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Cross-cultural comparisons of delay discounting of gain and loss

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Abstract

OBJECTIVES: People generally tend to discount future outcomes in favor of smaller but immediate gains (i.e., delay discounting). The present research examined cultural similarities and differences in delay discounting of gain and loss between Chinese and Japanese, based on a q-exponential model of intertemporal choice.

METHOD: Using a hypothetical situation, we asked 65 Japanese participants and 51 Chinese participants to choose between receiving (or paying) a different amount of money immediately or with a specified delay (1 week, 2 weeks, 1 month, 6 months, 1 year, 5 years, and 25 years). For each delay, participants completed a series of 40 binary choices for gain or loss.

RESULTS: Regardless of cultures, the q-exponential model was the optimal model. Both impulsivity and time-inconsistency were higher for future gains than for future losses. In addition to the cultural similarities, Chinese participants discounted future gains and losses more steeply than did Japanese. In contrast, Japanese participants were more time-inconsistent in delay discounting than were Chinese, suggesting that the reduction in their subjective value depended relatively on delay.

INTRODUCTION

People generally discount future outcomes and accordingly accept immediate but smaller gains. Economic analyses of this delay discounting assume an exponential model in which an individual's time preference is consistent and the subjective value of an outcome reduces proportionally at each unit of time (e.g., Samuelson, 1937). However, empirical evidence from studies of intertemporal choice suggests that individuals generally show delay discounting in a time-inconsistent manner: the reduction in subjective value of an outcome becomes smaller as the delay lengthens (e.g., Ainslie, 1975; Mazur, 1987). Indeed, a hyperbolic model considering the decrease in the reduction in subjective value by the increase in delay can account for delay decisions of humans and animals more extensively than an exponential model can (e.g., Kirby, 1997).

Whereas a hyperbolic discount function is suitable for explaining delay decisions across species, individual differences in impulsivity and self-control (e.g., see Green & Myerson, 2004, 2013; Mackillop *et al.* 2016; Teuscher & Mitchell, 2011) and the social contexts that individuals live

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in, such as socioeconomic status (SES), influence how steeply future outcomes are discounted (e.g., de Wit *et al.* 2007; Ishii, 2015; Reimers *et al.* 2009). In addition, cultural differences in interpersonal choice have been confirmed, although not fully investigated (Weber & Morris, 2010). Previous findings suggest that East Asians are less likely than Americans are to discount future rewards (e.g., Du *et al.* 2002; Ishii *et al.* in press; Kim *et al.* 2012; Takahashi *et al.* 2009). This difference may reflect cultural differences in uncertainty avoidance, which refers to the degree to which the members of a society feel uncomfortable with uncertainty and ambiguity, and long-term orientation, which expresses the degree to which the past is connected to present and future challenges (Hofstede *et al.* 2010). Indeed, a large-scale international survey of time preference conducted by Wang *et al.* (2016) supports this possibility.

In addition to this East-West difference, Du *et al.* (2002) examined delay discounting and probability discounting in Americans, Chinese, and Japanese and reported a cultural difference between the two East Asian groups. Although a hyperbolic discount model fitted the participants' decisions regardless of culture, both Chinese and Americans discounted future rewards more steeply than did Japanese. This difference cannot be understood based on long term orientation because China and Japan are recognized as the most long term orientation oriented societies. In addition, although China and Japan are quite different in terms of uncertainty avoidance, Japanese participants' higher uncertainty avoidance might encourage or facilitate impulsive decisions, which runs counter to their tendency in intertemporal choice. Thus, there is no convincing evidence to account for the difference between the two Eastern cultures at the moment. Given this, we should hasten to add that this difference within Eastern cultures is confirmed by a different discount task.

