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A timely account of the role of duration in decision making

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Abstract

The current work takes a general perspective on the role of time in decision making. There are many different relationships and interactions between time and decision making, and no single summary can do justice to this topic. In this paper we will describe a few of the aspects in which time and decision making are interleaved: (a) temporal perspectives of decisions – the various temporal orientations that decision-makers may adopt while making decisions, and the impact of such temporal orientations on the decision process and its outcomes; (b) time as a medium within which decisions take place – the nature of decision processes that occur along time; (c) time as a resource and as a contextual factor – the implications of shortage in time resources and the impact of time limits on decision making processes and performance; (d) time as a commodity – time as the subject matter of decision making. The paper ends with a few general questions on the role of duration in decision making.

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1. Introduction

Time is a dimension in which all living organisms adjust to their environment. Some of these adjustments take generations and even millenniums, while others last

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only hours, minutes or fractions of seconds. The current work focuses on one of the most important mechanisms for active fast adjustments, namely decision making, where decision making is defined as the ability to react to information in the environment, and to take one of a few different action alternatives in order ultimately to better the organism.

Clearly, every behavior of an organism is carried out within the time continuum, and in many cases behaviors are dynamically changed and shaped during their execution. Decision making is no exception; it takes time to make decisions and sometimes the decisions dynamically change with the passage of time. However there are a few aspects of time that are unique to their relationship with decision making. Some examples: people can make decisions about the duration of different experiences they would like to engage in (should I take the longer and more scenic bike ride home or the faster one?); they can set deadlines for themselves (I promise to finish that chapter by 1 December); and they can change their preferences for an action long before the fact (I will not have that cheese cake), and again, when the time draws close (can I have that cake please?).

Ranyard, Crozier, and Svenson (1997) expressed many interactions between time and decision making by saying that "time is an ever present and prominent dimension in all human decision making. Decisions are oriented towards future time, they take time to make, their consequences develop over time, and they are sometimes thought about for a long time afterwards" (p. 165). Some of these intimate relationships between time and decision making are reflected in "metadecision" questions asked by a decision maker facing important decisions, like: how much time have decisions like this one taken in the past? how long should this decision take? when should this decision be made? are the deadlines arbitrary or real? where should I concentrate my time and resources? how much time should I expect to spend on each phase of the decision process? (Russo & Schoemaker, 1989).

As is clearly apparent from the examples above, there are many different relationships and interactions between time and decision making. In fact, whether the different aspects of time are all related to decision making in similar ways or whether each of these aspects should be viewed independently is an interesting question, but we will neither take a position on this nor will we systematically discuss all aspects of time and decision making here. Instead, we will describe a few of the aspects in which time and decision making are interwoven. Specifically, we will discuss the following: (a) temporal perspectives of decisions, (b) time as a medium within which decisions take place, (c) time as a resource and as a contextual factor, (d) time as a commodity.

2. Temporal perspectives of decision making

Decision-makers evaluate objects and experiences with different time-relationship to their occurrences. In some cases, they make decisions about experiences and objects before they occur (when should I take my long due vacation?); make decisions during the experiences (should I continue on this hike or go back?); or make retrospective evaluations after the occurrence of an event (how was my last vaca-

tion?). How do decision makers evaluate experiences as a function of their time relationship to the experience? Before an experience takes place there might be unknown aspects about it. For example, before visiting California, one might not be able to estimate the majestic beauty of the coast of California or the rock formations at Yosemite. Similarly, after an experience has taken place, memory of it might be distorted. For example, one might not remember the agony of a long argument with one's spouse, or the sleepless nights spent with one's children. In such cases, whether it is an inability to estimate the effects of future events or a lack of memory for past events, time will clearly have an effect on the evaluations of experiences and the tendency to take actions about them.

If there were not any effects on knowledge and memory (for example, if we assumed that knowledge and memory were perfect), we could rationally expect that time would not have any effect on evaluations and decisions. After all, the value of an activity (such as preparing a lecture or writing a book chapter) is familiar and known. Thus it would seem that decisions about taking on such duties should not be influenced by temporal relationships. Despite this intuition, there is accumulating evidence that temporal relationships change both evaluations and decisions.

In addition to the general partitioning (before, during, and after) there is also a considerable effect of the distance in time from the event in question. When deciding about our vacation far in advance, we might not predict how much pressure we will be under at work, or how great our need will be for some sunshine during the long cold Boston winter. Similarly, at the beginning of an experience such as giving birth, a decision maker could choose not to take any painkillers, but this decision could change as the process progresses over time. Finally, after an experience is over and we consume its pleasure or pain only from memory, the distance from the event can change our perspective on the event. Immediately after our return from climbing the Himalayas, while our blisters and snow burns are painful, our memory might not be so favorable, but as time progresses we might remember the experience more favorably and even recommend this trip to our friends. We will next present some evidence on the three different time perspectives (before, during, and after), and we will also present evidence regarding the distance from the experience.

