Journal of Cognitive Psychology, 2015
Vol. 27, No. 8, 921–928, http://dx.doi.org/10.1080/20445911.2015.1055274

Routledge
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Rapid makes risky: Time pressure increases risk seeking in decisions from experience

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Time pressure is a common constraint on many real-world decisions, such as those made by traders placing orders in the stock market, bidders in an auction, or gamblers at a casino. Many of these situations also involve elements of risk or uncertainty. Previous research has mostly found that time pressure leads to more risky choices. These previous studies, however, have examined decisions made from probabilities that were explicitly described, rather than learned through experienced outcomes. Here we tested how time pressure influences decisions from experience, while manipulating outcome value. Participants under greater time pressure chose risky options more often, independent of outcome value. Our results suggest that, as with decisions from description, time pressure moderately increases risk seeking in decisions from experience.

Keywords: Decisions from experience; Decision-making; Risky choice; Time pressure.

INTRODUCTION

From traders in the stock market to consumers in a store, many real-world decisions are made under time pressure (e.g., Bourgeois & Eisenhardt, 1988; Dhar & Nowls, 1999; Roth & Ockenfels, 2002; Thompson et al., 2008). This time pressure can alter many facets of decision-making, potentially making people more impulsive, defensive, or stressed, and occasionally more risk seeking (Ariely & Zakay, 2001; Dror, Busemeyer, & Basola, 1999; Gladstein & Reilly, 1985; Kelly & Karau, 1999; Nursimulu & Bossaerts, 2014; Zakay & Wooler, 1984). Time pressure may also cause a shift towards more automatic, heuristic-based decisions (Kahneman & Frederick, 2002). For instance, it has been suggested that time pressure causes an increase in the subjective salience of immediate outcomes, while discounting the salience of delayed outcomes (Ariely & Zakay, 2001).

Most research on the effects of time pressure on risky decisions has investigated decisions from

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Door images were extracted from “Irish Doors” on fineartamerica.com with permission from Joe Bonita.
No potential conflict of interest was reported by the authors.
This research was funded by grants from the Alberta Gambling Research Institute (AGRI) and the National Science and Engineering Research Council of Canada (NSERC) held by M.L.S. C.R.M was supported by scholarships from AGRI and NSERC.

description, wherein people are explicitly told the probabilities and outcomes for each option. These decisions from description form a cornerstone in behavioural economics: for example, when explicitly given a choice between a guaranteed win of $20 or a 50/50 chance of winning $40, people tend to be risk averse (e.g., Kahneman & Tversky, 1979). When time pressure is applied to these decisions, however, people tend to become more risk seeking (e.g., Hu, Wang, Pang, Xu, & Guo, 2015; Huber & Kunz, 2007; Kocher, Pahlke, & Trautmann, 2013; Young, Goodie, Hall, & Wu, 2012, with one exception: Ben Zur & Breznitz, 1981). This effect of time pressure on risky choice in decisions from description may be caused by changes in information-processing strategies. For instance, time pressure may cause a shift in the scope with which people evaluate the different options, whereby people filter and process only key details of the problem, rather than extensively processing all available information (e.g., Maule, Hockey, & Bdzola, 2000). This possibility is also borne out by recent computational work, which shows that time pressure can increase the risk attractiveness of gains in a modified version of prospect theory (Young et al., 2012).

Often, however, information about odds and outcomes is not acquired through explicit description, but is instead learned through experience with the outcomes. Recently, a number of studies have shown that such decisions from experience can yield very different patterns of behaviours than decision from description, especially when the outcomes occur rarely (e.g., Camilleri & Newell, 2011; Hertwig, Barron, Weber, & Erev, 2004; Hertwig & Erev, 2009; Ludvig & Spetch, 2011). The general finding is that in decisions from experience, as in decisions from description, people are generally risk averse for gains with moderate probabilities (Erev et al., 2010; Ert & Yechiam, 2010). In a series of recent studies, we have found two manipulations that do lead to greater risk-seeking behaviour in decisions from experience. One manipulation that can induce risk seeking involves priming memories for past winning outcomes (Ludvig, Madan, & Spetch, 2015). A second manipulation involves altering the decision context: risky options that lead to the best possible outcome in a context are more likely to be chosen, a pattern termed the extreme-outcome rule (Ludvig, Madan, Pisklak, & Spetch, 2014b; Ludvig, Madan, & Spetch, 2014; Madan, Ludvig, & Spetch, 2014; see also Tsetsos, Chater, & Usher, 2012; Zeigenfuse, Pleskac, & Liu, 2014). In this paper, we evaluate whether time pressure, known to increase risk seeking in decisions from description, is a third manipulation that would increase risk seeking in decisions from experience. Further, we evaluate whether any effects of time pressure interact with outcome value.

