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Why Time Seems to Pass Slowly for Unpleasant Experiences and Quickly for Pleasant Experiences: An Explanation Based on Decision Theory

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Why Time Seems to Pass Slowly for Unpleasant Experiences and Quickly for Pleasant Experiences: An Explanation Based on Decision Theory

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Abstract It is known that our perception of time depends on our level of happiness: time seems to pass slower when we have unpleasant experiences and faster if our experiences are pleasant. Several explanations have been proposed for this effect. However, these explanations are based on specific features of human memory and/or human perception, features that, in turn, need explaining. In this paper, we show that this effect can be explained on a much more basic level of decision theory, without utilizing any specific features of human memory or perception.

1 Formulation of the Problem

Perceived time is different from actual time: empirical fact. Many of us have felt that time seems to pass quickly for pleasant experiences and slowly for unpleasant ones. We seem to overestimate time elapsed for unpleasant experiences and underestimate time elapsed for pleasant ones. For example:

- If we are watching a movie we really like, or if we are out on a date with someone we love, hours go by and it fells like only few minutes have passed.
- On the other hand, if we are in a situation where we have to conceal something from people around us – a situation that makes us uncomfortable – we cannot wait for the focus of people or the topic of conversation to be shifted to someone or something else, in such a situation even few seconds feels like long minutes; see, e.g., [10].

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In all these cases, while the actual time for those experiences doesn't change, our perception of this time changes depending on the experience.

How is this phenomenon explained now. There are several explanations for this effect; see e.g. [1, 2, 3, 13], but these explanations are based on specific features of human memory and/or human perception, features that, in turn, need explaining.

What we do in this paper. In this paper, we show that this effect can be explained on a much more basic level of decision theory, without utilizing any specific features of human memory or perception.

2 Decision Theory: A Brief Reminder and the Resulting Explanation

What is decision theory. Decision theory describes the preferences of a rational agent – i.e., a person who, e.g., if he/she prefers option A to option B and B to C, will always prefer option A if provided with two options: A and C; see, e.g., [5, 7, 9, 11, 12].

Comment. In real life, people are rarely fully rational, as our ability to process information in short time and make optimal decision is limited; see, e.g., [6, 8]. However, decision theory still provides a reasonably accurate description of human behavior.

Utility: the main notion of decision theory. Decision theory shows that for each rational agent, we can assign a number – known as *utility* – to each possible alternative, so that in each situation of choice, the agent selects an alternative whose utility is the largest [5, 7, 9, 11, 12].

Utility is influenced by the past evens as well. People's moods and preferences are affected not only by the current events, but also by the events that happened in the past. This makes sense: past experiences help make reasonable decisions.

In decision theory terms, preferences are described by the utility values. In these terms, a person's current utility value depends not only on the situation at the present moment of time t_0, but also on the utilities $u_1, u_2, \ldots$, at the previous moments of time $t_1 > t_2 > \ldots$

How can we describe this influence: the notion of discounting. Let us denote by u_0 the utility that we would have gotten at the current moment of time t_0 if the past did not influence our current decision making. To describe this influence, we need to find out how the current utility value u depends on this utility u_0 and on the utilities u_1, u_2, etc., at the previous moments of time, i.e., what is the dependence

$$u = f(u_0, u_1, u_2, \ldots) \tag{1}$$

The effect of past events on our behavior is relatively small, the largest factor is our decisions is still the current situation. Since the effect of the values $u_1, u_2, \ldots,$

etc. is small, we can do what physicists do in similar situations (see, e.g., [4, 14]): expand the dependence (1) in Taylor series in terms of u_i and keep only linear terms in this expansion. Thus, we get the following formula:

$$u = f_0(u_0) + f_1(u_0) \cdot u_1 + f_2(u_0) \cdot u_2 + \ldots \tag{2}$$

When there is no influence of past events, the resulting utility is simply equal to u_0 – by definition of u_0. Thus, we have