2.1. Time discounting

There is growing evidence in the area of behavioral economics that people systematically change their preference as a function of time relationship (Rachlin, 1989). For example, we often tell ourselves in advance that we should not have crème brûlée for dessert, but when the time comes to order dessert we act in accordance with a different set of preferences and order this tasty dessert after all. The issue here is not whether having dessert is right or wrong, but the fact that it is inconsistent with the preferences of the decision maker at some points in time (either before or after the event). One way to think about these issues is that individuals have a set of preferences X at some point in time (or under a certain set of environmental conditions) and a different set of preferences Y at some other point in time. In the case of crème brûlée, we prefer not to have it $[Y]$ before going to the restaurant, we prefer to

have it $[X]$ while ordering dessert and consuming it, and we prefer that we had not had it, after the meal is over $[Y]$. Consuming crème brûlée is not the only example in which such self-control problems occur. Other examples include: exercise, itching, nail biting, smoking, practicing safe sex, drug abuse, saving, and others.

A graphical illustration of the changes in preferences as a function of distance to the decision can be seen in Fig. 1. Here the decision maker is facing a choice between the "good option" (fresh fruit) represented by the thicker line and the "bad option" (chocolate) represented by the thinner line. Much before the decision is made, the fresh fruit has a higher overall reward (healthier and not contributing to weight gain). In the restaurant, just before the decision is made, the value of the chocolate seems larger. Finally, after the decision has been made, the value of the chocolate over the fresh fruit diminishes and the choice of chocolate in retrospect become questionable. Note that in the case depicted in Fig. 1, the changes in discount rates are the same before and after the decision. In reality, there are most likely cases in which the discount rate is higher before or after the event, depending largely on the "empathy" we have with our own behaviors in other states, and on factors that allow us to have "psychological repair work".

2.2. Changes in thought processes

One of the causes for change in preferences at different points in time can be attributed to changes in the saliency of costs and benefits of the activity in question

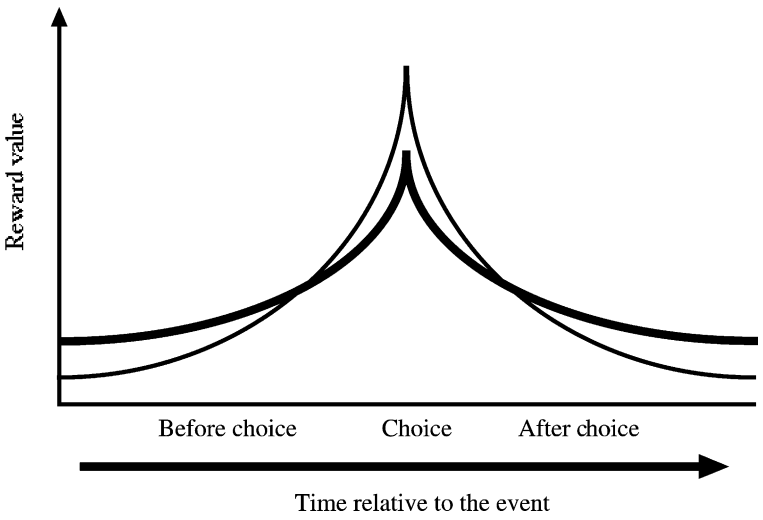

Fig. 1. Decisions and time: valuation before and after the decision. *Note*: The decision maker is facing a decision between the "good" option (fresh fruit) represented by the thicker line and the "bad" option (chocolate) represented by the thinner line. Much before the decision, the fresh fruit has a higher overall reward (healthier and not contributing to weight gain). In the restaurant, just before the decision, the value of the chocolate seems larger. Finally, after the decision, the value of the chocolate over the fresh fruit diminishes and the choice of chocolate in retrospect become questionable.

(Akerlof, 1991). For example, the saliency argument suggests that well in advance, the benefits of writing a book chapter loom large, and the costs seem small. As a consequence, we take on such tasks. But as the deadline draws nearer, the saliency of the costs and benefits change and we become much more aware of the time needed for completing the chapter, while the benefits of writing the chapter become increasingly less clear. Such inconsistent time preferences are most likely at the core of procrastination and other inconsistent time preferences (see Fig. 1).

Liberman and Trope (1998) recently introduced the Temporal Construal Theory, according to which alternatives are evaluated somewhat differently at different points in time. They argued that alternatives' characteristics can be categorized into desirability and feasibility types. Whereas desirability characteristics refer to long-term, "ideal-type" wishes (i.e., self-development), feasibility characteristics refer to short-term, concrete characteristics (i.e., resources like time and money needed for implementing a decision). Liberman and Trope found that the dominant characteristics by which alternatives are evaluated belong to the "desirability" type when the temporal distance from implementation of a decision is high, and to the "feasibility" type, the closer the decision process is to the actual implementation of a decision. The temporal construal theory was empirically supported by Zakay and Milchtaijch (2000), who studied the decision process of students facing vocational choices. The students in their study were interviewed three times along the course of the decision process, from its onset until implementation (registration to a study program). It was found that at the beginning of the process the most influential characteristics were characterized as the "desirability" type, but the impact of the "feasibility" type characteristics surpassed those of the former as the registration deadline loomed closer. It was further found that a successful implementation of a choice (in terms of registering and being satisfied with it) was dependent on such a shift from thinking in terms of desirability to thinking in terms of feasibility.