The limited extant literature on effects of time pressure on decisions from experience suggests that people will indeed gamble more under time pressure. For example, in the Iowa Gambling Task (IGT), people more often chose the bad decks (high stakes gambles with low expected value) when there was time pressure (Cella, Dymond, Cooper, & Turnbull, 2007). A similar effect on performance in the IGT was reported for perceived time pressure induced through instructions in which participants were told that the allotted time typically was or was not sufficient to learn and complete the task (DeDonno & Demaree, 2008). Interestingly, simply inducing people to think fast can increase risky choice in the balloon analogue risk task (BART; Chandler & Pronin, 2012). Although these results suggest that time pressure increases risky choice, the experimental designs of the IGT and BART do not allow us to fully disentangle effects of risk preference and expected value, as the options differ in both risk and outcome value. Other experience-based tasks have also been used to investigate the effects of time pressure on risky choice, but these have also manipulated additional choice variables, such as using asymmetric probabilities or non-binary outcomes for the risky options or different expected values for the safe and risky options (Goldstein & Busemeyer, 1992; Nursimulu & Bossaerts, 2014). Thus, it has not yet been shown if time pressure would increase risk seeking in decisions from experience when other choice variables are held constant.

Animal studies, which by necessity involve learning about the outcomes and probabilities through experience, have also provided evidence for an effect of temporal parameters on risk seeking. For example, Hayden and Platt (2007) investigated monkeys' choices between fixed and risky options that had the same expected value and found that monkeys were more risk seeking when choices were separated by shorter inter-trial intervals (ITIs) (cf. Heilbronner & Hayden, 2013). This suggests that animals make riskier choices when decisions are presented to them rapidly than when choices are experienced at a more leisurely pace.

In the current study, we used a straightforward decisions-from-experience risky-choice task, similar to that used in animal research, in which participants chose between safe and risky options that had equal expected value. The main purpose of the study was to evaluate whether increases in time pressure lead to more risk seeking in these decisions from experience, as has been previously found with decisions from description (e.g., Maule et al., 2000). Time pressure was manipulated between subjects: for the *fast* group, choices were presented rapidly and participants had a short period of time to make their decisions; for the *slow* group, choices were more spaced and participants had a more lenient deadline to make their decision. In other words, here we manipulated time pressure in two ways: the choice deadline forced participants to make each decision faster. The shorter ITI presented these decisions at a faster pace. By simultaneously manipulating time pressure in both of these ways, we aimed to maximise the likelihood of finding any effect of time pressure on risky choice in decisions from experience.

A second purpose of the study was to determine whether the effects of time pressure on risky choice would depend on the decision context provided by choices yielding different outcome value (i.e., magnitude). In previous research, we found that people are more risk seeking for high-value options than for low-value options when both are provided in the same context. This difference in risk seeking appears to reflect the overweighting of extreme values, termed the extreme-outcome rule (Ludvig, Madan, & Spetch, 2014), and memory biases appear to underlie this effect (Madan et al., 2014). Here we tested whether time pressure would interact with these context effects and mitigate or exaggerate the influence of the extreme-outcome rule on risky choice. Participants in both groups were presented with two sets of choices: one set provided low-value outcomes and the other high-value outcomes (Figure 1). For the low-value set, the certain option paid 20 points and the risky option paid 0 or 40 points with equal odds. For the high-value set, the payouts were 60 for the certain option and a 50/50 chance of 40 or 80 for the risky option. Based on our previous research using the same outcome values (Ludvig, Madan, Pisklak, et al., 2014; Ludvig, Madan, & Spetch, 2014, Exp. 4G; Madan et al., 2014, Exp. 2), we predicted that participants would be more risk seeking for the high-value options (relative gains) than the low-value options (relative losses). Of interest here was whether time pressure would modulate these effects.

