

# **Influence of linguistic tense marking on temporal discounting: From the perspective of asymmetric tense marking in Japanese**

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## **Abstract**

There has been much discussion around the Linguistic-Savings Hypothesis (LSH), which postulates that language can affect intertemporal choices of its speakers; the validity of this claim has remained controversial. To test the LSH independent from the possible influencing factors, such as cultural differences, we focused on the Japanese language, which features asymmetric tense marking, in that past tense is grammatically marked but future tense is not. Adopting a within-participant design, we compared the discounting behavior between past and future gains in native Japanese participants. Our results revealed that Japanese speakers tended to discount the values placed on rewards in an asymmetry way: to discount the value of past gains more heavily than that of future gains. We believed our results corroborated the LSH and linguistic relativity.

**Keywords:** Intertemporal discounting; Intertemporal choice; Linguistic-Savings Hypothesis; Tense; Linguistic relativity

## **Introduction**

Intertemporal choices, regarding trade-offs between time and benefits, are very common in everyday life, such as the decision on whether to spend the salary on a trip to Kyoto immediately after receiving it, or whether to save up for years to buy an apartment in Tokyo. Economical behaviors such as investment and insurance purchasing, as well as health issues such as nicotine addiction and drug abuse, are also manifestations of intertemporal decisions (see Thaler, 1981; Frederick, Loewenstein & O'Donoghue, 2002 for reviews). On a macro level, it may even play a part in very important economic issues such as national saving rates (Springstead & Wilson, 2000). Because of this ubiquity and significance, intertemporal choices remain a topic of lasting research interest.

Numerous studies dealing with intertemporal preference and temporal discounting behavior have shown that people psychologically discount future gain or loss, and tend to discount more for longer temporal distance (Thaler, 1981; Kirby & Marakovic, 1996).

Previous studies have also found that intertemporal discounting behaviors vary individually and culturally (Gell, 1992; Hofstede, 1997). One of the most intriguing hypotheses holds that people's native language may exert an influence on their intertemporal choices (Chen, 2013).

## **Does language matter in intertemporal discounting?**

Whether the language people speak will influence their intertemporal choices has recently been under hot debate. Linguistic-Savings Hypothesis (LSH), proposed by Chen (2013), has been one of the most intriguing hypotheses on this topic. According to Chen (2013), speakers of languages which grammatically distinguish between present and future, such as English, and speakers of languages with no such distinction, such as Mandarin, tend to have different feelings about temporal information, leading to different discounting behaviors. Specifically, for futureless language speakers, the distinction between present and future is vaguely construed, while speakers of languages with separate tense marking for present and future tend to perceive the distinction more clearly. As a result, speakers of a futureless language tend to discount future rewards more heavily than those of a futureless language. Chen (2013) substantiated the hypothesis by results from analysis of massive databases of savings rates, health behaviors and retirement assets across many countries. This simple yet intriguing hypothesis has attracted major attention (e.g., by 2018, over 1,790 thousand views on TED talk, 2012).

Meanwhile, the hypothesis has been also criticized and challenged from multiple perspectives. First of all, it has been pointed out that the analysis of massive database is basically indirect (i.e., focusing on correlational relationships). Thus, the validity of causal inferences may be doubtful (Roberts & Winters, 2013). Secondly, it may be difficult to eliminate the influence of cultural differences. Previous cross-cultural analyses of temporal discounting behavior have generated contradictory results (Thoma & Tytus, 2018), thus rendering the results indefensible when taking cultural differences into account. Lastly, empirical evidence on the hypothesis is

mixed. While there is evidence from behavioral experiments in support of the LSH (e.g., Lergetporer et al., 2014), opposite results have also been obtained (e.g., Thoma & Tytus, 2018).

Against this background, our research started with the same point of view with the LSH, but tried to eliminate the influence of alternative explanations, such as the influence of cultural differences, by conducting the experiment using within-participant design.

### Asymmetric tense marking in Japanese

In the present study, we examined how Japanese people discounted the value of past and that of future.

Even though the measurement of the intertemporal discount in past is not as familiar as that of future in the field of economics and psychology, it is widely applied in the field of health behavior. The discounting rate of past can be a valid indicator of patience as well as an effective predictor of cigarette and drug abuse.