2.3. Overcoming inconsistent time preferences

As was illustrated in the two sections above, changes in preferences as a function of time relationship are sometimes reasonable (such as when we forget how painful childbirth or writing a book chapter is), but they can sometimes lead to self-defeating behaviors, such as overspending, drug abuse, procrastination, etc. Although such inconsistent preferences can form serious obstacles to following our plan of action, they can sometimes be overcome. Specifically, one of the ways people can, and do try to control their inconsistent preferences is by binding their behavior (Ainslie, 1975; Rachlin, 1989). The idea is that if we want to keep our diet, but also know that the temptation of crème brûlée will cause a deviation from our preferred behavior, we can simply go to less tempting restaurants. Other examples of binding behaviors include health retreats where desirable food types are not available, saving in Christmas clubs, or paying a premium for small packages of cigarettes or potato chips (Wertenbroch, 1998). At the most extreme levels, binding behaviors include drug addicts locking themselves in a room without access to drugs, and dieters putting braces on their teeth to prevent themselves from eating solids. In one such

account (see Schelling, 1992), drug addicts were given the opportunity to write self-incriminating confession letters about their drug abuse to whomever they wanted, and these letters were temporarily held at the clinic. The clinic committed to: (a) hold onto the confession letters, (b) carry out random blood tests of the letter writers, and (c) send the letters to the addressee if the blood tests indicated drug use. The idea was that people could strategically address the letter to the person or organization that they least wanted to find out about their drug use and that the fear of having this party discover their behavior would be so strong that even when they were in a state of craving for drugs, the fear would overweigh their desire.

In a somewhat simpler context, Ariely and Wertenbroch (2000) demonstrated that decision makers have procrastination problems, and that in order to overcome the tendency to procrastinate, they will self-impose deadlines on themselves if they are given the opportunity to do so (even when doing so incurs cost). In one of their experiments, Ariely and Wertenbroch gave participants three boring proof-reading tasks and paid them on the basis of their performance. In their evenly spaced deadline condition, participants were asked to submit one of the tasks every seven days. At the end deadline condition, participants were asked to submit all three tasks at the end of three weeks (27 days). In the self-imposed deadline condition, participants were asked to choose their own deadline for each of the three tasks. The results showed that in the self-imposed deadline condition, participants did space their tasks in time, and that this spacing improved their performance over the performance of participants in the end deadline condition. The results also showed that the performance in the self-imposed deadline condition was lower than the performance in the evenly spaced deadline condition. In other words, while participants did use self-imposed deadlines in order to impose self-control over their own behavior, they did not do so optimally. Ariely and Wertenbroch argue that when facing a situation where decision makers can set deadlines for themselves, they understand both the normative reasons to set the deadlines as late as possible (increased flexibility and time) on the one hand, and the value of binding themselves in order to take control over procrastination, on the other hand. When making deadline decisions, decision makers combine these two perspectives and come up with a set of deadlines that is not ideal, but is better than delaying all deadlines to the last possible date.

2.4. Increased stability in decision making over time

A ubiquitous characteristic of decision making lies in its future orientation: choices are made of courses of action with consequences in the future (Gärling, Karlsson, Romanus, & Selart, 1997). Thus it can be seen as somewhat hazardous to base decisions on the past. Yet, the past might influence current decision processes in several ways (Elster & Loewenstein, 1992). One way, is of course, learning from the past while trying not to repeat what is perceived as erroneous decisions.

The simplest form of past-oriented decision making is habit formation. Habit-based behaviors reflect automatic implementation of past decisions, which resulted with reasonable or positive outcomes. Verplanken, Aarts, and Knippenberg (1997) demonstrated the profound effects that habit might have on the appreciation of

information about choice situations and choice options. Although they are very important (as reducing cognitive effort), habit-based behaviors can also lead decision makers to non-optimal implementation of past decisions. Such mistakes can occur when past decisions are based on either wrong information or a different environment.

An example of the role of past decisions on later decisions comes from the work by Hoeffler and Ariely (1999) showing that once decision makers make a decision in a certain domain, their certainty about the ideal weights of the product attributes (e.g., power of a microwave) became more stable. They also showed that this "preference consolidation" occurred most rapidly when decision makers made implicit and difficult trade-offs between alternatives. They argue that the need to face trade-offs forces decision makers to consolidate how they feel about the different attributes, and forces them to stabilize their own understanding of their value for the different attributes.

Examining the issues of preference consolidation, Ariely, Loewenstein, and Prelec (2000) recently proposed a model in which once people make a decision, they use it as an input for future decisions and thus converge to a stable decision. Their model can basically be considered a "self-herding mode", similar to intra-personal hoarding modes, but one in which a person's own past behavior is used as a signal of preferences and hence influences future behaviors. As an illustration of this idea, consider the following intra-personal herding behavior. A person walks by a restaurant and notices that there is one person in line. The person takes this as a signal that the food is good and joins the line. Another person walks by and notices two people standing in line, so this person takes this as a signal that the food is good and joins the line. Another person walks by and notices three people standing in line so this person takes this as a signal that the food is good and joins the line. This process continues until there are many people in line. However, in this example, the amount of information about the food quality is not related to the line length and in fact all but the first person are redundant in terms of the information they provide. Ariely et al. (2000) suggest that a similar phenomenon occurs within a person. They argue that once people make a decision, even if it is an arbitrary or random decision, the next time they encounter a similar situation, the outcome of past decisions will be used as a signal of their own preferences. The logic could go as follows. Once we have made a decision to buy coffee for $3, the next time we are thinking about buying coffee, we do not go back and think about the value of coffee to us, but rather we access our past decisions, notice that we have made this decision before, use it as a signal that our preferences are in fact to pay $3 for a cup of coffee and do so again. Over time, our decisions look more and more stable, even though the "seed" of the decision might not reflect true preferences.