We also examined whether participants' response times (RTs) differed depending on the outcome value (high or low), or on the selected option (risky or safe). Here we predict that response latencies will be shorter for the high-value than low-value options, consistent with results found for humans (e.g., Madan, Fujiwara, Gerson, & Caplan, 2012; Shenhav & Buckner, 2014; Tobler, O'Doherty, Dolan, & Schultz,

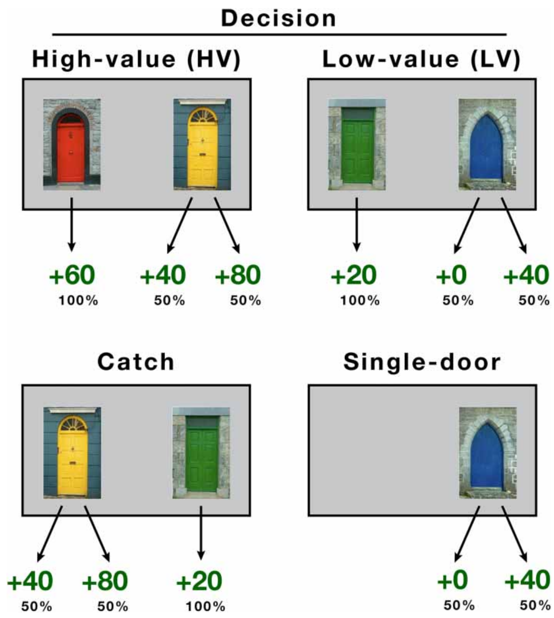

Figure 1. Doors led to either high-value or low-value outcomes. Fixed doors always led to a safe outcome. The risky doors led equiprobably to one of two possible outcomes. Participants were not provided with the outcome probabilities at any point in the task. Choices were always followed by feedback about the amount of points gained on the current trial. [To view this figure in colour, please visit the online version of this Journal.]

2006) and starlings (Shapiro, Siller, & Kacelnik, 2008). This prediction is also convergent with the notion that a fundamental purpose of movements is to obtain rewards, leading people to move faster when a higher value reward is the predicted goal (e.g., Haith, Reppert, & Shadmehr, 2012; Madan, 2013).

METHODS

Participants

Seventy-two introductory psychology students at the University of Alberta participated for course credit (48 females; M_{age} (SD) = 19.07 (1.35) years). Participants were randomly assigned to the fast (N = 38) or slow group (N = 34). The research was approved by a university ethics board.

Procedure

Figure 1(a) illustrates the trial procedure. On each trial, participants saw images of one or two doors on the computer screen and selected one by clicking on it with the computer mouse. Participants in the fast group had 1.5 s to make their choice, and participants in the slow group had 5.0 s. If a participant reached their choice deadline, a black screen was presented for 1.0 s informing the participant that they were too slow, and the participant earned 0 points on that trial. When the participant made a choice before their respective deadline, the number of points earned was immediately presented on the computer screen for 1.2 s. Total accumulated points were continuously presented at the bottom of the screen. In the fast group, the ITI was 0.5 s; in the slow group, the ITI was 4.0 s.

Experimental sessions were made up of six blocks of 48 trials. Each block consisted of several types of trials (Figure 1(b)). Twenty-four *decision trials* required a choice between a safe door that led to a fixed, guaranteed outcome and a risky door that led equiprobably to two possible outcomes. Both doors had the same expected value. Half of the decision trials were high-value decision trials, where the choice was between a fixed door that led to winning 60 points and a risky door that led to winning 40 or 80 points. The remaining half of the decision trials were low-value decision trials, where the fixed door led to winning 20 points, and the risky door led to winning 0 or 40 points. For each participant, each door image was consistently mapped to a value and risk level. Performance on decision trials was the primary-dependent measure (i.e., risk preference; proportion of trials where the risky door was chosen). Sixteen *catch trials* were presented, where participants had to make a choice between a high-value door and a low-value door. These trials were included to ensure that participants were engaged in the task and to assess whether participants learned the contingencies. Eight *single-door trials* were also included, where only one door was presented and the participant had to choose it. These trials were included to ensure that participants experienced all reward contingencies, even if the doors were initially unlucky, thereby limiting any hot-stove effects (Denrell & March, 2001). Participants were paid $1 for every 3600 points earned to a maximum of $5.