Extending the findings of Du *et al.* (2002), the present research examined cultural similarities and differences in delay discounting between Chinese and Japanese, based on a q-exponential model of intertemporal choice, which has been proposed by recent studies in econophysics (Cajueiro, 2006; Han & Takahashi, 2012; Takahashi *et al.* 2014). The equation is

$$V(D) = \frac{V(0)}{\exp_q(k_q D)} = V(0)/[1+(1-q)k_q D]^{1/(1-q)}, \quad (1)$$

where $exp_q(x)$, which is equal to $[1+(1-q)x]^{1/(1-q)}$, is a q-exponential function; V(D) is the time-discounted value of a reward (or payment) at delay D; and k_q is a parameter of impulsivity at delay D=0, which corresponds to a discount rate. When a parameter q=1, eq. (1) expresses $V(D)=V(0)*\exp(-k_1 D)$, which is equal to the exponential model. When q=0, eq. (1) expresses $V(D)=V(0)/(1+ k_0 D)$, which is equal to the hyperbolic model. As a result, 1–q indicates the extent to which an individual discounts reward (or payment) in a time-inconsistent manner. This means that individuals are more time-inconsistent in delay discounting as 1–q becomes larger (i.e., q becomes smaller). Thus, this q-exponential model makes it possible to separate the effect of impulsivity, which manifests as the extent to which an individual discounts future outcomes, from that of time-inconsistency in intertemporal choice, which reveals that the decline of subjective value of outcomes depends on how far the delay is from now, even if the time unit of the delay is identical (e.g., one day of delay from now vs. one day of delay one year later).

In the present research, for each cultural group, we estimated the parameters in q-exponential, exponential, and hyperbolic models and compared the fitness of each model. Given that the q-exponential model is considered as an optimal discount model (Lu & Zhuang, 2014) and that discount function is mostly universal across cultures, we predicted that the q-exponential model would be the best-fitting model for both cultures. In spite of such a cultural similarity, however, cultural differences might also emerge in the level of a discount rate. Du *et al.* (2002) applied the hyperbolic model and found that Chinese participants discounted future rewards more steeply than did Japanese. If the findings are replicated, this cultural difference would appear in not only the hyperbolic model but also the q-exponential model in the present research. Moreover, to our knowledge, this is the first attempt to examine a difference in time-inconsistency between Chinese and Japanese. Although there is no clear prediction, owing to such an exploratory purpose, given previous findings in intertemporal choices that the pattern in impulsivity is positively associated with that in time-inconsistency (Takahashi *et al.* 2009; Takahashi, Oono, Inoue, *et al.* 2008; Takahashi, Oono, & Radford, 2008), Chinese may be expected to be more inconsistent in delay discounting than are Japanese.

Furthermore, we examined the extent to which Chinese and Japanese discount not only future gain but also future loss. To our knowledge, no study has investigated cultural differences in delayed loss between Chinese and Japanese. Previous studies suggest that impulsivity and time-inconsistency are higher for future gain than for future loss (e.g., Frederick *et al.* 2002; Takahashi *et al.* 2009; Takahashi, Oono, Inoue, *et al.* 2008). Because this gain-loss asymmetry, which is known as a sign effect, has been considered as one deviation from a standard utility model on delay discounting, it should emerge regardless of cultures. In addition to the cultural similarity, cultural differences in the levels of impulsivity and time-inconsistency may appear even in the judgment of future loss as well as future gain.

METHOD

A total of 65 Japanese students (32 females and 33 males, M_{age}=19.66, SD=0.91) and 51 Chinese students (40 females and 11 males, M_{age}=23.01, SD=2.40) at Kobe University participated in the study. The Chinese participants were temporarily studying at Kobe University. They had stayed at the university for 2 months at most. They were paid 800 yen (about $8). The study was reviewed and approved by the Experimental Research Ethics Committee at the Graduate School of Humanities, Kobe University.

The participants were asked to engage in a decision-making task including hypothetical gains and losses in which they could choose between receiving (or paying) a different amount of money immediately or receiving (or paying) 100,000 yen (about $1,000), with a specified delay (1 week, 2 weeks, 1 month, 6 months, 1 year, 5 years, and 25 years). The amount of money given (or paid) immediately varied from 0 to 100,000 yen, either in increments of 2,500 yen in ascending order or in decrements of 2,500 yen in descending order. Participants thus completed a series of 40 binary choices for each outcome type (i.e., gain or loss) for each delay for each order. The task was identical to that developed and used in previous studies by Takahashi and colleagues (Han & Takahashi, 2012; Takahashi *et al.* 2007). Gains and losses were expressed in yen for Japanese participants and converted into yuan for Chinese participants, with 1 yen equaling 0.05 yuan.