Two other interesting cases that illustrate the impact of the past on current judgment are the sunk cost effect (Arkes & Blumer, 1985; Thaler & Johnson, 1990) and the escalation effect (Brockner, 1992). These two cases apply to situations when a decision maker faces a choice between continuing or discontinuing an endeavor in which he/she has already invested resources like money, effort, or time (Gärling et al., 1997). From a rational point of view, the choice one makes should only take into

account the consequences of the current choice. However, sunk cost and escalation effects are exemplified in a persistent commitment to a failing course of action, like continuing to wait for a bus although other modes of available transportation would be faster.

3. Time as a medium within which decisions take place

Any decision process consumes time for processing information. Some decisions are very fast, and the decisions in many cases emerge with lightning speed. Such decisions are habitual or intuitive non-analytic decisions (also called heuristic decisions), which are not based on extensive information-processing (Russo & Schoemaker, 1989). However, even these decisions endure for some, though very short, duration. The more a decision process is analytic and algorithmic, the more time is needed for its utilization. For example, calculating the expected value of a choice between 40% to make $50 and 24% to make $90 requires that the expected value (or an approximate expected value) of each alternative in the set of alternatives is first established, and only then can the alternative with the highest expected value be identified. It seems that many day-to-day decisions fall in one of these two categories: some decisions take a very short duration and in fact seem automatic (e.g., driving, typing, deciding what to wear and what to eat), and others take a very long time and seem very laborious (e.g., where to go for a vacation, what to buy one's spouse for his/her birthday, what stocks to buy and sell).

3.1. Static and dynamic decision tasks

The differentiating factor between static and dynamic decisions is whether the decision maker actively takes time into account. In making a dynamic decision, it is not enough to know what should be done, but also when it should be done (Brehmer, 1992). Taking time into account can be either in terms of considering the duration needed to make the decision, the optimal time to make a decision, or the changes in the decision structure as a function of time. Static decisions, on the other hand, are ones in which the decision maker takes no account of any aspect of duration and treats the decision task and process as static. Examples of static decisions are: decision to purchase a lottery ticket, deciding whether to take a coffee break, picking a movie, etc. A prototypical example of a dynamic task is that of a firefighter trying to control a fire, while the context and the decision environment change over time (Klein, 1993), either as a function of the sequence of decisions, independently of them, or of both (Edwards, 1962). In fact, many, if not most, of day-to-day decision tasks are dynamic, that is tasks in which sequences of decisions are continuously changing. Even buying food in the supermarket or ordering dessert in a restaurant is essentially a dynamic decision process, since the outcome of previous decisions (how good the tomatoes were, how filling the entree was) enters into the considerations for future decisions. Similarly, simple decisions such as buying a lottery ticket, deciding whether to take a coffee break, or choosing a movie to go to can be considered in a

dynamic framework, since most likely they will have long-term implications and will influence other decisions that decisions makers are likely to make.

However, despite the importance and prominence of dynamic decision making, most of the decision making research has focused on static decision tasks. Kerstholt and Raaijmakers (1997) suggest that the reason for this emphasis on single-stage static decision tasks is due to the difficulty of investigating dynamic tasks, because of the lack of control resulting from the great number of different trajectories participants may activate through the decision space. Similarly, Edwards, Lindman, and Philips (1965) argued that only the dynamic approach can do justice to the complexity of real-world decisions.

Although research of dynamic decisions is not as common, there are a few examples of this type of work. For example, Kerstholt (1994, 1995) investigated the relationship between decision makers' timing of actions and the evolution and rate of change of the dynamic system in which they were operating. From normative models of the experimental task, it could be deduced that the higher the rate of change, the earlier decision makers should have started their intervention. The results showed that participants were not sufficiently sensitive to the task's rate of change and instead based their intervention decision on the system's current state. As a consequence, less time remained for corrective actions when the system rapidly deteriorated, resulting in suboptimal performance. Kerstholt concluded that decision makers are not very good at selecting the right timing for intervention.

3.2. Single- and multiple-stage decision models

Despite the fact that most of the research on decision making tends to be based on static decisions, some of the models that are used to describe the decision making process are multi-stage models. These models are not dynamic per se (because they do not take time into account directly); nonetheless, they do form a bridge between static and dynamic decision models.

What differentiates most multi-stage models from each other is the specification of the different steps and processes that take place during these stages. For example, prospect theory (Kahaneman & Tversky, 1979) assumes that decision making is divided into two steps: editing and evaluation (ignoring stages like the generation of alternatives). Editing is the initial phase in which the decision maker builds his/her internal representation of the decision problem. In the evaluation step, the prospects of each alternative are derived from the prospect function. Another multi-stage decision process is Simon's (1972) model, in which he argues that a typical decision making process is composed of four sequential steps: identification of the need to make a decision, information gathering, defining potential alternatives, and choosing the best alternative.

