

Another dimension of psychological time: judgments of anticipated future duration

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Abstract

Whereas a great deal of research has examined the perception of elapsed time (time that has passed), little is currently known about how people perceive future durations (time that will pass). The current article discusses our findings on judgments of future durations that have important ramifications in understanding individuals' inter-temporal decisions. Our work demonstrates that people do not perceive future durations accurately, but rather subjectively scale them non-linearly (i.e., they show diminishing sensitivity to longer durations), consistent with classic psychophysical processes. We show that this property of non-linear scaling explains hyperbolic discounting, or why the tendency to prefer smaller-sooner rewards over larger later rewards becomes disproportionately stronger when the sooner rewards is available immediately. Our works further show that judgment of future durations is susceptible to a range of contextual influences, including as time-space interdependence, sexually arousing imagines, and tempo, which in turn then influence their valuation for delayed outcomes.

1. Introduction

When time passes, the length of the same duration is often judged differently across different situations or people. This subjective nature of duration judgment has been extensively documented in psychology literature. Researchers have proposed various theories and mechanisms to explain how and why durations are perceived [1, 2, 3], and factors such as emotional states or physiological activation have been identified to influence duration perception (see Ref. [4] for a review).

Such investigations of duration judgments involve time that has actually passed, that is, durations that people have already experienced, as they are unfolding or looking back. But many decisions people make often involve judgment of durations of a different type; judgments of a time period that is set in the future, or *anticipated future durations*. Future duration is a key component for decisions involving outcomes at different points in time, often referred to as inter-temporal decisions. For instance, when there will be a price promotion

next month, people decide whether they want to purchase a product at a full price today or purchase it at a discounted price next month. In making such decisions, people's subjective judgment of future durations might be an important determinant. For instance, those who perceive the one-month wait to be long are more likely to opt for the immediate purchase than those who perceive it to be short, who are more likely to wait to get the price discount. Future duration is also an important attribute when determining the values of various types of goods. For experiential goods like vacation packages, price is generally higher the longer the experience is. For goods with service contract periods like gym membership, monthly prices are lower as the contract term becomes longer. For these goods, people's subjective judgment of experience durations or service periods would influence perceived value of these goods.

Although judgment of future durations are frequent in numerous situations, compared to the extensive study of judgments of durations that have passed (*elapsed duration*), investigations on the judgment of anticipated future durations are still very scant. The current paper aims to introduce recent empirical findings about judgments of future durations. We focus on one particular property of future duration judgment that has important ramifications in understanding inter-temporal decisions: the non-linearity of judged future durations. We further discuss two contextual factors that influence judgment of future durations.

2. Non-linearity in future duration judgment

Traditional research on psychophysics investigates how the objective magnitude of external stimulus is internally scaled or translated into subjective magnitude. To use vision as an example, researchers present participants with stimuli in different luminance and measure how bright they subjectively feel the stimuli to be. That is, they study the relationship between objective luminance and its perceived brightness. For many stimuli that are subject to human perception or sensation, researchers found that internal scaling of external stimuli is non-linear (e.g., Weber-Fechner Law or Steven's Power Law).

Zauberman and colleagues tested whether judgment of anticipated future durations are also non-linearly scaled (Kim & Zauberman, 2009; Zauberman, Kim, Malkoc, & Bettman, 2009). They presented participants various lengths of future durations (e.g., duration from today to a day in 3 months) and asked them to indicate how short or long they considered the duration to be. In line with findings in psychophysics, they found that subjective judgment of future durations is also non-linearly scaled. In particular, they found that when future durations become longer, the subjective judgment of future durations does not grow proportionally. That is, subjective future duration does not grow linearly on a 1:1 scale, but rather is better described using a power function, where the relationship between future duration and its subjective judgment can be described by a power exponent less than 1.

