^{v,f_x}_{Y_n}$ (with a strict

[7] This result needs an additional comment: the reference point is constant. It is equal to the certainty equivalent of Y_n. When the reference point is constant but is not exclusively derived from a same action Y_n, we do not have an *ex ante* POC but anticipated regret.

inequality $x < CE^{v,f_x}_{Y_n}$ for at least one f_x). Action Y_n is *ex ante* more valuable than X, but the reference point is no longer constant. It is anticipated that information about action Y_n will be received at the feedback stage.

When choosing X, a DM knows that another action Y_n is *ex ante* more valuable than X. There is thus an *ex ante* POC of choosing X. What is unknown at the decision stage, however, is exactly how much more valuable action Y_n is. Additional information on this point will only be known at the feedback stage. That is why we do not exclude the fact that the reference point, which fluctuates with information, also incorporates an anticipated feeling of regret in states in which the reception of good news about Y_n is anticipated.

5 Behavioral implications of POC sensitivity

POC sensitivity generates paradoxical decisions which are not consistent with the classical expected utility model. We establish, in this section, under which circumstances a POC-sensitive DM can choose an action which involves an *ex ante* POC. We also show that a POC-sensitive DM exhibits correlation loving and that POC sensitivity can decrease her willingness to take risk. Lastly, we focus on information at the decision stage. We show that a DM's expected utility can be negatively affected, when a relevant information for decision making is anticipated to be received at the decision stage. Information can be harmful, which is tantamount to saying that information value can be negative.

5.1 Arbitrage between an *ex ante* and an *ex post* POC

The c-utility function $v(x)$ is derived from the POC-utility function $u(x,r)$ by "neutralizing" the reference point: $v(X) = u(x,x)$. The c-utility model can, therefore, be interpreted as a DM's preferences if she were not sensitive to POCs. We can use it as the underlying expected utility benchmark.

Proposition 1. *If action Y_j is ex ante more valuable than action Y_k, then action Y_j is an optimal choice in the c-utility model whereas action Y_k is not.*

Proof. See Appendix A.

Proposition 1 implies that, in the traditional expected utility model, action Y_k would never be selected. Consequently, the choice of an action with an *ex ante* POC represents a behavioral deviation from the expected utility model.

The following proposition gives a necessary condition for a DM to choose to support an *ex ante* POC in the POC-utility model.

Proposition 2. *If there exists an action Y_n which is ex ante more valuable than X, and if $E\left[u\left(X, R^{F_X}\right)\right] \geq E\left[u\left(Y_n, R^{F_{Y_n}}\right)\right]$, then there is, at least, one value f_{y_n} such that $r^{f_{y_n}} > y_n$.*

Proof. See Appendix B.

The first condition means that there is an *ex ante* POC to choose action X. Condition $E\left[u\left(X, R^{F_X}\right)\right] \geq E\left[u\left(Y_n, R^{F_{Y_n}}\right)\right]$ means that action X is preferred to action Y_n, despite the *ex ante* POC. The above proposition states that a necessary condition for X to be preferred to Y_n is that, for some values f_{y_n} of F_{Y_n}, $r^{f_{y_n}} > y_n$. In other words, action X can be preferred only if choosing Y_n exposes to having a feeling of regret. The reason for this is that, at the decision stage, the DM refuses to choose action Y_n, fearing to expose herself to feeling regret. She can prefer to support an *ex ante* POC rather than to take the risk of experiencing regret. In other words, when it comes to protect herself against anticipated regret, a DM can choose to support an *ex ante* POC.

It should be noted that the situation described in Proposition 2 can happen under any feedback structure, except under the perfect feedback structure. We have already seen that, under a perfect feedback structure, choosing an action with an *ex ante* POC is never optimal. The full analysis of an *ex ante* POC requires thus to consider an imperfect feedback structure.

The following example illustrates Proposition 2. In the examples given in this paper, even if we do not advocate this particular utility function for regret modeling, we have made the choice to use a linear and additively separable utility function to make clear that our results are not explained by second order effects.

Example 1. *We consider a non-informative feedback structure, and a choice set containing two risky actions $\Phi = \{X, Y\}$. Action X takes value 2.5 with probability 0.1, and value 3 with probability*

0.9. *Action* Y *takes value* 0 *with probability* 0.2*, and value* 4 *with probability* 0.8*. The POC utility function is* $u(X,R) = X - \frac{R}{2}$.

Table 1: *ex ante versus ex post* POC

Z	$E[v(Z)]^{*}$	CE_Z^{v**}	$E\left[u\left(Z,R^Z\right)\right]^{\dagger}$
X	1.475	2.95	1.35
Y	1.6	3.2	1.305

$*$ Expected c-utility
$**$ Certainty equivalent
† Expected POC utility

As $CE_Y^v > CE_X^v$*, action* Y *would be optimal in the c-utility model. As all action* X *payoffs are lower than* CE_Y^v*, there is an ex ante POC of choosing* X*. Choosing* X *is painful, because it implies giving up the opportunity to obtain* 4 *with probability* 0.8*.*

