

# Primacy of Immediate Reward Underlying Violation

## Basic Study on Safety Management

Atsuo Murata<sup>(✉)</sup>, Yukio Ohta, and Makoto Moriwaka

Department of Intelligent Mechanical Systems,  
Graduate School of Natural Science and Technology,  
Okayama University, Okayama, Japan  
murata@iims.sys.okayama-u.ac.jp

**Abstract.** We generally tend to discount the satisfaction induced by the consumption in the future relative to the satisfaction at present. We feel more attractive to the immediate reward even if it is not a great amount of money. This is called primacy of immediate reward. Therefore, it is possible that this property forces us to put immediate profits or rewards before those in the future especially when the incentive to immediate awards or profits is stronger. It is speculated that such a property leads to cognitive biases to commit violation, and at the worst case causes a crucial accident such as the critical mass accident at the uranium processing plant of JCO Tokai Works Test Facility. As the basis for the prevention of violation-based human error, the primacy of immediate reward was explored in detail and an attempt was made to identify the condition under which the primacy of immediate reward is dominant. The primacy of immediate reward did not always arise, and it readily occurred under the following situation: (1) very uncertain situation under which a promise is not necessarily observed, and (2) situation under which one feels much starved and need money to eat something with. It was found that the urged to gain an immediate reward readily led to time discount.

**Keywords:** Time discount · Loss aversion · Irrationality · Primacy of immediate reward · Violation · Pursuit of immediate profit

## 1 Introduction

Recently, a lot of accidents which stem from violation (violating safety rule) frequently occur. These accidents include crucial accidents such as unintended crucial accidents like critical mass accident at the uranium processing plant of JCO Tokai Works Test Facility [1], derailment accident in Fukuchiyama Line at West Japan Railway Company (JR West), Chernobyl nuclear power plant explosion, and NASA space shuttle explosion accident [2]. In spite of increasing opportunity of accessing accident data base on the basis of the detailed accidental analysis, similar crucial accidents repeatedly occur.

Violation is committed through a prior intention to conduct this behavior [3]. On the roads, violations are relatively easy to observe. Errors are committed without a prior intention. Error and violations seems to be mediated by different cognitive mechanisms. Murata and Nakamura [4] discussed how cognitive biases distort decision making and lead to crucial accidents using analytical examples of critical mass accident at the uranium processing plant of JCO Tokai Works Test Facility and NASA space shuttle explosion accident. It is impossible to separate accidents, in particular, from the psychological and cognitive characteristics of persons involved in the accident. Therefore, the understanding of psychological and cognitive characteristics behind the accident plays a more significant role for the prevention of violation than the data bases of crucial accidents for stopping the repeated occurrence of similar crucial accidents.

We generally tend to discount the satisfaction induced by the consumption in the future relative to the satisfaction at present. We feel more attractive to the immediate reward even if it is not a great amount of money. This is called primacy of immediate reward [5]. Therefore, it tends that this property induces and forces us to put immediate profits or rewards before those in the future especially when the incentive to immediate awards or profits is stronger. It is speculated that such a property becomes a trigger of violation of rules, and, at the worst case, causes a crucial accident such as the critical mass accident at the uranium processing plant of JCO Tokai Works Test Facility.

The primacy of immediate reward assumes that we tend to choose (2) get \$120 after 31 days relative to (1) get \$100 after 28 days, and choose (1) get \$100 now relative to (2) get \$120 after 3 days. However, it is not certain whether the primacy of immediate reward is universal and robust in any situations. It might be reasonable to assume that this property is not always dominant. Therefore, it is useful and helpful to recognize under what condition the primacy of immediate reward is dominant. Until now, there seems to be few studies that made an attempt to address this issue.

As the basis for the prevention of violation-based accidents, the primacy of immediate reward was explored in detail and an attempt was made to identify the condition under which the primacy of immediate reward is dominant. In this study, the following four conditions (a)–(d) were assumed and made the participant answer Problem A ((1) get \$100 after 28 days, (2) get \$120 after 31 days) and Problem B ((1) get \$100 now, (2) get \$120 after 3 days).

- (a) control condition (no restraint).
- (b) condition under which the situation is very uncertain and promise is not necessarily observed.
- (c) condition under which the participants are urged to need money now.
- (d) condition under which the participants feel much starved and have no money to eat something with.

The participants were required to choose either (1) or (2) for both Problem A and Problem B, and simultaneously to rate the confidence of own choice. In such a way, we identified the condition under which the primacy of immediate reward is dominant. Some implications for the prevention of crucial accidents due to the primacy of immediate reward were given.