Trial order was randomised within blocks. Each door appeared equally often on either side of the screen and in combination with the other doors. Door colour was counterbalanced across participants.

Data analysis

Risk preference was operationalised as the probability of choosing the risky door over the final three blocks—after sufficient opportunity to learn the outcomes associated with each door (see also Ludvig, Madan, & Spetch, 2014; Madan et al., 2014). As the literature suggests time pressure should increase risk seeking, a one-tailed statistic was used. To ensure that our manipulation was successful in inducing time pressure, we compared RTs between the two groups of participants. To account for the asymmetries in RT distributions, RTs were log-transformed, and the median was used as the measure of central tendency. RTs were calculated separately based on both the decision type (high, low) and selected door (risky, fixed). Effects were considered significant based on an alpha level of .05. ANOVAs are reported with Greenhouse–Geisser correction for non-sphericity where appropriate.

Data from 3 participants from the fast group who chose the high-value door on fewer than 60% of the catch trials was excluded, yielding 35 participants in the fast group and 34 in the slow group. All significant results remain even if these participants were retained.

RESULTS

As predicted, Figure 2 depicts how the fast group was moderately more risk seeking than the slow group [$F(1, 67) = 3.53$; one-tailed: $t(67) = 1.88$, $p = .032$, $d = 0.44$]. As expected based on the extreme-outcome rule (Ludvig, Madan, & Spetch, 2014), there was more risk seeking for high- than low-value decisions [$F(1, 67) = 47.79$, $p < .001$, $\eta_p^2 = 0.42$]. There was no significant interaction

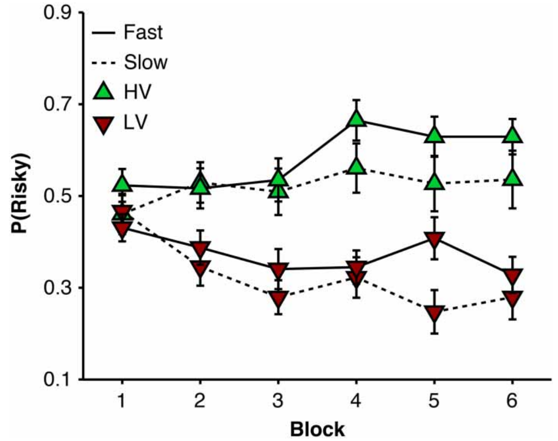

Figure 2. Mean risk preference (±SEM) for high- and low-value decision trials for each block, separated by participant group (fast and slow). [To view this figure in colour, please visit the online version of this Journal.]

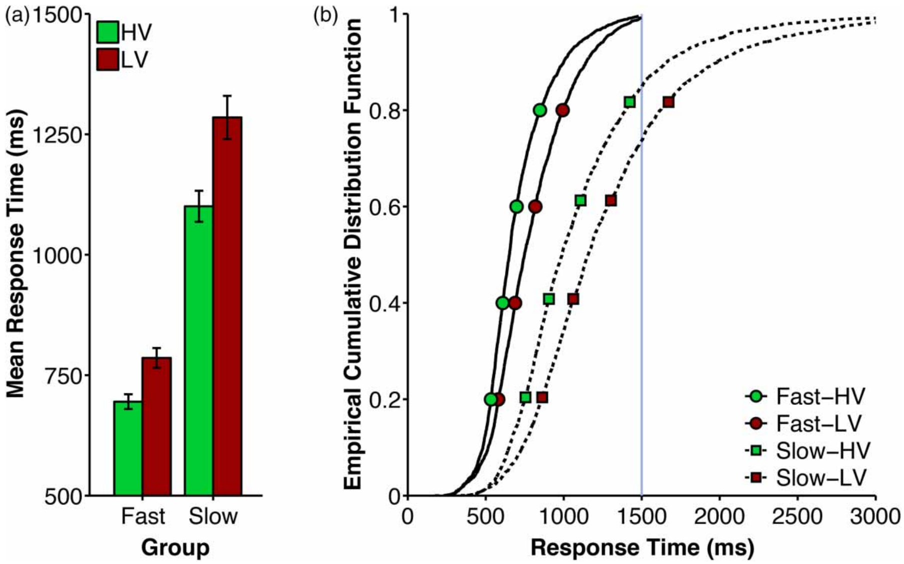

Figure 3. RTs for high- and low-value decisions (HV and LV, respectively), separated by participant group (fast and slow). (a) Mean RTs (±SEM). (b) Empirical cumulative distribution functions (CDFs) for all individual participants' RTs for high- and low-value decision trials, separated by participant group (fast and slow). Markers denote 20th percentiles within the respective CDF. [To view this figure in colour, please visit the online version of this Journal.]