When $Y = 0$*, action* Y *generates some regret (*$Y = 0 < CE_X^v$*).*

Column † indicates that X *is optimal in the POC-utility model. In this example, the DM fears the regret associated with the event* $Y = 0$*. Action* X *is chosen, despite the associated ex ante POC. For action* X*, the difference between the c-utility and the POC utility is explained by the ex ante POC, whereas, for action* Y*, that difference comes from anticipated regret. We also observe a preference reversal between the c-utility model and the POC-utility model. Rationally, action* Y *represents the best option but emotional determinants lead the DM to forgo action* Y *in favor of action* X*. The details of the computation are given in Appendix C.*

Our model offers a theoretical framework for Tykocinski and Pittman (1998)'s experimental study, in which people have to choose between inaction and action[8]. Although action represents a better opportunity, people tend to choose inaction in order to avoid having to feel regret. Foregoing action represents an opportunity cost or, in Tykocinski and Pittman's terminology, an avoidance cost. The knowledge of missing out on a better opportunity, negatively affects the utility obtained from inaction. Inaction utility is thus lower than what it would be in a situation in which inaction does not result from a choice. In our model, the avoidance cost is measured by the *ex ante* POC.

[8] See Section 2 for a presentation of Tykocinski and Pittman (1998)'s experimental study.

5.2 POC sensitivity and attitude toward risk

let us consider a choice set containing two risky actions $\Phi = \{Y_1, Y_2\}$. In what follows, we assume that Y_j $(j = 1, 2)$ is a binary random variable, which takes the value $\underline{y}$ with probability p_j and the value $\overline{y}$ with probability $1-$ p_j. Without loss of generality, we assume that $0 < \underline{y} < \overline{y}$ and $p_1 \geq p_2$. We also assume that the joint distribution of Y_1 and Y_2 is parametrized by a correlation coefficient ρ (see Denuit *et al.* 2010):

$$
\begin{aligned}
\Pr\left(Y_1 = \underline{y}, Y_2 = \underline{y}\right) &= p_1 p_2 + \rho \qquad (7)\\
\Pr\left(Y_1 = \overline{y}, Y_2 = \underline{y}\right) &= (1 - p_1)\, p_2 - \rho \\
\Pr\left(Y_1 = \underline{y}, Y_2 = \overline{y}\right) &= p_1 (1 - p_2) - \rho \\
\Pr\left(Y_1 = \overline{y}, Y_2 = \overline{y}\right) &= (1 - p_1)(1 - p_2) + \rho
\end{aligned}
$$

with $Max\{-p_1 p_2, -(1 - p_1)(1 - p_2)\} \leq \rho \leq (1 - p_1)\, p_2$ to ensure probability values between 0 and 1.

When $\rho = 0$, the DM faces with an independent choice set. When ρ is positive (resp negative), the DM faces with a positive (negative) dependent choice set. The relationship between ρ and the Pearson correlation coefficient $\rho_{Y_1Y_2}$, whose value lies between -1 and $+1$, is $\rho_{Y_1Y_2} = \frac{\rho}{\sqrt{p_1(1-p_1)}\sqrt{p_2(1-p_2)}}$. An increase in ρ corresponds to a correlation increasing transformation of the joint distribution as defined by Epstein and Tanny (1980) and a DM, who dislikes (likes) such a transformation, is said to be correlation averse (lover). This transformation, which shifts weight towards realizations where both variables are small or large, leaves the marginal distributions of Y_1 and Y_2 unchanged.

The feedback structure $F_\Phi = \{F_{Y_1}, F_{Y_2}\}$ is defined as follows: information I_j $(j = 1, 2)$ in $F_{Y_j} = (Y_j, I_j)$ is a signal on action Y_k $(k = 2, 1)$. If we focus on action F_{Y_1} (we make similar assumptions on F_{Y_2}), the probability distribution of I_1 is:

$$\begin{array}{rclcl}
\Pr\left(I_1 = \underline{i} \middle| Y_1 = \underline{y}, Y_2 = \underline{y}\right) & = & \underline{q}_1 & \text{and} & \Pr\left(I_1 = \overline{i} \middle| Y_1 = \underline{y}, Y_2 = \underline{y}\right) = 1 - \underline{q}_1 \\
\Pr\left(I_1 = \underline{i} \middle| Y_1 = \underline{y}, Y_2 = \overline{y}\right) & = & \underline{p}_1 & \text{and} & \Pr\left(I_1 = \overline{i} \middle| Y_1 = \underline{y}, Y_2 = \overline{y}\right) = 1 - \underline{p}_1
\end{array} \tag{8}$$

Information I_1 is a signal on Y_2. The above probability distribution is given when $Y_1 = \underline{y}$. When $Y_1 = \overline{y}$, a DM, who has chosen Y_1, does not feel any regret and information on Y_2 is useless. Without loss of generality, we assume $\overline{i} > \underline{i}$ and $\underline{q}_1 \geq \underline{p}_1$. The signal I_1 is perfectly informative when $\underline{q}_1 = 1$ and $\underline{p}_1 = 0$, is not informative when $\underline{q}_1 = \underline{p}_1$ and is partially informative in the other cases.