## 2 Primacy of Immediate Reward

Time discount is a phenomenon which makes us to discount the satisfaction produced by the consumption in the future relative to the satisfaction produced by the consumption at present. The degree of discount is called discount rate. In short, we tend to prioritize the profit at present as compared with that in the future.

The concept of primacy of immediate reward is shown in Fig. 1. In Situation A, most participants respond in what seems rational by choosing the alternative (2) get \$120 after 31 days, while most participants respond by choosing the alternative (1) get \$100 now in Situation B. Although the phenomenon of time discount does not occur in Situation A, the time discount which discount the satisfaction produced by the consumption in the future relative to the satisfaction produced by the consumption at present occurs in Situation B. This corresponds to the primacy of immediate reward. Until now, it has not been thoroughly clarified under what condition this phenomenon is predominant.

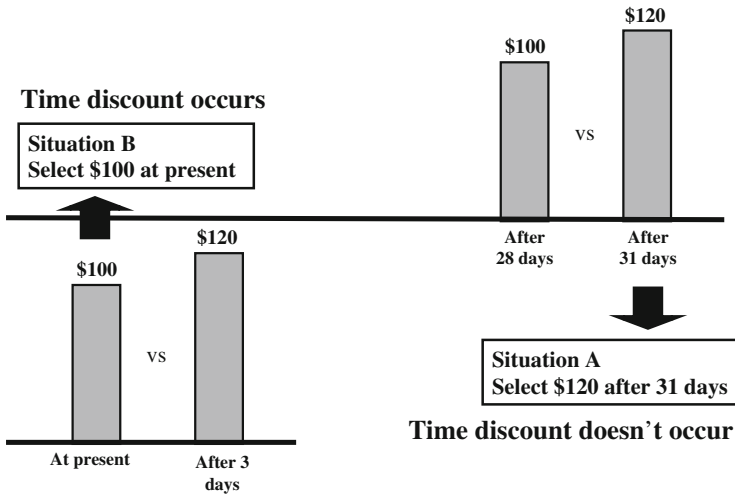


Fig. 1. Explanation of primacy of immediate reward

## 3 Method

### 3.1 Participants

146 graduate or undergraduate students from 22 to 28 years old took part in the experiment. All of them majored in system engineering in undergraduate or graduated school. All participants signed the document on informed consent after receiving a brief explanation on the experiment.

### 3.2 Task

The participants were required to choose either (1) or (2) for both Problem A and problem B, and simultaneously to rate the confidence of own choice.

Problem A: (1) get \$100 after 28 days, (2) get \$120 after 31 days.

Problem B: (1) get \$100 now, (2) get \$120 after 3 days.

### 3.3 Design and Procedure

The following four conditions (a)–(d) were assumed.

- (a) control condition (no restraint).
- (b) condition under which the situation is very uncertain and promise is not necessarily observed.
- (c) condition under which the participants are urged to need money now.
- (d) condition under which the participants feel much starved and have no money to eat something with.

For each condition, the participants were required to assume that he or she was forced to each condition, and choose either (1) or (2) in both Problem A and Problem B. The participants were simultaneously required to rate the confidence of own choice using 10-point scale from 1 (the lowest confidence) to 10 (the highest confidence). The order of performance of the conditions (a)–(d) was randomized across the participants. Moreover, the order of performance of Problem A and Problem B was counterbalanced across the participants for each of four conditions (a)–(d).

## 4 Results

In Fig. 2(a)–(d), the percentage of choice for alternatives (1) and (2) is plotted for both Problem A and Problem B. In this figure, the mean confidence of own answer for alternatives (1) and (2) is also plotted for both Problem A and Problem B.

A statistical test of the proportion of two alternatives (1) and (2) for both Problems A and Problem B was conducted for the four conditions (a)–(d). As for the condition (a) (see Fig. 2(a)), the proportion of the alternative (2) was significantly higher (Problem A:  $z = 14.318$ ,  $p < 0.01$ , Problem B:  $z = 8.313$ ,  $p < 0.01$ ). Concerning the condition (b) (see Fig. 2(b)), the proportion of the alternative (2) in Problem A was significantly higher ( $z = 6.074$ ,  $p < 0.01$ ), while the proportion of the alternative (1) in Problem B was significantly higher ( $z = 11.012$ ,  $p < 0.01$ ). As for the condition (d) (see Fig. 2(c)), the proportion of the alternative (1) was significantly higher (Problem A:  $z = 2.444$ ,  $p < 0.01$ , Problem B:  $z = 13.735$ ,  $p < 0.01$ ). The result of the condition (d) (see Fig. 2(d)) was as follows. The proportion of the alternative (2) was higher in Problem A ( $z = 12.112$ ,  $p < 0.01$ ), while the proportion of the alternative (1) was higher ( $z = 3.902$ ,  $p < 0.05$ ).