Two of the best-known multi-step models – elimination by aspects (EBA) (Tversky, 1972), and the Lexicographic model (e.g., Svenson, 1979) – can be seen as dynamic models, since the steps are actually similar in terms of the underlying cognitive process and they describe a process of iterations that continues until some criterion is met. However, they are not dynamic models in the full sense of the

definition, because these models cannot account for vacillations. Another approach that bridges static multi-step models and dynamic models is the perspective that decision makers utilize a sequence of two or more decision strategies in order to reach a final decision, and that the particular strategies used depend on the task context. For example, if the number of alternatives in the offered set of alternatives is large, the decision maker might first utilize an EBA-type strategy for eliminating the number of alternatives to only two or three, and then he/she may apply a more analytic-compensatory strategy for making the final choice (Payne, Bettman & Johnson, 1988).

4. Time as a resource and as a contextual characteristic

Since decision making is usually a time-consuming process, time is an important resource for making optimal decisions. The allocation of less time than that needed or perceived as needed for making a decision might cause a feeling of time-stress and might harm the optimality of decision processes. For example, time-stress might cause decision makers to make choices that do not correspond to the outcomes predicted by multi-attribute-utility models or might cause not choosing the alternative with the highest expected value (Payne et al., 1988, Payne, Bettman & Johnson, 1993; Zakay & Wooler, 1984). The importance of understanding how and why time-stress influences decision making stems from the fact that in many real-life situations (e.g., completing an examination or a project) and especially in emergency situations, shortage of time, or the existence of a deadline is a natural characteristic of the decision environment.

4.1. What is time-stress?

An unsolved methodological problem underlying time-stress research is the lack of a definition of time-stress. The common method for inducing time-stress is by shortening the duration available for making a decision (MacGregor, 1993). But the nature of the function, which relates objective duration with time-stress, is not clear. Due to this methodological problem, most of the knowledge acquired about decision making under time-stress is mainly related to the impact of objective time shortage. People can react differently to time pressure. Some can be stimulated to engage in more thought and even do better when deadlines are imposed, while others are doing much worse than they would under normal conditions (Christensen-Szalanski, 1980; Hogarth, 1983). Findings like these indicate that the relationship between objective shortage of time and time-stress might be a complex one and not limited to direct effects of time-stress on decision outcomes.

4.2. Effects of time-stress

Time-stress is an important contextual variable that has an impact on the nature of the decision processes and in particular, on the strategies decision makers select.

The negative effect of time-stress on decision making effectiveness has been reported by many investigators, and the pattern of results obtained is quite homogeneous and consistent (Ben-Zur & Breznitz, 1981; Edland & Svenson, 1993; Janis, 1982; Keinan, 1987; Rothstein, 1986; Svenson & Edland, 1989; Svenson & Maule, 1993; Wright, 1974; Zakay, 1985; Zakay & Wooler, 1984). However, some of the consequences of time-stress are not necessarily negative. For example, Svenson and Benson (1993) found that the framing bias was weaker under time-shortage. In brief, the general effects of time-stress on decision making are:

1. A reduction in information search and processing.
2. A reduction in the range of alternatives and dimensions that are considered.
3. An increased importance of negative information.
4. Defensive reactions, such as neglect or denial of important information.
5. Bolstering of the chosen alternative.
6. A tendency to use a strategy of information filtration; that is, information that is perceived as most important is processed first, and then processing is continued until time is up.
7. Increased probability of using non-compensatory choice strategies instead of compensatory ones.
8. Forgetting important data.
9. Wrong judgment and evaluation.

Decision making as a complex cognitive process consumes mental and attentional resources. As in any other cognitive functions, the impact of limited resources on the performance can be noxious (e.g., Reason, 1998; Wickens, 1992). There are several reasons why mental resources might be reduced under time-stress. One potential reason is information-processing overload caused by the need to process large amounts of information in short periods of time. Janis and Mann (1980) argue that time constraints are one among a number of variables identified as inducing stress-states. Cognitive functioning in general, including decision making processes, deteriorates under stress, since it enhances the utilization of suboptimal cognitive processes and the appearance of cognitive errors and biases (Goldberger & Breznitz, 1999; Holsti & George, 1975). Thus, psychological stress is a mediator between shortage of time and decision making behavior (e.g., Mano, 1992). This view implies that the impact of time-stress on decision making is not unique and should be similar to that of other causes of psychological stress, like the criticality of the decision, the impact of its potential outcomes and the accountability of the decision maker.

4.3. Decision strategies and time-stress

An important question to ask regarding the effects of time pressure on decision making is whether time-pressure changes decision strategies. If decision makers are not sensitive to the duration in which they can execute their decision, they might try to apply algorithmic-compensatory strategies under time pressure, but due to shortage of time and mental resources the decision maker might not be able to

complete all the steps or might make cognitive errors while following the rules implied by the strategy (Ben-Zur & Breznitz, 1981; Payne et al., 1988). To overcome the potential reduction of decision quality in these situations, Payne et al. (1993) argued that there might exist a possible hierarchy of responses to time pressure. First, people might try to respond simply by working faster. If this were insufficient, people might then focus on a subset of the available information (utilization of suboptimal micro-strategies). Finally, if this were still insufficient, people might change their processing strategies, utilizing simpler nonlinear decision strategies (Ben-Zur & Breznitz, 1981; Christensen-Szalanski, 1978, 1980; Mano, 1992; Wright, 1974; Wright & Weitz, 1977), which were cognitively simpler than linear compensatory ones (Einhorn, 1970).