The POC.-utility of Y_j is:

$$E\left[u\left(Y_j, R^{F_{Y_j}}\right)\right] = p_j E_{I_j}\left[u\left(\underline{y}, CE_{Y_k}^{v,\underline{y},I_j}\right)\middle| Y_j = \underline{y}\right] + (1 - p_j)\, u\left(\overline{y}, \overline{y}\right) \tag{9}$$

where $(i, k) \in \{(1,2), (2,1)\}$. The expectation operator $E_{I_j}\left[.\middle| Y_j = \underline{y}\right]$ represents the conditional expectation with respect to I_j, given that $Y_j = \underline{y}$. The notation $CE_{Y_k}^{v,\underline{y},i_j}$ refers to the certainty equivalent of Y_k, given that $Y_j = \underline{y}$ and $I_j = i_j$, with $i_j \in \left\{\underline{i}, \overline{i}\right\}$.

Unless $CE_{Y_k}^{v,\underline{y},i_j} = \underline{y}$, regret occurs when $Y_j = \underline{y}$ and the utility is $u\left(\underline{y}, CE_{Y_k}^{v,\underline{y},i_j}\right)$.

We obtain the following proposition:

Proposition 3. *A DM, who chooses between Y_1 and Y_2, is a correlation lover.*

Proof. See Appendix D.

Appendix D shows that a DM's utility, $E\left[u\left(Y_j, R^{F_{Y_j}}\right)\right]$, $j = 1, 2$, increases with ρ (see Equation 9). In a regret state, the reference point is $CE_{Y_k}^{v,\underline{y},i_j}$, which depends on the level of correlation between Y_1 and Y_2. Compared to the case of independence ($\rho = 0$), a positive correlation decreases regret intensity, while a negative correlation increases regret intensity. This result is valid whatever the feedback structure and is obtained without any assumption on risk preferences.

In what follows, we consider a non-informative feedback structure. Action X no longer represents the chosen alternative but a riskless action which generates a sure payoff. According to the traditional expected utility model (c-utility model), a DM, who has the choice between a riskless action X and a risky action Y, chooses the riskless action when $v(X) \geq E[v(Y)]$, which is equivalent to having $X \geq CE_Y^v$. On the contrary, she chooses the risky action Y when $v(X) < E[v(Y)]$ or, equivalently, when $X < CE_Y^v$.

We show, in this section, that POC sensitivity increases a DM's tendency to choose the riskless action when the feedback structure is non-informative. In other words, a DM not only chooses action X when $X \geq CE_Y^v$, but she can also be found choosing X when $X < CE_Y^v$. This result is independent of the DM's risk preferences since we do not make any assumption related to this point.

In what follows, we give the definition of the POC certainty equivalent of a risky action Y_n, which we henceforth refer to as $CE_{Y_n}^u$ (with u in superscript).

Definition 9. *If we consider a POC-sensitive DM, who faces the choice set $\Phi = \{X, Y\}$, which contains a riskless action X and a risky action Y, then the POC certainty equivalent of action Y corresponds to action X's payoff which makes the DM indifferent between X and Y.*

Under a non informative feedback structure, the POC certainty equivalent CE_Y^u is the X-solution of

$$u(X, Max(X, CE_Y^v)) = E[u(Y, Max(Y, X))] \tag{10}$$

We obtain the following proposition:

Proposition 4. *When the feedback structure is non-informative and the choice set is $\Phi = \{X, Y\}$, in which X is a riskless action and Y a risky action,*

CE_Y^u *exists and is unique*

$\underline{y} < CE_Y^u < CE_Y^v$ *where $\underline{y}$ denotes the minimum value that Y can take on its support W_Y.*

Proof. See Appendix E.

The meaning of Proposition 2 is easy to grasp. Let us first consider a DM facing the particular choice set $\Phi = \{CE_Y^v, Y\}$, which contains a risky action Y and the sure payoff CE_Y^v, which corresponds to the Arrow-Pratt certainty equivalent of Y. The DM is not indifferent between the two options. She strictly prefers the sure payoff CE_Y^v, which protects her from *ex ante* and *ex post* POCs, when the information structure is not informative. Under $A3$, we have:

$$u\left(CE_Y^v, CE_Y^v\right) > E\left[u\left(Y, Max\left(Y, CE_Y^v\right)\right)\right] \tag{11}$$

where the left hand side of the inequality is the POC utility of the sure payoff CE_Y^v and the right hand side is the expected POC utility of Y. Under $A1$, the sure payoff CE_Y^u, which makes a DM indifferent about choosing action Y or choosing the sure payoff CE_Y^u, is thus lower than CE_Y^v. The riskless action systematically protects the DM against anticipated regret, since its payoff is certain and no feedback is anticipated to be received about the risky action. The DM is thus more likely to choose the riskless action X, even in some cases where that choice involves a certain level of *ex ante* POC (when $CE_Y^u < X < CE_Y^v$). The difference $CE_Y^v - CE_Y^u$ indicates to what extent the DM is ready to support an *ex ante* POC in order to avoid regret. Therefore, whatever the DM's risk preference, POC sensitivity increases her aversion for the risky choice.