A statistical non-parametric test (Mann-Whitney u-test) was used to test whether there was statistically significant difference of the confidence between the two alternatives (1) and (2) for both Problem A and Problem B. The result of the condition (1) was as follows. Although the confidence score of the alternative (2) was significantly higher ( $z = -2.688$ ,  $p < 0.01$ ) in Problem A, no significant difference was detected between the alternatives (1) and (2) in Problem B. As for the condition (b), only the confidence score of the alternative (1) with higher proportion was significantly higher ( $z = -2.548$ ,  $p < 0.01$ ). As for the condition (c), only the confidence score of the alternative (1) with higher proportion in Problem B was significantly higher ( $z = -3.569$ ,  $p < 0.01$ ). The result of the condition (d) showed that only the confidence score of the alternative (1) with higher proportion in Problem A was significantly higher ( $z = -2.240$ ,  $p < 0.05$ ).

The primacy of immediate reward was not observed for the conditions (a) and (c) (see Fig. 2(a) and (c)). On the other hand, the promacy of immediate reward was observed in the conditions (b) and (d).

## 5 Discussion

Different from the hypothesis in Fig. 1, the primacy of immediate reward was not observed for the conditions (a) and (c).

As the condition (a) (control condition (no restraint)) did not force the participants to pursue an immediate profit, this led to the more gain (\$120) for both Problem A and Problem B. In both situations, the time discount did not occur. This indicates that some trigger or motivation or incentive is necessary for the time discount to occur. As mentioned in Results, the proportion of choosing the alternative (2) (\$120) was significantly higher. The confidence score for the alternative (2) was significantly higher (more than 8 points), which indicated that the alternative (2) was chosen with confidence.

When the participants were urged to need money now (condition (c)), this must have worked so that the participants prioritize an immediated profit (time discount occurred) in both Problem A and Problem B. In spite of recognizing that much money can be gained to wait for another two days, the urge to get money immediately must have become an incentive to pursue an immediate profit. As shown in Fig. 2(c), the proportion of choosing the alternative (1) in Problem B was significantly higher, and the corresponding confidence score was significantly higher (about 9 points). Even in Problem A, the proportion of choosing the alternative (1) in was significantly higher. The confidence score for both alternatives (1) and (2) was about 7 points, and lower than that of the alternative (1) in Problem B. Due to urgent need for money and the short interval between getting \$100 and \$120, the participants must hesitate to make decision between getting \$ 100 at present and getting \$120 after 3 days in Problem A. Thus, the participants could not rate their confidence of choice highly.

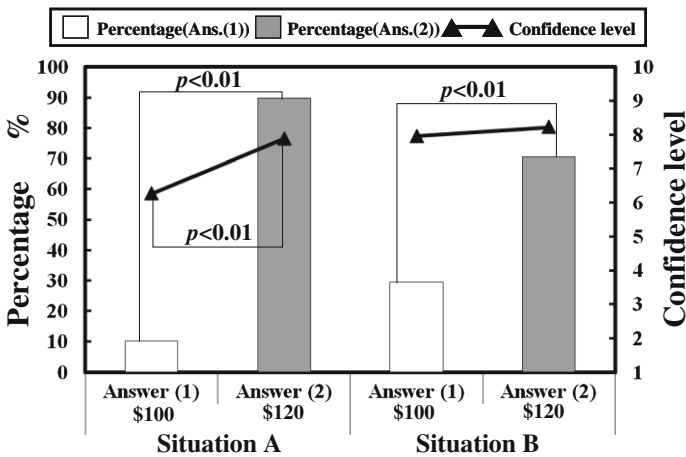
Although time discount arose even in the conditions (b) and (d), the confidence score and the proportion of choosing the alternative (1) of Problem B in the condition (c) were the highest, which might indicate that the condition (c) (the participants are urged to need money now) most readily leads to time discount. For only the condition (c), time

discount arose in Problem A. In other words, the condition (c) induced time discount even in Problem A, and hindered the hypothesis of primacy of immediate reward shown in Fig. 1. It might be reasonable to conclude that the condition (c) never fails to produce time discount, and that time discount readily occurs.