Following Han and Takahashi (2012), for each participant, we obtained an indifference point at which gain (or loss) with a certain delay was subjectively equivalent to immediate gain (or loss). Concretely, for each of the seven kinds of delay, we initially computed an amount at a switching point by averaging an amount of immediate gain (or loss) corresponding to the amount of fixed future gain (or loss) chosen last and an amount of immediate gain (or loss) chosen shortly after the last choice of future gain (or loss). We then averaged the amount computed in case of ascending order and that in case of descending order. Thus, each participant had seven indifference points for either gain or loss.

In addition, to estimate the extent to which participants discounted delayed gains or losses, we computed an area under the curve (AUC) for each outcome type for each participant, following Ohmura, Takahashi, and Kitamura (2005). Initially, the delays and the indifference points were standardized so that these values varied between 0 and 1. We then computed the size of the total area under this standardized indifference points curve by summing the size computed from the equation (y2+y1) * (x2–x1) / 2, where x1 and x2 are successive delays (x2 is a future time compared to x1) and y1 and y2 are the subjective values of a gain or loss with these delays (when x1=0, y1=1). The AUC becomes smaller as a subject's discounting becomes steeper.

Furthermore, we fitted the three types of discount model (exponential, hyperbolic, and q-exponential) to the mean indifference points in each culture for each outcome type. The Akaike Information Criterion (AIC) was used to estimate fitness. The fitness of a model becomes better as the AIC becomes smaller.

RESULTS

Demographic variables (gender [male=0, female=1] and age) were entered along with each culture (Chinese=0, Japanese=1) to predict AUC for gains and losses, respectively. As predicted, AUC was significantly smaller for Chinese (M=0.35, SD=0.23) than for Japanese (M=0.60, SD=0.27) for gains (b=0.34, standard error (SE)=0.07, $t(113)=5.09$, $p<0.0001$). The same tendency was found for losses (Chinese [M=0.51, SD=0.29], Japanese [M=0.81, SD=0.23], b=0.34, standard error (SE)=0.07, $t(112)=4.84$, $p<0.0001$). Neither age nor gender influenced AUC except that AUC was significantly smaller for males than for females for gains (b=0.10, standard error (SE)=0.05, $t(113)=2.15$, $p<0.05$). The AUC for gains was highly positively correlated with that for losses for both Chinese (r=0.55, $p<0.0001$) and Japanese (r=0.37, $p<0.01$). Moreover, a 2 (culture: Chinese and Japanese) × 2 (outcome type: gain and loss) ANOVA on AUC showed significant main effects of culture ($F(1,114)=44.09$, $p<0.0001$, $\eta^2_p=0.28$) and outcome type ($F(1,114)=53.07$, $p<0.0001$, $\eta^2_p=0.32$). As predicted, the AUC for gains (M=0.49, SD=0.28) was smaller than the AUC for losses (M=0.68,

Tab. 1. Parameters and AIC for discount models in Chinese and Japanese data.

	Gain			Loss		
	exponential	hyperbolic	q-exponential	exponential	hyperbolic	q-exponential
Chinese						
AIC	−3.28	−8.28	−19.43	−6.53	−11.70	−25.71
Parameter	k=7.43	k=14.43	k_q=87.61	k=1.62	k=3.62	k_q=17.95
			q=−3.68			q=−3.73
Japanese						
AIC	−8.99	−12.39	−38.48	−24.54	−25.91	−41.26
Parameter	k=0.99	k=1.90	k_q=14.70	k=0.37	k=0.46	k_q=2.69
			q=−5.37			q=−9.39

SD=0.30). This effect was not moderated by culture, $F(1,114)=0.92$, $p=0.34$.