5.3 POC sensitivity and information value

In this section, we study the value of an information I, which arrives at the decision stage, and which can be used by a DM to make her choice. While information value is always positive in the expected utility model (see, for example, Gollier 2011), we show that information can be harmful in the POC-utility model. We consider a choice set $\{X, Y_1, .., Y_N\}$, where X represents a DM's optimal choice before information's arrival. If X_I denotes the DM's optimal choice given information I, we can define information value as follows[9]:

Definition 10. *Information value $V^u(I)$ satisfies $E\left[u\left(X_I - V^u(I), R^{F_{X_I}}\right)\right] = E\left[u\left(X, R^{F_X}\right)\right]$.*

[9] The definition of information value is not critical to our results. Our point consists in the idea that information can decrease a DM's expected utility.

$V^u(I)$ represents a DM's willingness to pay for information I. Under $A2$, information value is negative when information is expected to decrease the DM's utility.

We distinguish two channels through which information operates:

1. First, a DM revises her beliefs according to Bayes' rule. Probability distributions are modified. We call this channel the *probability effect*.

2. Secondly, information can modify the regret that the DM anticipates feeling when she chooses a strategy. We call this channel the *regret effect*. For example, a good signal on action Y can decrease the expected POC-utility from action X, because choosing X can expose to feeling more regret than before (the regret of not having chosen Y).

Negative information value might seem somewhat surprising, because we assume that information is processed in an optimal way. In order to illustrate this point and understand its underlying mechanisms, we give, in what follows, an example in which information is harmful. We should stress that, in this example, the DM effectively uses the information. She chooses, in an optimal way, her strategy conditionally to the realization of the information. However, despite its apparent usefulness, information is globally harmful because the DM only adapts her strategy in order to protect herself against the anticipated regret generated by the information.

Example 2. *We consider a non-informative feedback structure and a choice set* $\Phi = \{X, Y\}$ *containing two risky actions. Action* X *takes values* 1 *with probability* 0.4 *and* 2 *with probability* 0.6*. Action* Y *takes values* 0*,* 1 *and* 2.5 *with equal probabilities. In this example, information* I *is about* Y*. We consider a signal on action* Y *which takes the value* i_1 *when* $y = 0$ *and* i_2 *otherwise. The observation of* i_1 *is bad news about* Y*, while the observation of* i_2 *is rather good news. The DM receives the signal at the decision stage and uses it to determine her best choice. The POC utility function is* $u(X, R) = X - \frac{R}{2}$*.*

Table 2: Information value

Z	$E[v(Z)]$	CE_Z^v	$E\left[u\left(Z,R^Z\right)\right]$	CE_Z^{v,i_1}	CE_Z^{v,i_2}
X	0.8	1.6	0.766	1.6	1.6
Y	0.583	1.166	0.216	0	1.75

Column 4 *in Table 2 indicates that action X is the optimal strategy before information arrival. The POC-utility is equal to* 0.766*. The signal modifies the certainty equivalent of Y while keeping unaffected action X certainty equivalent (see columns* 5 *and* 6*).*

Table 3: Information value

Z	$E\left[u\left(Z,R^Z\right)\right]$	$E\left[u\left(Z,R^Z\right)\middle\vert i_1\right]$	$E\left[u\left(Z,R^Z\right)\middle\vert i_2\right]$	$E\left[u\left(Z_I,R^Z\right)\right]$
X	0.766	0.8	0.65	0.75
Y	0.216	-0.8	0.725	

In Table 3, we see that $X_{i_1} = X$ and $X_{i_2} = Y$ (see columns 3 *and* 4*).*

Given i_1, X remains optimal. Since $Y = 0$, the DM does not feel any regret ($\forall x, x > 0$) and her expected POC-utility is higher than before, that is to say $0.8 > 0.766$ (see column 4 *in Table 2 and column* 3 *in Table 3).*

Given i_2, Y becomes the optimal strategy. Choosing X exposes to more regret than before because action Y certainty equivalent is greater $CE_Y^{v,X,i_2} = 1.75 > 1.166$ (see columns 3 *and* 6 *in Table* 2*). This is the regret effect of the signal. Even if the signal is about action Y, it affects the expected POC-utility obtained from action X. The comparison between column* 4 *in Table 2 and column* 4 *in Table 3 indicates that the expected POC-utility from choosing X has decreased with information i_2. Column* 4 *in Table 3 also indicates that Y becomes the optimal choice.*

However, given i_2, the POC-utility from choosing Y is equal to 0.725*, which is lower than* 0.766 *(the expected POC-utility obtained from X without the signal). This means that, if the expected POC-utility obtained from X had not decreased, Y would not have become optimal. The probability effect of the signal i_2 is not sufficient, in itself, to make Y optimal. The strength of regret effect explains why the DM switches from action X to action Y, while the weakness of the probability effect explains why this switching results in a decrease of the overall utility (see column* 5*). The details of the computation are given in Appendix F.*

Information arrival at the feedback stage is also of interest in regret theory. Bell (1983) considers a two-choice model in which the outcome produced by the foregone lottery can be resolved or unresolved. Bell shows that a DM prefers to have the foregone lottery unresolved when the regret function $\widehat{R}(.)$ (see Equation 2) is concave. In our model, a similar result can be obtained when $u_{22}(x,r) < 0$. In this paper, however, we have made the choice to present only those results that does not require any assumption on second derivatives.