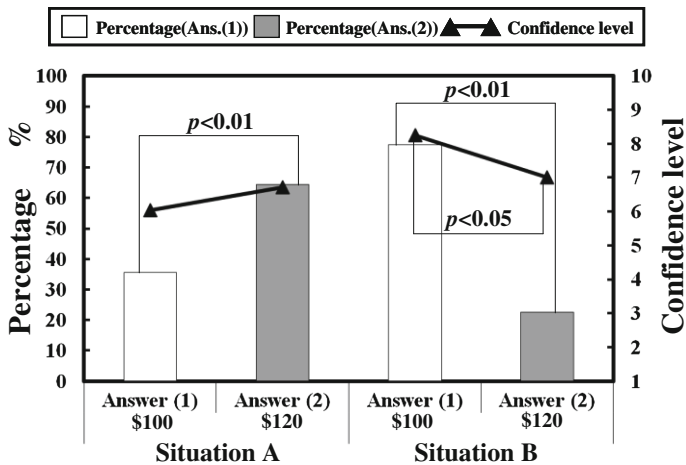
Opposite to the conditions (a) and (c), the primacy of immediate reward was observed for the condition (b) and (d).

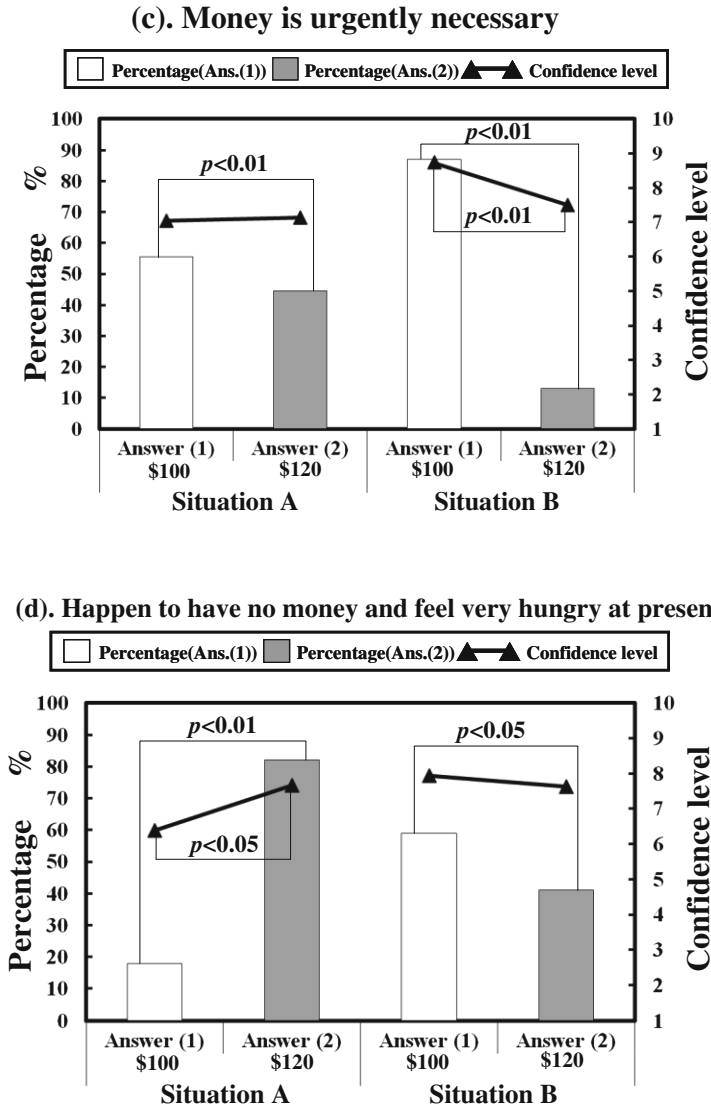
When the situation is very uncertain and a promise is not necessarily observed (condition (b)), the participants tended to choose the alternative (1) (less money in the near future) in Problem B. In Problem A, the situation worked so as to restrain time discount, and eventually the participants tended to choose to get more money (\$120).

**(a). Control condition (no restraint)**



**(b). A future promise is not necessarily kept**





**Fig. 2.** Percentage of choice and corresponding confidence of answers (1) and (2) ((a) control condition (no restraint), (b) situation under which a future promise is not necessarily kept (c) situation under which money is urgently necessary, (d) situation under which one happens to have no money) -continued-

When the participants feel much starved and have no money to eat something with condition (d), time discount was observed in Problem B. As Problem A deals with the far future as compared with Problem B, the participants must have chosen (2) \$120 after 31 days (time discount did not occur).