between outcome value and participant group on risk seeking [$p = .62$, $\eta_p^2 = .004$], indicating that time pressure did not modulate the effect of extreme outcomes on risky choice.

As expected, Figure 3(a) shows that the fast group made decisions significantly faster than the slow group [$F(1, 66) = 89.61$, $p < .001$, $\eta_p^2 = .58$; $RT_{diff} = 385$ ms]. In addition, both groups responded faster for the high-value than low-value decisions [$F(1, 66) = 70.00$, $p < .001$, $\eta_p^2 = .52$; $RT_{diff} = 125$ ms]. Participants were also slightly slower when choosing the risky option than the safe option [$F(1, 66) = 6.00$, $p = .017$, $\eta_p^2 = .083$; $RT_{diff} = 38$ ms]. None of the interactions were significant [$p > .1$, $\eta_p^2 < .03$]. Figure 3(b) plots empirical cumulative distribution functions for all individual participants' RTs based on outcome value.

GENERAL DISCUSSION

Here we found evidence that time pressure moderately increases risk seeking in decisions from experience. We used a straightforward risky-choice task in which the risky and safe options provided equal expected values. This main effect of time pressure on risky choice did not interact with outcome value. Specifically, we replicated the extreme-outcome effect in which people were more risk seeking for high-value decisions than for low-value decisions (Ludvig, Madan, & Spetch, 2014), and time pressure did not modulate this effect. These results provide further evidence that the effect of time pressure on risky decision-making is robust and does not interact with other decision factors such as the description-experience gap, the probability or value of outcomes, or the extreme-outcome rule. Thus, the effect of time pressure on decision-making may occur through a distinct mechanism that functions in parallel to these other decision factors.

In the current study, we replicated and extended an experimental design used previously to demonstrate the extreme-outcome rule (Ludvig, Madan, Pisklak, et al., 2014; Ludvig, Madan, & Spetch, 2014, Experiment 4G; Madan et al., 2014, Experiment 2). Here we incorporated a between-subjects manipulation of time pressure along with the same outcome values used in the previous experiments. The extreme-outcome rule suggests that the highest and lowest outcomes experienced are overweighted in the decision process (Ludvig, Madan, & Spetch, 2014), likely due to the extreme outcomes being more salient in memory (Madan et al., 2014; Madan & Spetch, 2012). This memory bias in decision-making is similar to the well-known peak-end rule in affective judgements (Kahneman, Fredrickson, Schrieber, & Redelmeier, 1993; Redelmeier & Kahneman, 1996; Stone, Schwartz, Broderick, & Shiffman, 2005). Our previous results also rule out the potential alternate explanation that people are merely avoiding the zero or null payout in the low context—as we have shown that the effect appears both in the loss domain and when zeroes are explicitly eliminated (e.g., Ludvig, Madan, & Spetch, 2014). Despite the addition of the time pressure manipulation, we still found a strong effect of outcome value in both participant groups, extending the generalisability of the extreme-outcome rule.

If the effect of time pressure is indeed mediated by memory, then decisions from experience, which necessarily rely on memories of past outcomes, might be particularly susceptible to time pressure. Some prominent process models of decision-making suppose that people make decisions by repeatedly sampling outcomes from memory for the different options available (e.g., decision by sampling, Stewart, Chater, & Brown, 2006; decision field theory, Busemeyer & Townsend, 1993; and the drift-diffusion model, Ratcliff & Rouder, 1998). Under this conceptualisation, time pressure would provide less time to sample from memory, perhaps leading to biases. In this case, however, a memory-mediated effect of time pressure would likely have been presented as an interaction between outcome value and time pressure on choice behaviour. Specifically, extreme outcomes (the highest and lowest values experienced) are generally more accessible in memory (as found by Madan et al., 2014), so reducing the time to sample from memory would have led to an increased bias to base choices on these extreme values.