6 Conclusion

Regret theory has essentially been developed under perfect information. The general version of regret theory offered here accommodates any type of feedback context and allows a better understanding of the reference point in a utility function à la Quiggin (1994). We show that the reference point does not exclusively represent a feeling of regret but characterizes a more general emotional mechanism: the fact that choosing has an impact on utility via a mental process which makes the idea of choice painful. We designate this emotional mechanism as a *Psychological Opportunity Cost*. Our model highlights the interweaving between the psychological mechanism studied here and information.

Appendix A

Action Y_j is *ex ante* more valuable than action Y_k:

$$\forall f_{y_k}, CE_{Y_j}^{f_{y_k}} = Max\left\{CE_{Y_1}^{f_{y_k}}, .., CE_{Y_{k-1}}^{f_{y_k}}, y_k, CE_{Y_{k+1}}^{f_{y_k}}, ..., CE_{Y_{N+1}}^{f_{y_k}}\right\} \tag{A.1}$$

$$\Leftrightarrow \forall f_{y_k}, v\left(CE_{Y_j}^{f_{y_k}}\right) = Max\left\{v\left(CE_{Y_1}^{f_x}\right), ..., v\left(CE_{Y_{k-1}}^{f_x}\right), v\left(y_k\right), v\left(CE_{Y_{k+1}}^{f_x}\right), ..., v\left(CE_{Y_{N+1}}^{f_x}\right)\right\} \tag{A.2}$$

$$\Leftrightarrow \forall f_{y_k}, E\left[v\left(Y_j\right)\middle| f_{y_k}\right] = Max\left\{E\left[v\left(Y_1\right)\middle| f_{y_k}\right], ..., E\left[v\left(Y_{k-1}\right)\middle| f_{y_k}\right], v\left(y_k\right), E\left[v\left(Y_{k+1}\right)\middle| f_{y_k}\right], ..., E\left[v\left(Y_{N+1}\right)\middle| f_{y_k}\right]\right\} \tag{A.3}$$

$$\Rightarrow E\left[v\left(Y_j\right)\right] = Max\left\{E\left[v\left(Y_1\right)\right], ..., E\left[v\left(Y_{k-1}\right)\right], E\left[v\left(Y_k\right)\right], E\left[v\left(Y_{k+1}\right)\right], ..., E\left[v\left(Y_{N+1}\right)\right]\right\} \tag{A.4}$$

with $E\left[v\left(Y_k\right)\right] < E\left[v\left(Y_j\right)\right]$ since there exist, at least, one f_{y_k}such $CE_{Y_j}^{f_{y_k}} > y_k$ (See Definition 8). Action Y_J would represent an optimal strategy in the c-utility model while action Y_k would not.

Appendix B

If Y_n is *ex ante* more valuable than X then (see Appendix A):

$$E\left[v\left(X\right)\right] < E\left[v\left(Y_n\right)\right] \tag{B.1}$$

and, under $A3$,

$$E\left[u\left(X, R^{F_X}\right)\right] = E\left[u\left(X, CE_{Y_n}^{v,F_X}\right)\right] < E\left[v\left(X\right)\right] \tag{B.2}$$

We thus have:

$$E\left[u\left(X, R^{F_X}\right)\right] < E\left[v\left(Y_n\right)\right] \tag{B.3}$$

And we also have:

$$E\left[u\left(Y_n, R^{F_{Y_n}}\right)\right] \leq E\left[v\left(Y_n\right)\right] \tag{B.4}$$

with equality when $\forall f_{y_n}, r^{f_{y_n}} = y_n$.

Given equations B.3 and B.4, $E\left[u\left(X, R^{F_X}\right)\right] \geq E\left[u\left(Y_n, R^{F_{Y_n}}\right)\right]$ is possible only when B.4 is written with a strict inequality, which occurs when there is, at least, one value f_{y_n} such that $r^{f_{y_n}} > y_n$. This condition means that choosing action Y_n exposes a DM to the possibility of facing regret. It is easy to verify that an action, which is more valuable than another action, cannot itself involve an *ex ante* POC.

Appendix C

First, we compute the expected c-utilities of X and Y:

$$E\left[v\left(X\right)\right] = 0.1\frac{2.5}{2} + 0.9\frac{3}{2} = 1.475 \tag{C.1}$$

$$E\left[v\left(Y\right)\right] = 0.2\frac{0}{2} + 0.8\frac{4}{2} = 1.6 \tag{C.2}$$

From this, we can easily compute $CE_X^v = 2.95$ and $CE_Y^v = 3.2$.

The expected POC utilities are:

$$E\left[u\left(X, R^X\right)\right] = 0.1\left(2.5 - 0.5 \times Max\left\{2.5, 3.2\right\}\right) + 0.9\left(3 - 0.5 \times Max\left\{3, 3.2\right\}\right) = 1.35 \tag{C.3}$$

$$E\left[u\left(Y, R^Y\right)\right] = 0.2\left(0 - 0.5 \times Max\left\{0, 2.95\right\}\right) + 0.8\left(4 - 0.5 \times Max\left\{4, 2.95\right\}\right) = 1.305 \tag{C.4}$$