Comparing the proportion of choosing (2) \$120 after 31 days in Problem A between the conditions (b) and (d), the proportion was higher under the condition (d) than under the condition (b). The condition (b) (the situation is very uncertain and a promise is not necessarily observed) induced more frequently the feelings that the getting less in early stage is better. Comparison of the proportion of choosing (1) getting \$100 now in Problem B between the conditions (b) and (d) showed that the proportion was higher under the condition (b) than under the condition (d), which indicates that this condition readily leads to time discount.

When the participants are urged to need an immediate reward (condition (c)), the participants must regard the procrastination of consumption or receiving a reward as a loss. In such a situation, the participants must avoid loss and be in a psychological state of loss aversion [6–11]. Therefore, time discount phenomenon of the future value must occur in both Problem A and Problem B, and the participants must choose an immediate reward even in the far future in Problem A.

Discussion above showed that the primacy of immediate reward does not necessarily occur, and the dominance of this phenomenon depends on the situation of the chooser (participants). In particular, the incentive like the condition (b) or (d) is necessary so that the participants choose more gain (\$120) after 31 days relative to \$100 after 28 days. Without such an incentive, the primacy of immediate reward hypothesized in Fig. 1 doesn't readily occur. Moreover, it tended that urgency of an immediate reward (condition (c)) functioned so that the participants pursue an immediate reward (gain in the near future) in both Problem A and Problem B. The psychology to be fascinated by an immediate reward might hinder the acceptance of a reasonable reward in the near future. This is one of our irrational behaviors. Such an irrational behavior, together with the tight financial situation, makes the organization commit violation activities, and this can be a trigger of crucial accidents. The irrational characteristics demonstrated in this study suggests a meaningful implication to prevent violation-based crucial accidents.

Future work should investigate how the amount of money affect the decision making by changing the amount of money as an experimental factor. The following generalization is necessary. The effect of  $X$ ,  $V$ ,  $W$ , and  $r$  ( $> 0$ ) on the decision making and the occurrence of primacy of immediate reward must be systematically explored.

Problem A: (1) get  $\$X$  after  $V$  days, (2) get  $\$X(1 + r)$  after  $V + W$  days.

Problem B: (1) get  $\$X$  now, (2) get  $\$X(1 + r)$  after  $W$  days.

As the situation under which one is urged to pursue an immediate reward readily lead to time discount phenomenon, future research should verify how such a situation induces defective (non-cooperative behavior) corresponding to the violation behavior even in Prisoner's dilemma situations.

It is speculated that such a property leads to violation, and at the worst case causes a crucial accident such as the critical mass accident at JCO Tokai Works Test Facility uranium processing plant. In Fukushima Daiichi nuclear power plant, the reactor #1 had been operating for about 40 years when the crucial accident occurred, and it was said that the reactor should be decommissioned at its lifetime of 40 years. Such a property to pursue immediate profit (put immediate rewards (profit obtained by continuing to operate the reactor#1) before rewards (safety and health of people living



around the nuclear power plant) in the future) must have hindered decommissioning a nuclear reactor, and have worked as one of causes of Fukushima Daiichi nuclear power plant accident occurred on March in 2011 [12–14].

We generally tend to discount the satisfaction induced by the consumption in the future relative to the satisfaction at present. We feel more attractive to the immediate reward even if it is not a great amount of money (primacy of immediate reward). Therefore, it tends that this property induce and forces us to put immediate profits or rewards before those in the future especially when the incentive to immediate awards or profits is stronger. Such time discount and primacy of immediate reward cannot be separated from the safety management of plants or large-scaled systems such aircrafts or oil tankers. We must pay be cautious to such an irrational behavior as well as group think pointed out by Janis [15–16].

## 6 Conclusions

As the basis for the prevention of violation-based human error, the primacy of immediate reward was explored in detail and an attempt was made to identify the condition under which the primacy of immediate reward is dominant. The results can be summarized as follows.

- (1) The primacy of immediate reward does not always arise, and it readily occurs under the following situation.
  - (b) very uncertain situation and a promise is not necessarily observed.
  - (d) situation under which the participants feel much starved and need money to eat something with.
- (2) When one is urged to gain an immediate reward, this readily leads to time discount. At the worst cases, this might be a trigger of violation.

Future research should discuss how the finding on the time discount and the primacy of immediate reward should be effectively utilized for the prevention of violation-based crucial accidents.

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