Such non-linear scaling in judgment of future durations has important implications for our understanding of how people think of future durations and then how they use this information in their decisions. We argue that it is important to study future durations in the context of these decisions, because it provides a context in which the perceptual process can be studied, as well as demonstrates its implications. The inter-temporal choice literature has a well-documented phenomenon often labeled as hyperbolic discounting. This phenomenon depicts a pattern of behavior that people's tendency to prefer sooner but smaller rewards over larger later rewards becomes stronger as the sooner rewards are more immediately available. In other words, when people have to delay immediately available rewards they are very impatient, but when they have to delay rewards that are already set in the future they tend to be much less impatient. This means that devaluation over a given future delay depends on when this delay occurs. Although this phenomenon has instigated numerous empirical studies and has been demonstrated for different species (both human and animals), for different types of rewards, and for various individual difference factors (i.e., people in different age, education level, or health-related conditions), not much is known about the underlying processes (see Ref. [5] for a review). The non-linear scaling we propose in future duration judgment provides an explanation for the phenomenon [6, 7]. The non-linearity in future duration judgment implies that the same length of delay will be judged subjectively longer when it is a delay from an earlier time point than from a later time point. Therefore, they would also perceive the same waiting time subjectively longer when they contemplate delaying immediate rewards rather than delaying rewards already in the future.

In the next sections, we discuss two contextual factors that influence judgment of future durations. In particular, we review one cognitive (*i.e.*, space-time dependency) and one affective (*i.e.*, sexual arousal) process that influence judgment of future durations, and their role in time-related decisions.

3. Cognitive influence: spatial representation of time and future duration judgments

In this section we will probe the dependency between judgments of spatial distance and judgment of (future) temporal distance. The literature on embodied cognition and cognitive linguistics suggests that when people conceive abstract notions that they cannot directly experience, they rely on experiences in more concrete domains [8, 9, 10]. For instance, people often rely on the visual image of a horizontal line and depict the temporal relation of events along the line, or describe the duration of an event by its length (e.g., a long vacation [11]). Such reliance on a spatial line to conceive duration implies that people's judgment of future durations may be influenced by the spatial distance information that is associated with these durations. Suppose, for example, that someone is in New York today but will be in San Francisco in three months. If the person conceives the three month duration as a line, the person's judgment of duration may be influenced by the spatial distance information

associated with the duration (e.g., distance between New York and San Francisco) and thus may influence the judgment of this three month duration. For instance, the same three months may be judged longer when they are associated with longer distances (e.g., New York and San Francisco) than with shorter distances (New York and Philadelphia).

Kim, Zauberger, and Bettman [12] tested this dependency on spatial distance information in future duration judgment. They showed participants a map where the spatial distance between two locations is varied by conditions. For instance, some participants were given a map where the distance between a post office and a bookstore was longer while others received a map where it was shorter. They then imagined visiting these locations at two different points in the future. They found that participants who imagined visiting places placed larger apart judged the duration between two time points to be longer than those who imagined visiting places proximal to each other. These results indicate that judgment of anticipated future durations is susceptible to spatial distance cues. They also conducted other experiments using actual maps, and using mental elaborations. Combined, they show robust evidence that longer spatial distance leads to longer judgments of future durations associated with these spatial distances. They further show that these effects on the judgment of future durations lead to changes in the inter-temporal decisions relevant to these durations. In short, longer spatial distance leads to longer perceived durations, and so also leads to greater devaluation over time.

4. Affective influence: arousal and future duration judgments

We now discuss an affective factor that influences judgment of future durations. Multiple studies on elapsed duration judgment have demonstrated that tempo (*i.e.*, repeated stimulation in audition, vision, or bodily sensation) influenced judgment of elapsed time. For instance, participants who listened to fast auditory tempo (e.g., tones repeated at a fast rate) judged the same elapsed duration to be longer than those who listened to slow tempo [18]. Because fast tempo is physiologically arousing [19, 20], grounded on similar reasoning described above about the role of arousal on narrow temporal attention, fast auditory tempo may influence future duration judgment. Kim and Zauberger tested this possibility [21]. They played participants either a fast or slow tempo music piece and asked them to judge various future durations. Similar to the effects of tempo on future duration judgment, they found that participants who were listening to the fast tempo music piece judged the same future duration to be longer than those who were listening to the slow tempo music piece.