Appendix D

We focus on action Y_1. The same reasoning applies to Y_2. Equation 9 can be written as follows:

$$E\left[u\left(Y_1, R^{F_{Y_1}}\right)\right] = p_1 \Pr\left(I_1 = \underline{i} \middle| Y_1 = \underline{y}\right) u\left(\underline{y}, CE_{Y_2}^{v,\underline{y},\underline{i}}\right) + p_1 \Pr\left(I_1 = \bar{i} \middle| Y_1 = \underline{y}\right) u\left(\underline{y}, CE_{Y_2}^{v,\underline{y},\bar{i}}\right) + (1 - p_1)\, u\left(\overline{y}, \overline{y}\right) \tag{D1}$$

$$E\left[u\left(Y_1, R^{F_{Y_1}}\right)\right] = p_1\left[\left(p_2+\frac{\rho}{p_1}\right)\underline{q}_1+\left(1-p_2-\frac{\rho}{p_1}\right)\underline{p}_1\right]u\left(\underline{y}, CE_{Y_2}^{v,\underline{y},\underline{i}}\right)$$
$$+p_1\left[\left(\left(p_2+\frac{\rho}{p_1}\right)\left(1-\underline{q}_1\right)+\left(1-p_2-\frac{\rho}{p_1}\right)\left(1-\underline{p}_1\right)\right)\right]u\left(\underline{y}, CE_{Y_2}^{v,\underline{y},\bar{i}}\right)+(1-p_1)\,u\left(\overline{y},\overline{y}\right) \tag{D2}$$

with

$$v\left(CE_{Y_2}^{v,\underline{y},\underline{i}}\right) = \Pr\left(Y_2=\underline{y}\middle| Y_1=\underline{y}, I_1=\underline{i}\right)v\left(\underline{y}\right)+\Pr\left(Y_2=\overline{y}\middle| Y_1=\underline{y}, I_1=\underline{i}\right)v\left(\overline{y}\right) \tag{D.3}$$

and

$$v\left(CE_{Y_2}^{v,\underline{y},\bar{i}}\right) = \Pr\left(Y_2=\underline{y}\middle| Y_1=\underline{y}, I_1=\bar{i}\right)v\left(\underline{y}\right)+\Pr\left(Y_2=\overline{y}\middle| Y_1=\underline{y}, I_1=\bar{i}\right)v\left(\overline{y}\right) \tag{D.4}$$

Equations D.3 and D.4 give

$$v\left(CE_{Y_2}^{v,\underline{y},\underline{i}}\right) = \left[\frac{\left(p_2+\frac{\rho}{p_1}\right)\underline{q}_1}{\left(p_2+\frac{\rho}{p_1}\right)\underline{q}_1+\left(1-p_2-\frac{\rho}{p_1}\right)\underline{p}_1}\right]v\left(\underline{y}\right)+\left[1-\frac{\left(p_2+\frac{\rho}{p_1}\right)\underline{q}_1}{\left(p_2+\frac{\rho}{p_1}\right)\underline{q}_1+\left(1-p_2-\frac{\rho}{p_1}\right)\underline{p}_1}\right]v\left(\overline{y}\right) \tag{D.5}$$

and

$$v\left(CE_{Y_2}^{v,\underline{y},\bar{i}}\right)\left[\frac{\left(p_2+\frac{\rho}{p_1}\right)\left(1-\underline{q}_1\right)}{\left(p_2+\frac{\rho}{p_1}\right)\left(1-\underline{q}_1\right)+\left(1-p_2-\frac{\rho}{p_1}\right)\left(1-\underline{p}_1\right)}\right]v\left(\underline{y}\right)$$
$$+\left[1-\frac{\left(p_2+\frac{\rho}{p_1}\right)\left(1-\underline{q}_1\right)}{\left(p_2+\frac{\rho}{p_1}\right)\left(1-\underline{q}_1\right)+\left(1-p_2-\frac{\rho}{p_1}\right)\left(1-\underline{p}_1\right)}\right]v\left(\overline{y}\right) \tag{D.6}$$

Easy computations give

$$\frac{\partial v\left(CE_{Y_2}^{v,\underline{y},\underline{i}}\right)}{\partial CE_{Y_2}^{v,\underline{y},\underline{i}}}\frac{\partial CE_{Y_2}^{v,\underline{y},\underline{i}}}{\partial\rho}=-\frac{\underline{q}_1\underline{p}_1}{p_1\left[\left(\underline{q}_1-\underline{p}_1\right)\left(p_2+\frac{\rho}{p_1}\right)+\underline{p}_1\right]^2}\left[v\left(\overline{y}\right)-v\left(\underline{y}\right)\right]<0\Longrightarrow\frac{\partial CE_{Y_2}^{v,\underline{y},\underline{i}}}{\partial\rho}<0 \tag{D.7}$$

$$\frac{\partial v\left(CE_{Y_2}^{v,\underline{y},\overline{i}}\right)}{\partial CE_{Y_2}^{v,\underline{y},\overline{i}}}\frac{\partial CE_{Y_2}^{v,\underline{y},\overline{i}}}{\partial\rho}=-\frac{\left(1-\underline{q}_1\right)\left(1-\underline{p}_1\right)}{p_1\left[\left(\underline{p}_1-\underline{q}_1\right)\left(p_2+\frac{\rho}{p_1}\right)+1-\underline{p}_1\right]^2}\left[v\left(\overline{y}\right)-v\left(\underline{y}\right)\right]<0\Longrightarrow\frac{\partial CE_{Y_2}^{v,\underline{y},\overline{i}}}{\partial\rho}<0 \tag{D.8}$$