$$f_0(u_0) = u_0, \tag{3}$$

so

$$u = u_0 + f_1(u_0) \cdot u_1 + f_2(u_0) \cdot u_2 + \ldots \tag{4}$$

The value $f_i(u_0)$ depends on the moment of time t_i – naturally, the more recent ones affect more, the more distance one affect less. Let us describe this dependence by writing $f_i(u_0)$ as $F(u_0, t_i)$. Here, the function $F(u_0, t)$ is non-positive – since positive past events make us feel better, while negative past events make us feel worse. As time t decreases, the effect decreases, i.e., the function $F(u_0, t)$ is increasing, going from the zero limit value $F(u_0, t)$ when $t \to -\infty$ to a positive value $F(u_0, t)$ for moments t which are close to the current moment t_0. Thus, the formula (4) takes the following form:

$$u = u_0 + F(u_0, t_1) \cdot u_1 + F(u_0, t_2) \cdot u_2 + \ldots \tag{5}$$

Comment. As we have mentioned, the past values u_1, u_2, etc., affect the utility less than current value u_0. In economics, a similar decrease of value with time is a particular example of a *discount*. Because of this analogy – and since economics is one of the main application areas of decision theory – this decrease is known as *discounting*.

Time is subjective. In contract to computers that have inside a reasonably precise clock, we humans operate on subjective time: sometimes our processes go faster, sometimes they go slower – e.g., when we are sleepy or asleep. The whole empirical phenomenon that we try to explain is exactly about the difference between this subjective time and the clock-measured physical time.

To a large extent, whether we slow down our perception of time or speed up, is within our brain's control. So how does the brain select whether to slow down or to speed up subjective time?

Let us apply decision theory to our selection of subjective time. In line with the general ideas of decision theory, our brain decides whether to slow down or to speed up depending on which option leads to larger utility.

How does subjective time affect our utility? Subjective time is all we observe, all we feel. Thus, in the formula (4) describing current utility, we should use subjective times s_1, s_2, etc., instead of the actual (physical) moments of time t_i. In other words,

in view of the fact that the subjective time may be different from the physical time, the formula (5) describing current utility value takes the following form:

$$u = u_0 + F(u_0, s_1) \cdot u_1 + F(u_0, s_2) \cdot u_2 + \ldots \tag{6}$$

Interestingly, already this formula leads to the desired explanation. Let us explain how.

Resulting explanation: case of pleasant experiences. If we are in the middle of a positive time period, i.e., if the current experience and all recent past experience are positive, this means that $u_i > 0$ for all i. In this case, the larger each coefficient $F(u_0, s_i)$, the larger the resulting sum (6).

We have mentioned that the function $F(u_0, t)$ is an increasing function of time. Thus, to increase the value $F(u_0, s_i)$, we need to select the subjective value s_i of the i-th past moment as large as possible – i.e., bring it as close to the current moment of time as possible, i.e., take $s_i > t_i$.

In this case, the subjective time duration $t_0 - s_i$ decreases in comparison with the corresponding period $t_0 - t_i$ of physical time, i.e., subjective time goes faster – exactly as we observe.

Resulting explanation: case of unpleasant experiences. On the other hand, if we are in the middle of a negative time period, i.e., if the current experience and all recent past experience are negative, this means that $u_i < 0$ for all i. In this case, the smaller each coefficient $F(u_0, s_i)$, the larger the resulting sum (6).

We have mentioned that the function $F(u_0, t)$ is an increasing function of time. Thus, to decrease the value $F(u_0, s_i)$, we need to select the subjective value s_i of the i-th past moment as small as possible – i.e., bring it as far away from the current moment of time as possible, i.e., take $s_i < t_i$.

In this case, the subjective time duration $t_0 - s_i$ increases in comparison with the corresponding period $t_0 - t_i$ of physical time, i.e., subjective time goes slower – exactly as we observe.

Conclusion. So, in both cases, decision theory indeed explains the desired phenomenon.

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