In a different approach to the same issue, Zakay (1993) introduced a model that suggested that the reduced amount of resources which are available for the decision maker operating under time limit conditions is caused partly by an automatic allocation of attentional resources for monitoring the passage of time itself. A major assumption of this model is that whenever the decision maker perceives a situation as characterized by time-shortage, a resource-demanding process of continuous prospective duration estimation starts automatically. Supporting these ideas, Zakay and Wooler (1984) demonstrated that training participants improve their performance under normal conditions, but not under time-stress (where training in fact decreased decision quality).

4.4. The adaptive perspective

As noted in Section 4.2, a vast amount of work has demonstrated the adverse outcomes of time-stress. However, it is important to ask whether these changes in decision strategy and reductions in decision quality are an error. It is possible that decision makers wisely choose simple strategies that indeed produce lower quality decisions, but they are strategies that can be implemented within the time allotted (e.g., Ford, Schmitt, Schechtman, Hults, & Doherty, 1989). Following this line of reasoning, Payne et al. (1993) and Johnson and Payne (1985) view strategy selection as a function of both costs, primarily the effort required to utilize a decision strategy, and benefits, primarily the ability of a strategy to select the best alternative. These authors argue that decision makers, facing time limits, may be forced to resort to strategies that are less demanding, less time-consuming but also less accurate. Their results show that generally, participants appear to select a decision strategy that save them from considerable effort at the expense of only a small decline in accuracy. The adaptive perspective (Payne et al., 1993) suggests that decision makers adapt to time pressure in ways that appear to be sensitive to the accuracy of the decision process. Under moderate time-pressure, decision makers appear to adapt by being more selective in the information they consider, but under severe time-pressure, they shift to strategies that are qualitatively, and not just quantitatively different. The utilization of these strategies is a must for being able to perform well under time-pressure, and decision makers who do adapt do better than those who do not.

4.5. Effects of deadlines

It is interesting to note that in any of the models in which time-stress mediates the usage of different strategies, it is the perception of time-stress that plays a role, whether or not real time-stress is present. In this regard, deadlines are an interesting topic because they impose a subjective feeling of finality and thus can cause subjective time-stress as the deadlines get closer. Research indeed demonstrates that deadlines have a strong influence on behavior.

In a set of studies examining the effects of ending rules of second price auctions on the behavior of Internet bidders, Ariely, Ockenfels, and Roth (2000) show that fixed ending rules can cause participants to pay higher prices compared with auctions that have less deterministic ending rules (see also, Roth & Ockenfels, 2000). Fixed ending rules are like the one used by eBay (www.ebay.com), in which the auction has a specified ending time and it ends on that time (e.g., the auction will end at 12 PM). Less deterministic rules are like the one used by Amazon (www.amazon.com), in which the auction has a specified ending time, but it ends on that time only if no bids are submitted during the last 10 min. If bids are transmitted during the last 10 min, the auction is prolonged until there is a period of 10 min in which no bids have been submitted.

In a different study of deadlines, Amir and Ariely (2000) show that giving on-line shoppers coupons that expire can increase the shoppers' propensity to purchase. In one study there were coupons that expired after 16, 32, or 64 s, as well as coupons that did not expire. The results show that in all cases, time constraints made people decide faster (in fact they did not use all the time that the coupons allowed them), and sometimes changed people's propensity to purchase. Subjects in the highest time constraint condition (16 s) purchased the same amount as the subjects in the no time constraint condition, and the ones in the 64 s condition. However, subjects in the 32 s conditions purchased at a rate that was twice as high as that of the other three conditions. The authors speculated that there are two forces at work. On the one hand, deadlines increase the need to take decisive action; on the other hand, deadlines can create a feeling of lower decision quality. Thus, in order for expiring coupons to be effective, they need to increase decisiveness, while at the same time, they need to allow sufficient time so that the decision makers will trust their own ability to make high-quality decisions.

5. Time as a commodity

5.1. Effects of intensity changes over time on overall evaluations

Common experiences such as vacations, meals, and pregnancies unfold over time through a stream of transient states that vary in intensity over time. Some of the moments of such experiences are better and some are worse, some are improving and others are deteriorating. Such extended episodes are generally referred to as experience profiles, patterns, or sequences. Decision-makers often need to evaluate the

overall goodness or badness of such extended episodes, in order to assist future decisions or convey information to others. In some cases, people evaluate the goodness or badness of episodes they experienced in the past; in other cases people predict the overall desirability of episodes that they have not yet experienced. Both retrospective and prospective summary evaluations are important as inputs into decisions to repeat (or not repeat) different experiences.

Overall evaluations are not only important for decision making, but can also have direct hedonic consequences on the experiences themselves. Prospective assessment of an experience can evoke sensations such as anticipation and dread, before the experience ever takes place (Loewenstein, 1987), and retrospective evaluations can influence the utility that can be derived from consuming memories after the experience occurs. For example, a painful visit to the dentist can cause a long-term fear, and a brief exotic vacation can produce memories to be re-savored for a lifetime. Summary evaluations can also alter the experience itself. For example, anticipating an unpleasant flight can result not only in negative feelings long before setting foot on the airplane, but also in exacerbating the impact of events in the flight, such as momentary turbulence.