And

$$\begin{aligned}&\frac{\partial E\left[u\left(Y_1,R^{F_{Y_1}}\right)\right]}{\partial\rho}=\\&\left(\underline{q}_1-\underline{p}_1\right)\left[u\left(\underline{y},CE_{Y_2}^{v,\underline{y},\underline{i}}\right)-u\left(\underline{y},CE_{Y_2}^{v,\underline{y},\overline{i}}\right)\right]+p_1\left[\left(p_2+\frac{\rho}{p_1}\right)\underline{q}_1+\left(1-p_2-\frac{\rho}{p_1}\right)\underline{p}_1\right]u_2\left(\underline{y},CE_{Y_2}^{v,\underline{y},\underline{i}}\right)\frac{\partial CE_{Y_2}^{v,\underline{y},\underline{i}}}{\partial\rho}\\&\quad+p_1\left[\left(p_2+\frac{\rho}{p_1}\right)\left(1-\underline{q}_1\right)+\left(1-p_2-\frac{\rho}{p_1}\right)\left(1-\underline{p}_1\right)\right]u_2\left(\underline{y},CE_{Y_2}^{v,\underline{y},\overline{i}}\right)\frac{\partial CE_{Y_2}^{v,\underline{y},\overline{i}}}{\partial\rho}\end{aligned} \tag{D.9}$$

Since $CE_{Y_2}^{v,\underline{y},\overline{i}}>CE_{Y_2}^{v,\underline{y},\underline{i}}$, under $A3$, $\frac{\partial E\left[u\left(Y_1,R^{Y_1}\right)\right]}{\partial\rho}>0$.

7 Appendix E

When $X=\underline{y}$, Equation 10 is not satisfied. Under $A1$ and $A3$, we have:

$$u\left(\underline{y},CE_Y^v\right)<E\left[u\left(Y,Y\right)\right] \tag{E.1}$$

When $X=CE_Y^v$, Equation 10 is not satisfied. Under $A3$, we have:

$$u\left(CE_Y^v, CE_Y^v\right) > E\left[u\left(Y, Max\{CE_Y^v, Y\}\right)\right] \tag{E.2}$$

We demonstrate the following lemma:

Lemma 1. *Function* $u\left(x, Max\{x, CE_Y^v\}\right)$ *strictly increases with* x *and function* $E\left[u\left(y, Max\{x, y\}\right)\right]$ *strictly decreases with* x.

Proof. When $x \leq CE_Y^v$, $u\left(x, Max\{x, CE_Y^v\}\right) = u\left(x, CE_Y^v\right)$ which strictly increases with x under $A2$. When $x > CE_Y^v$, $u\left(x, Max\{x, CE_Y^v\}\right) = u\left(x, x\right) = v\left(x\right)$ which strictly increases with x under $A1$. Fonction $u\left(x, Max\{x, CE_Y^v\}\right)$ is thus strictly increasing with x.

When $x < y$, $u\left(y, Max\{x, y\}\right) = u\left(y, y\right)$ which is independent of x. When $x \geq y$, $u\left(y, Max\{x, y\}\right) = u\left(y, x\right)$ which strictly decreases with x under $A3$. Function $E\left[u\left(y, Max\{x, y\}\right)\right]$ is thus strictly decreasing with x as soon as $x \geq \underline{y}$. □

Given equations E.1 and E.2 and Lemma 1, and under assumption $A0$, the X-solution of Equation 10 exists, is unique and belongs to $\left]\underline{y}, CE_Y^v\right[$.

Appendix F

First, we compute the expected c-utilities and the certainty equivalents of X and Y:

$$E\left[v\left(X\right)\right] = 0.4\frac{1}{2} + 0.6\frac{2}{2} = 0.8 \text{ and } CE_X^v = 1.6 \tag{F.1}$$

$$E\left[v\left(Y\right)\right] = \frac{1}{3}\frac{0}{2} + \frac{1}{3}\frac{1}{2} + \frac{1}{3}\frac{2.5}{2} \simeq 0.583 \text{ and } CE_Y^v \simeq 1.166 \tag{F.2}$$

The expected POC-utilities when there is no signal are

$$E\left[u\left(X, R^X\right)\right] = 0.4\left(1 - 0.5 \times Max\left\{1, 1.166\right\}\right) + 0.6\left(2 - 0.5 Max\left\{2, 1.166\right\}\right) \simeq 0.766 \tag{F.3}$$

$$E\left[u\left(Y,R^{Y}\right)\right]=\frac{1}{3}\left(0-0.5\times Max\left\{0,1.6\right\}\right)+\frac{1}{3}\left(1-0.5\times Max\left\{1,1.6\right\}\right)+\frac{1}{3}\left(2.5-0.5\times Max\left\{2.5,1.6\right\}\right)\simeq 0.216 \tag{F.4}$$

Action X represents the optimal choice.

When information i_1 is received, the expected POC-utilities become

$$E\left[u\left(X,R^{X}\right)\middle|\, i_1\right]=0.4\left(1-0.5\times Max\left\{1,0\right\}\right)+0.6\left(2-0.5\times Max\left\{2,0\right\}\right)=0.8 \tag{F.5}$$

$$E\left[u\left(Y,R^{Y}\right)\middle|\, i_1\right]=0-0.5\times Max\left\{0,1.6\right\}=-0.8 \tag{F.6}$$

We thus have $X_{i_1}=X$.