Previous research found native speakers of English in the U.S. tend to discount the value of future and past gains in a symmetrical way, with no significant difference between the discounting rate for past and future gains (Bickel et al., 2008; Yi et al., 2006). This finding can be explained by the LSH, which predicts that the tense encoding in a language can influence its speakers' time perception and intertemporal discounting behavior. Therefore, native speakers of English are predicted to discount the future and past values in the same way since both past tense and future tense exist in the English language. This symmetric tense marking in English can lead to the symmetric discounting behavior towards past and future gains.

However, not all languages encode tense in the same way. Japanese, for example, has asymmetric encoding in marking only the past tense. The grammaticalization of tense in English, Japanese, and Mandarin is summarized in Table 1.

The LSH can be tested in the Japanese language which features asymmetric tense marking. According to the LSH, the grammaticalization of tense in a language will influence its speakers' discounting behavior towards past and future gains. Therefore, Japanese speakers are predicted to showcase discounting behaviors also in an asymmetric way. To be specific, since there is past tense and no future tense in Japanese, speakers may feel the distinction between past and present more clearly (i.e., larger) than that between present and future, leading to higher discounting rate for past gains than that for future gains.

In the current research, we recruited native speakers of Japanese as participants, and compared the discounting rate of past gains with that of future gains of each participant. Since only Japanese speakers were targeted, the effect of culture was controlled for. Furthermore, the within-participant design also excluded the influence of other potent factors such as individual characteristics, educational level, and economic status between different groups.

To our knowledge, this is the first study to examine LSH directly by comparing discounting rates of past and future

gains while excluding the influence of cultural differences as well as other factors.

Table 1: Tense marking in English, Japanese, and Mandarin.

	Past Tense	Future Tense
English	+	+
Japanese	+	-
Mandarin	-	-

## Statistical analyses

### Indicators and models of temporal discounting

A brief account of the analytical procedure is given in this sub-section. The first step is to estimate the indifference point between two intertemporal choices (e.g., Kirby & Marakovic, 1996; Toubia et al, 2013). An indifference point is reached where the amount available now (following Yi et al., (2006), we regarded 'one hour ago' and 'in one hour' as 'now') is equivalent to the delayed amount in the future. For instance, if a participant preferred to 'receive ¥80,000 (¥10,000 is approximately \$100) in one hour' rather than 'receive ¥100,000 in seven days,' but meanwhile chose to 'receive ¥100,000 in seven days' rather than 'receive ¥70,000 in one hour,' we thus assume that the indifference point between now and a delay of seven days lies between ¥70,000 and ¥80,000 and we determined the indifference point at a delay of seven days of ¥100,000 to be the average of two amounts (in the above example, ¥75,000 in one hour). Likewise, the indifference points can be located for the past scenarios. For example, if a participant preferred to 'receive ¥60,000 one hour ago' rather than 'receive ¥100,000 seven days ago,' but at the same time chose to 'receive ¥100,000 seven days ago' rather than 'receive ¥50,000 one hour ago,' we assumed ¥55,000 as the indifference point.

Based on the estimated indifference points, we conducted both statistical and model-based analyses. For statistical analysis, we compared discounting rate and the Area Under the Curve (AUC) between values in the past versus future scenarios. Analysis was based on four models: linear model, exponential model, hyperbolic model, and q-exponential model, among which the fitted models serves as a basis for discussion on participants discounting behavior.

In the following section, we shall explain these methods in detail.

### Discounting rate

Discounting rate of specific temporal distance ( $r_d$ ) can be calculated with the following equation:

$$r_d = \frac{V_0 - V'}{V_0}$$

where  $V_0$  is the original value and  $V'$  the discounted value.

This equation estimates the discounting rate for each specific temporal distance. To reveal the general tendency in

individual participant's discounting behavior, we also adopted AUC and model-based approaches.

## AUC

AUC is a very common model-free approach to estimate the discounting behavior (Myerson et al., 2001). To calculate AUC, each indifferent value point should be plotted in the same figure and then lined up to form a curve. The area under the curve is then calculated to be AUC. In general, as a participant discounts the value more heavily, the AUC value become lower.

In the current study, we used the standardized AUC (i.e., ranging from 0 to 1) as an indicator of a general tendency of discounting.

## Model-based analyses

In the following explanation of the four models,  $V'$ ,  $V_0$ , and  $d$  denote discounted value, original value, and the temporal distance, respectively.  $k$  and  $q$  are discounting and adjusting parameter, respectively.