Recent research demonstrates that when people summarize experiences, they do not simply integrate the transient states they experienced as the events unfolded (see Ariely & Carmon, 2000). Rather, two types of defining features of the effective profile of an experience (i.e., gestalt-characteristics) appear to dominate overall retrospective evaluations. One reflects the change over time in the intensity of the transient state components. Prominent examples of such characteristics include the trend of the profile (Ariely, 1998; Loewenstein & Prelec, 1993) and its rate of change (Hsee & Abelson, 1991; Hsee, Abelson & Salovey, 1991). The other type of gestalt-characteristic reflects the intensity of the transient experience at particular key points in time. Specifically, a variety of studies found that the momentary experience at the most intense and final moments (peak and end, respectively) can account for global retrospective evaluations (Fredrickson & Kahneman, 1993; Kahneman, Fredrickson, Schreiber & Redelmeier, 1993; Redelmeier & Kahneman, 1996; Varey & Kahneman (1992)).

In two such studies, Ariely (1998) inflicted pain on participants by either using a heat probe or by pressing their finger in a vise. The stimuli were of different durations and also differed on how they progressed over time (increasing, decreasing, increasing and decreasing, etc.). After each experience, participants were asked to rate their overall pain, and these ratings were regressed on the features of the stimuli. The results showed that participants were most sensitive to changes in intensity. Intensity that increased was perceived as very painful, and intensity that decreased was perceived as not painful – even when the sum of momentary intensities was the same. This sensitivity to change was highest toward the end of the experience, and there was also an effect for the final intensity. Whether the experience is perceived to be composed of single versus multiple parts (i.e., continuous vs. discrete) moderates these results, with a significantly reduced preference for improving trends over deteriorating ones, if the experience is composed of discrete parts (Ariely & Zauberman, 2000).

5.2. Effects of duration on overall evaluations

The role of duration in overall evaluations is another interesting issue. First, simply based on the fact that decision makers place higher weight on other features of the experience (such as slope, end, and peak), it is clear that decision makers do not perfectly integrate duration. In other words, they do not perfectly integrate the area under the experience curve (add up all the intensities over time). What decision makers do instead is less clear. Work by Kahneman and his collaborators (Fredrickson & Kahneman, 1993; Kahneman et al., 1993; Redelmeier & Kahneman, 1996; Varey & Kahneman, 1992) suggests that while people place a high value on some salient features, they ignore duration, which they term "duration neglect". Fredrickson and Kahneman (1993) borrowed a metaphor from Kundera (1991), and suggested that memory is built on snapshots and not on film. They suggest that memory is one of the features of extended experiences that is usually not attended to. There is a class of events that naturally seems to fall into this category. For example, one's wedding can be remembered by a few key moments, and so are some medical treatments, discovery processes, and mountain climbing.

Ariely and Loewenstein (2000) argued recently that the role of duration should be considered separately in two aspects of behavior: encoding, and making choices. They argue that when encoding (or communicating to others) the goodness and badness of experiences, ignoring duration is not necessarily a mistake and can even be desirable. Consider, for example, a friend who returned from a trip to Israel. When you ask your friend how his trip was, do you want his answer to reflect the duration of his trip? The answer is probably *no*. If your friend were to answer that his trip was perfect/awful just because he was in Israel for a very long/short time, he would mislead you. In fact, you might want to know how much he enjoyed the trip so as to help you decide how long a trip you should take. The idea here is that in many cases, overall evaluations are used to classify events into classes of desirable and non-desirable objects, and their duration is often a separate factor that can be considered later (at the choice stage). In the case of making choices, the role of duration should be very different. When choosing, it would be a mistake not to take duration into account, because this could cause a wrong allocation of time to different activities. For example, if we were not to take into account the time it takes to commute to work, the length of the line in the supermarket, and time to spend with our family, we would make non-normative allocation decisions of time to different activities.

We would like to offer the following general model for understanding the effects of duration on the evaluation of sequences. When encoding experiences, particular attention is given to salient attributes, which in most cases do not include duration. Therefore in encoding, duration is mostly ignored (exceptions are prison sentences, childbirth, waiting at the supermarket, etc.). The same type of underweighting of duration takes place when remembering an experience or when conveying information to others. However, when making decisions about future events, the picture changes, and in these cases, decision makers take into account the expected intensity and duration (for a more general discussion see Ariely, Kahneman & Loewenstein, 2000).

The big question is whether the lack of attention paid to duration is normatively desirable or whether it will lead to errors in decision making. Ariely and Loewenstein (2000) argue that in fact in most cases it would be a *mistake to incorporate duration into the representation of an experience.* They argue that if a decision maker experienced an event and now wants to make a decision about an event of a different duration, having a composite representation makes the decision much more difficult. In such a case, the decision maker would have to factor out the duration of the past experience from its representation and next incorporate the expected duration of the future event. Such a process is much more complicated than using duration-free evaluations of part events and taking the duration of future events directly into account. Moreover, Ariely and Loewenstein (2000) argue that for many decisions, duration is not imputed, which means that the decision maker can decide about the duration during the experience itself.