Parameters and AICs computed as a result of fitting three models (exponential, hyperbolic, and q-exponential) in each culture for each outcome type are summarized in Table 1. Fitted curves of exponential, hyperbolic, and q-exponential functions for mean indifference points in each culture are shown in Figure 1. Regardless of culture, the parameter q was smaller than 0. This suggests that the discount functional form deviates from the exponential model. Indeed, for both gains and losses, the fitness of the exponential model was worse than that of the other models. Instead, as predicted, the q-exponential model best fitted the behavioral data of both Japanese and Chinese. On the other hand, regardless of model, these parameters suggest that gain is more steeply discounted than loss is in both cultures.

In addition to these cultural similarities, we found cultural differences in delay discounting and time-inconsistency. Consistent with the cultural difference in AUC reported above, for both gains and losses, k_q estimated in the q-exponential model was larger for Chinese than for Japanese. Likewise, discount rates estimated in both exponential and hyperbolic models were larger for Chinese than for Japanese. Greater impulsiveness among Chinese than among Japanese is consistent with Du *et al.* (2002). In contrast, q was smaller for Japanese than for Chinese for both gains and losses. This suggests that Japanese subjects discounted delayed gains and losses in a more time-inconsistent way than Chinese did.

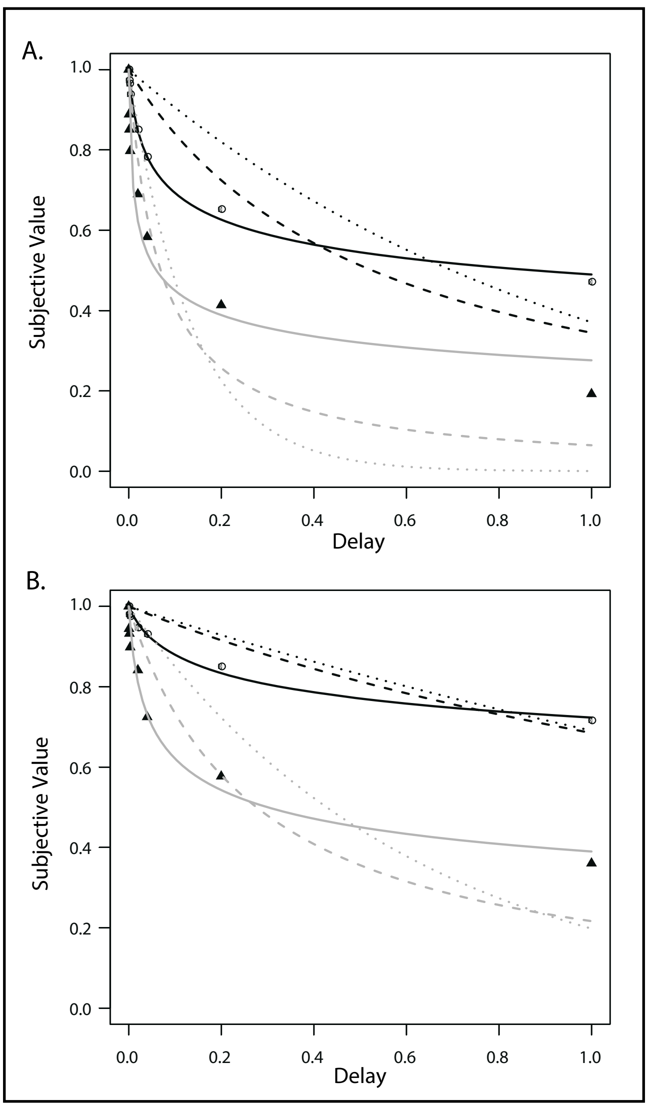

Fig. 1. Time-discount functions with delay for gain (A) and for loss (B). The solid, dashed, and dotted curves correspond to q-exponential model, hyperbolic model, and exponential model, respectively. The curved lines were illustrated in black for Japanese and in gray for Chinese. Mean indifference points were plotted in circle for Japanese and in triangle for Chinese.

DISCUSSION

We found cultural similarities and differences in delay discounting by testing Chinese and Japanese. Regardless of culture, the q-exponential model was the optimal model. Both impulsivity (i.e., AUC and discount rate) and time-inconsistency (i.e., q in the q-exponential model) were higher for future gains than for future losses. The results support previous findings on deviations in individuals' decision making (i.e., a hyperbolic discounting and a gain-loss asymmetry in delay discounting) from a standard utility model on delay discounting.