When information i_2 is received, Y can take values 1 and 2.5 with equal probabilities. Let us begin by computing the expected c-utility of Y and its certainty equivalent given i_2.

$$E\left[v\left(Y\right)\middle|\, i_2\right]=\frac{1}{2}\frac{1}{2}+\frac{1}{2}\frac{2.5}{2}=0.875 \text{ and } CE_{Y}^{v,i_2}=1.75 \tag{F.7}$$

The expected POC-utilities become

$$E\left[u\left(X,R^{X}\right)\middle|\, i_2\right]=0.4\left(1-0.5\times Max\left\{1,1.75\right\}\right)+0.6\left(2-0.5Max\left\{2,1.75\right\}\right)=0.65 \tag{F.8}$$

$$E\left[u\left(Y,R^{Y}\right)\middle|\, i_2\right]=\frac{1}{2}\left(1-0.5\times Max\left\{1,1.6\right\}\right)+\frac{1}{2}\left(2.5-0.5\times Max\left\{2.5,1.6\right\}\right)=0.725 \tag{F.9}$$

We thus have $X_{i_2}=Y$. Information i_2 increases utility obtained from strategy Y, and decreases utility obtained from strategy X.

Before receiving the information, the expected POC-utility is

$$E\left[u\left(X_I,R^{X_I}\right)\right]=\frac{1}{3}\times 0.8+\frac{2}{3}\times 0.725=0.75<0.766 \tag{F.10}$$

The expected POC-utility when information I is expected to be received is lower than when no information is anticipated. Information value is negative.

References

Arkes H.R., Kung Y. H., & Hutzel L. (2002). 'Regret, valuation, and inaction inertia', Organizational Behavior and Human Decision Processes, 87(2), 371–385.

Bell, D. E. (1982). 'Regret in decision making under uncertainty', Operations Research, 30(5), 961-981.

Bell, D. E. (1983). 'Risk premiums for decision regret', Management Science, 29(10), 1156-1166.

Bleichrodt, H. & Wakker, P.P. (2015). 'Regret theory: a bold alternative to the alternatives', The Economic Journal, 125 (March), 493–532.

Carmon, Z., Wertenbroch, M., & Zeelenberg, M. (2003). 'Option attachment: when deliberating makes choosing feel like losing', Journal of Consumer Research, 30(1), 15-29.

Denuit, M., Eeckhoudt, L., & Rey, B. (2010).'Some consequences of correlation aversion in decision science', Management Science 53(1), 117-124.

Epstein, L. G., & Tanny, S.M. (1980). 'Increasing generalized correlation: A definition and some economic consequences'. Canadian Journal of Economics, 13, 16-34.

Epstude, K., & Roese N. J. (2008). 'The functional theory of counterfactual thinking', Personality and Social Psychology Review, 12(2), 168-192.

Gilovich, T. (1983). 'Biased evaluation and persistence in gambling', Journal of Personality and Social Psychology, 44(6), 1110-1126.

Gollier, C. (2011). 'The economics of risk and time', MIT Press.

Humphrey, S., Mann, P., & Starmer, C. (2005). 'Testing for feedback conditional regret effects using a natural lottery', University of Nottingham, School of Economics, The Centre for Decision Research and Experimental Economic Discussion Papers, 2005-07.

Krähmer, D., & Stone, R. (2008). 'Regret in dynamic decision problems'. Working paper.

Loomes, G., & Sugden, R. (1982). 'Regret theory: an alternative theory of rational choices under uncertainty', The Economic Journal, 92(368), 805-824.

Loomes, G., & Sugden, R. (1987). 'Some implications of a more general form of regret', Journal of Economic Theory, 41(2), 270-287.

Mellers, B. A. , Schwartz, A., & Ritov, I. (1999). 'Emotion-based choice', Journal of Experimental Psychology: General, 128(3), 332-345.

Mellers, B. A. (2000). 'Choice and the relative pleasure of consequences', Psychological Bulletin, 126(6), 910-924.

Quiggin, J. (1994). 'Regret theory with general choice sets', Journal of Risk and Uncertainty, 8(2), 153–165.

Roese, N.J. (1997). 'Counterfactual thinking', Psychological Bulletin, 121(1), 133-148.

Sevdalis, N., Harvey N., & Yip, M. (2006). 'Regret triggers inaction inertia – but which regret and how?', British Journal of Social Psychology, 45(4), 839–853.

Strack, P., & Viefers, P. (2014). 'Too proud to stop: regret in dynamic decisions', Available at http://dx.doi.org/10.2139/ssrn.2465840.

Sugden, R. (1993). 'An axiomatic foundation for regret theory', Journal of Economic Theory, 60(1), 159-180.

Tykocinski, O. E., & Pittman, T. S. (1998). 'The consequences of doing nothing: inaction inertia as avoidance of anticipated counterfactual regret', Journal of personality and social psychology, 75(3), 607-616.

Zeelenberg, M., & Pieters, R. (2007). ‘A theory of regret regulation 1.0’, Journal of Consumer Psychology, 17(1), 3-18.

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