In fact, Ariely and Loewenstein (2000) argue that duration should be normatively incorporated into overall evaluations only under very restricted set of circumstances. Such circumstances are when (a) decision makers do not know how long future experiences will last, (b) they cannot control the duration of future experiences, but (c) they know that the duration of future experiences will be the same as the duration of past experiences. Finding such circumstances seems rather rare, and therefore, neither encoding nor reporting duration seems to be a desirable approach.

5.3. Why and how do gestalt-characteristics influence summary assessments?

As we suggested earlier, research to date clearly supports the notion that two types of defining features of the experience (gestalt-characteristics) are significant predictors of its summary assessment. One type represents configural aspects of the experience, such as the trend of its profile; the other represents the transient state at key moments (end, peak). A remaining challenge is to identify the specific gestalt characteristics of common types of experiences and to understand how they are encoded in memory and how they influence judgments and decisions. We believe that a productive approach toward this is to consider the reasons people might form overall evaluations of extended experiences.

One of the reasons decision makers might summarize experiences is to facilitate effective decisions by helping to predict future states. To illustrate, imagine a patient undergoing a painful and long medical treatment that becomes less painful over time. Based on such a trend of decreasing pain, the patient may extrapolate that the future is likely to be less painful, or even infer that she or he is closer to full recovery.

A second reason why decision makers summarize experiences may be to cope with their cognitive limitations, which requires efficient representation of the many detailed characteristics of stimuli such as experienced events. For many situations such parsimonious representation of experiences with a few key characteristics seems highly adaptive, and hence reasonable. The alternative, collecting and representing each of the individual transient states of an experience, may often be too demanding of the person's cognitive resources, and may offer relatively minor marginal benefits. A similar argument can be made for limited resources during the information

retrieval and response generation process. This encoding view predicts that only a few features of the experience will be encoded and will influence summary evaluations (see Kahneman, 1995). Examples of such features are likely to include particularly salient characteristics such as the most intense state (peak) and the final state (end) of the experience.

6. Summary and future questions

In the current paper, we have attempted to take stock of some of the issues relating time and decision making. This account is by no means complete, and it reflects our individual biases. The topics we identified and discussed were fourfold: (a) We identified and discussed the temporal perspectives of decision making; within this topic we discussed time discounting, changes in thought processes as a function of time, overcoming inconsistent time preferences, and evidence for (perhaps artificial) increased stability in decision making over time. (b) Second, we identified time as a medium within which decisions take place. Within this topic we discussed static and dynamic decision tasks, and single and multiple stage decision models. We feel strongly that these distinctions are important and that insufficient research has been directed to dynamic decision making. (c) Third, we identified and discussed time as a resource and as a contextual characteristic. Within this topic, we discussed time-stress and its effects, the influence of time-stress on decision strategies, time-stress as a contextual factor, the adaptive perspective on the relationship between time-stress and decision strategies, and a description, at the end, of some new research regarding the effects of deadlines. (d) Fourth, we identified and discussed time as a commodity. Within this topic we discussed the effects of intensity changes over time on overall evaluations, the effects of duration on overall evaluations, and two reasons why gestalt-characteristics may influence summary assessments.

While writing this review we identified some unsolved questions that we believe demand future research in order to better understand the interactions and relationship between time and decision making:

(1) We believe that it is important to understand the effects of temporal-distance on the evaluation of alternatives, both before and after the decision implementation point in time. We presented a simple symmetrical time-discounting illustration in Fig. 1, from which many interesting questions can emerge. What are the determinants of discount rates? What are the discounts rated for different durations (see Chapman, this issue)? What are the relationships between forward and backward discounting?

(2) Most of the research in the decision making domain is focused on the step in which alternatives are compared and one alternative is chosen. However, other steps like alternatives' generation or problem recognition, which in some cases might determine the fate of a decision, are not well understood. There is a need to identify all the steps that decision makers use while looking at decision making from a broader perspective and to define the processes utilized in each one of the relevant steps.

(3) We believe that there is a need to examine more deeply dynamic decision tasks, since they are so common in real life, and since it is clear to us that the strategies used for single or multiple stage static decisions are not going to provide a comprehensive account of the dynamic processes. It is of special interest to find out if decision makers apply unique decision strategies while facing such tasks, or whether they utilize the same strategies that are common in static tasks, but perhaps in different combinations. An additional reason for a more detailed examination of dynamic decision processes is based on the observation that decision making in real life does not stop after reaching a first decision. The effort that people invest in many decisions seems to be mainly focused at resolving vacillations and conflicts. We feel that we need to better understand how such internal conflicts are solved.

(4) The nature of the relationship between objective time available for making a decision and perceived time-stress should be defined. This is a complex question, since people might mobilize energy if they perceive time-stress, regardless of the objective time (Svenson & Benson, 1993). Moreover, there is the need to build a theory that can explain when and how micro-strategies are utilized under time-stress.

(5) As we noted in the section on the evaluations of overall experiences, little is understood about the mechanisms underlying the different gestalt characteristics. Why is it that these gestalt characteristics have such a large influence on overall evaluations? Other important questions in this domain involve the role of memory. How are evaluations changed as a function of distance from the experience either before or after the event? Finally and perhaps most significantly, all the experiences studied thus far were either pleasurable or painful. How will the rules described by the gestalt characteristics apply for experiences that have both pleasure and pain spaced over time, over different sensory modalities (pleasant smell and a toothache), or different body parts (pleasure in the hand and back pain)?

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