We argue that sexual cues influence future duration judgment for a similar reason (*i.e.*, arousal-based process). Studies in inter-temporal decisions have demonstrated that heterosexual male participants who were exposed to sexual cues (e.g., photograph of women in lingerie) discounted the value of delayed rewards more heavily than those who were exposed to neutral stimuli or exposed to photographs of unattractive women [13, 14]. As discounting

delayed rewards involve judgment of future durations (i.e., waiting time to receive delayed rewards), this effect may also be explained by the subjective nature of future duration judgment. To test this possibility, Kim and Zauberan [15] showed male heterosexual participants photographs of either sexual cues (e.g., women in lingerie) or neutral objects, then asked them to judge various future durations. They found that those participants who were exposed to sexual cues judged the same future durations to be longer than those with neutral cues. That is, the participants who were exposed to sexual cues perceived the same future temporal distance to be farther away than those not exposed to sexual cues. Consequently, those exposed to sexual cues and perceived a given future duration to be longer also devalued future monetary rewards compared to present rewards. This again demonstrates the contextual dependency of future duration judgment and its effects in decisions.

Kim and Zauberan [15] suggested that such effects they observed on future duration judgment may be due to the arousing nature of sexual cues. Physiological arousal has been shown to induce narrow visual attention [16, 17]. Likewise, Kim and Zauberan [15] proposed arousal may also induce narrow temporal attention. For organisms' survival in the environment, focusing on the present moment would be critical for their survival as much as focusing on the central information in the visual field. That is, when individuals are aroused, they will be likely to focus on the present moment and to disregard the future (as much as they focus on the central information in the visual field), thus the same future date will seem farther away.

5. Future research

We discussed one important property of future duration judgment (i.e., non-linear scaling) and two contextual factors influencing future duration judgment such as spatial representation of time and sexual arousal. These effects all point to the psychological nature of future duration judgment. We now discuss venues for future research.

First, future research may investigate specific factors influencing non-linearity in future duration judgment. Non-linearity in duration judgment involves relativity between judgment of near durations and far durations. In other words, non-linearity concerns how much near durations are perceived to be longer than far durations. The factors we discussed in this paper that influence future duration judgment alters the magnitude of judged future durations rather than their relativity (i.e., curvature). That is, these factors make judged future durations to be perceived as longer or shorter in general. Because relativity in future duration judgment has direct implication on inter-temporal decisions—in particular, hyperbolic discounting—investigating such factors would be very valuable with important practical ramifications.

Second, future research may investigate the relationship between judgments of elapsed (past)

durations and that of future durations. Judgments of elapsed durations involve experiences of actual time passage and many researchers of time perception assume that time experiences are processed by a sort of an internal clock. Because future durations are time that has not been experienced, a mechanism based on an internal clock would not be relevant to the judgment of future durations. There is, however, a reason to believe that these judgments could be related. Future durations are in their nature abstract information that does not have direct bodily experiences. Because elapsed durations are more concrete (i.e., directly experienced), people may use their perception of durations currently passing to judge anticipated future durations. Then, those who feel that a duration they just experienced is long (i.e., time is passing slowly) may project their feelings and judge future durations to be long. For instance, when individuals are physiologically aroused, they feel that time is passing slowly and, as a result, feel that the future is farther away (i.e., the future is approaching slowly). Future research may systematically investigate this possible link.

Third, methodologies of precisely measuring future duration judgment would be necessary. For the judgments of elapsed durations, there are a variety of ways to measure time perception such as duration production, duration reproduction, or duration comparison. In addition, researchers used different paradigms such as prospective paradigms, where participants know that they are going to judge elapsed durations, and retrospective paradigms, where they do not anticipate to judge elapsed durations but do so only retrospectively. But for the judgment of future durations, methodological development is still very limited. Researchers mostly use a standard Likert-type scale or its variant (e.g., a continuous line scale) to measure judged future durations. Future research may develop more precise scales and paradigms that allow researchers to measure and judged future durations both more accurately and easily.

6. Conclusion

Future durations are as important to many important decisions people make as are elapsed durations, yet much less research has examined judgments of future durations. The current paper notes two important aspects of future durations. First, although future duration is often considered as objective information, its judgment is inherently subjective. People judge future durations non linearly and future durations of the same length are perceived to be subjectively longer or shorter across individuals and situations. Second, judgments of future durations are sensitive to various contextual factors. We discussed a few of these factors such as spatial distance, sexual cue, and tempo. But there would be many other factors in the environment that influence people's judgment of future durations even without their awareness. Investigating these factors would enlighten our understanding of the intriguing nature of future duration judgment as well as help people to make better decisions for various time-related outcomes.

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