Instead, one possible account for the observed effect of time pressure on risk preference is an optimism bias: participants preferentially sample the best possible outcome first. Optimism biases appear in many domains of behaviour (see Sharot, 2011). Along these lines, when faced with a rapid, perception-based gambling task, people's decisions were asymmetrically influenced by the larger outcomes of the risky options, though this study did not explicitly manipulate time pressure (Zeigenfuse et al., 2014). One possibility, therefore, is that time pressure may exaggerate this optimism bias because the constraints imposed by a time pressure manipulation prevent or reduce a continuation of decision-making beyond this initial optimism bias. Thus, participants in the fast group may have been more influenced by the best outcome for the risky choice. Because the optimism bias causes the better outcomes (+40 and +80) to be overweighed in the decision process, and the extreme-outcome rule would result in the overweighting of the extreme outcomes (+0 and +80), these effects would summate in the high-value case, but work in opposition in the low-value case (Figure 2). As a result, the risk seeking observed in the high-value case is enhanced by time pressure, but the risk aversion observed in the low-value case is reduced by time pressure (i.e., also more risk seeking). If the optimism bias is diluted over longer decision times, but the extreme-outcome rule persists regardless, these effects together could explain our results.

It is also important to note that we manipulated time pressure in two ways: altering both the choice deadline and the duration of the ITI. With these two aspects of time pressure in concert, we found a moderate effect of time pressure on risky decisions from experience. We are not, however, able to determine the unique contribution of each of these manipulations, or if there was an interaction between the two (i.e., if they led to additive or multiplicative changes in risk preference). Given the effect size observed here with both aspects of time pressure working together, a much larger sample size would be necessary to effectively disentangle the unique contributions of deadline and ITI to this increase in risk seeking.

A further interesting aspect of our results is that RTs were faster for the high-value decisions than for the low-value decisions. Considering that the time pressure manipulation produced greater risk seeking, there is a nice convergence in that participants were also faster to respond on trials where they were also relatively more risk seeking. This secondary result provides additional correlational evidence for a relationship between the time allotted to a decision and the risk preference exhibited for the decision. Other studies have also found that participants respond faster to higher value decisions (e.g., Madan et al., 2012; Shenhav & Buckner, 2014; Tobler et al., 2006). This connection between reward value and RT could also be thought of as a potentiation of motivated movements (Madan, 2013).

Our results also shed light on how time pressure may generally influence risky choice in the gain domain. Some recent studies of decisions from experience have observed risk seeking for gains (e.g., Ludvig, Madan, Pisklak, et al., 2014; Ludvig, Madan, & Spetch, 2014; Tsetsos et al., 2012; Zeigenfuse et al., 2014), even though the bulk of studies does not (e.g., Erev, Glozman, & Hertwig, 2008; Erev et al., 2010). Though the experimental procedures used in these studies differ on a variety of dimensions (e.g., number of outcomes and presence of extreme values), the two studies that involved some time pressure observed risk seeking for gains (Tsetsos et al., 2012; Zeigenfuse et al., 2014), though not for losses. The current results further suggest that time pressure may indeed be an important contributor to these differences in risky-choice behaviour in the gain domain.

In general, decision-making studies have found that time pressure increases risk seeking (e.g., Hu et al., 2015; Huber & Kunz, 2007; Young et al., 2012; but see Ben Zur & Breznitz, 1981). This general finding of increased risk attractiveness due to time pressure can be interpreted using the dual systems view of decision-making (Carruthers, 2009; Evans, 2003; Kahneman, 2003). System 1 is associated with intuition, which involves quick and automatic processes (i.e., heuristics, such as the optimism bias). System 2 is associated with reasoning, which involves controlled and effortful processes. Time pressure may interrupt the decision-making process before system 2 is able to influence the final choice to a notable extent, resulting in a more dominant effect of system 1 biases.

The effects of time pressure on decision-making appear to be pervasive, occurring independent of many other decision factors. This finding has important implications for naturalistic decisions, such as financial and medical decisions, where significant time pressure is commonplace.

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