In addition to the cultural similarities, Chinese participants discounted future gains and losses more steeply than did Japanese, which replicated and extended the findings of Du *et al.* (2002), exhibiting Chinese participants' higher impulsivity for future gain. Furthermore, to our knowledge, we have shown the first evidence that Japanese are more time-inconsistent in delay discounting than Chinese are. This pattern suggests that, compared to Japanese, Chinese may discount their subjective value relatively consistently, independent of delay; Japanese participants may be more likely than Chinese participants are to perceive the distant future non-linearly. The cultural difference in time-inconsistency may thus reflect the fact that Japanese are more likely than Chinese to exhibit a tendency in which time intervals in the future beyond some point are not estimated exactly but perceived as shrinking logarithmically. Further research will be needed to explore such a potential cultural difference in the distortion of psychological time.

Although the present research focused only on the demonstration of cultural differences between Chinese and Japanese, it is crucial to explore the underlying mechanisms in future work. A key factor to explain the differences between Chinese and Japanese may be uncertainty avoidance. Uncertainty avoidance is a societal level index, which is considered to be higher in Japan than in China (Hofstede *et al.* 2010). This may result in a difference in time-inconsistency by motivating more Japanese than Chinese to follow formalized and strict rules and procedures and to avoid change and exception, thereby rendering them more myopic in that they tend to think that their following of rules and procedures at the moment assures society's security. By contrast, the fact that Chinese society is relatively tolerant of uncertainty and ambiguity may encourage entrepreneurial activities and risk-taking behaviors. Indeed, Chinese have been shown to be less risk averse than Americans are (Weber & Hsee, 1998). Weber and Hsee (1998) interpreted this tendency on the basis of the cultural feature of collectivism, which cushions the blow of individuals' losses. Although this interpretation would not be applicable to Japanese participants' intertemporal decisions, such a cultural feature might facilitate impulsivity in Chinese, alongside their low level of uncertainty avoidance. Future work should examine these possibilities and clarify the causal relationships.

Moreover, it would be informative to explore the extent to which genetic variations in dopamine and serotonin regulating genes interact with cultural environments to impact impulsive and time-inconsistent discounting behavior. For example, McClure *et al.* (2004) showed that parts of limbic structures (e.g., ventral striatum) associated with the midbrain dopamine system are activated by choices involving immediate outcomes. Also, Takahashi, Oono, Inoue *et al.* (2008) suggested that low serotonergic activities are associated with the increase of a discount rate at short delays, whereas they are associated with the decrease of a discount rate at long delays. Given past research showing that one's psychological tendency may emerge as a result of an interaction between genetic and environmental factors, and that certain genes may be associated with greater plasticity or susceptibility to the environment (e.g., Belsky, *et al.* 2007, Manuck & McCaffery, 2014), future work to address the extent to which cultural environments moderate the association between genes and impulsive and time-inconsistent discounting behaviors would be needed.

The present research entails some shortcomings. First, it was based on a hypothetical scenario. Although previous studies found no difference between real and hypothetical rewards in terms of delay discounting (e.g., Johnson & Bickel, 2002), if participants are asked to make a choice about real monetary rewards, it may yield different consequence across cultures. It is nevertheless to be noted that real monetary tasks also have disadvantages, in that (i) we cannot ethically impose real monetary losses on participants, and (ii) it is virtually impossible to provide very large monetary gains in temporal discounting tasks. Second, the present research could not reject a potential effect of the market interest rate, which varies between China and Japan (but please note that at the time of this experimental study, the negative interest rate had not been introduced by the Bank of Japan). In spite of these issues, the present research provided initial evidence that the q-exponential model fits the participants' decisions better than the exponential and hyperbolic models do regardless of cultures, and that not only in gains but also losses, the Chinese are more impulsive than the Japanese are, whereas the Japanese are more time-inconsistent than the Chinese are. Further investigation is needed to establish the generality of the current findings. However, we believe that the results of the present research deserve serious attention because it demonstrates stimulating variations within East Asian cultures, which exist alongside East-West differences but have not been not fully investigated.

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