### Linear Model

Linear model is the simplest model to predict how value is discounted with the span of time.

$$V' = V_0 - kd$$

### Exponential Model

Exponential model is the standard model adopted in related empirical works, with an advantage in explaining drastic discounting behaviors.

$$V' = V_0 \cdot e^{-kd}$$

### Hyperbolic Model

Overall, the hyperbolic model (Mazur, 1987) shows a better fit than the exponential model for its strength in predicting a more decelerated rate of value depreciation over time, which resembles discounting behavior.

$$V' = \frac{V_0}{1 + kd}$$

### Q-exponential Model

Apart from the most popular models (i.e., the exponential model and the hyperbolic model) in intertemporal behavior study, recent research suggests that q-exponential model could be a better fit since it can be seen as the generalized style of the above models (Cajueiro, 2006; Takahashi et al., 2014).

$$V' = \frac{V_0}{(1 + k(1 - q)d)^{\frac{1}{1-q}}}$$

In this model,  $q$  is the adjusting parameter and determines the form of fitting model. When  $q$  reaches 1, the model equals

the exponential model. In contrast, when  $q$  reaches 0, the model equals the hyperbolic model.

## Behavioral experiment

**Participants** Five hundred and five Japanese people ( $M_{age} = 45.08$ ,  $SD_{age} = 14.55$ ) participated in this experiment, with balanced age groups, i.e., 98, 102, 102, 102, 101 participants respectively in their 20s, 30s, 40s, 50s and over 50s. There were 255 males and 250 females. They were recruited online and enrolled the study via the Qualtrics system (<https://www.qualtrics.com>). As a reward, each participant received a coupon which could be redeemed for online shopping in Japan.

**Tasks** Participants were instructed to perform altogether the following three tasks.

**Task 1: Binary choice task** Participants were instructed to make a series of binary choices in two hypothetical scenarios, i.e., past (Figure 1) and future (Figure 2).

In both scenarios, instructions were given (i.e., 'Which option would you prefer?') and participants were required to make binary choices between an ¥100,000 reward with temporal distance, and an immediate reward with 10 monetary amounts evenly divided between ¥100,000 and ¥10,000 (i.e. ¥10,000, ¥20,000, ¥30,000, ... ¥100,000). In the example, the temporal distance is 30 days and the choices are presented in a descending order (from ¥100,000 to ¥10,000). Six temporal distances (i.e., 1, 7, 30, 90, 180, and 365 days) were involved and the amounts were presented in two possible orders (ascending or descending).

Altogether, each participant was required to make 120 binary choices (two tense scenarios × 10 monetary amounts × six temporal distances) in this task. Presentation was counterbalanced for tense scenario (past or future) and order of amount (ascending or descending) and randomized for temporal distances.

**Task 2: Impulsiveness measurement** Participants were then asked to answer the questionnaire of Barratt Impulsiveness Scale 11 (BIS11), a widely-used measure of individual impulsivity (Patton et al., 1995) containing 30 questions. The Japanese version of the scale was used in the present study (Someya et al., 2001).

**Task 3: Demographic information collection** Participants were requested to report age, sex, nationality and language skills. The language skills reported included four languages, i.e., Japanese, English, Mandarin and French, and participants' self-evaluation was anchored on a scale of 101 points, from 0 (Unable to Understand), 40 (Conversational Level), 70 (Business Level) to 100 (Native Speaker Level).

**Procedure** All the participants were presented with the same questions, and with the order of task 1, task 2 and task 3. The questions in the task 2 and task 3 were presented in the same order for all participants and the questions in task 1 were kept counting balanced (as described above). All the questions were presented in Japanese.

Which option would you prefer?

Received ¥100000 reward 30 days ago	<input type="radio"/>	<input type="radio"/>	Received ¥100000 reward 1 hour ago
Received ¥100000 reward 30 days ago	<input type="radio"/>	<input type="radio"/>	Received ¥90000 reward 1 hour ago
Received ¥100000 reward 30 days ago	<input type="radio"/>	<input type="radio"/>	Received ¥80000 reward 1 hour ago
Received ¥100000 reward 30 days ago	<input type="radio"/>	<input type="radio"/>	Received ¥70000 reward 1 hour ago
Received ¥100000 reward 30 days ago	<input type="radio"/>	<input type="radio"/>	Received ¥60000 reward 1 hour ago
Received ¥100000 reward 30 days ago	<input type="radio"/>	<input type="radio"/>	Received ¥50000 reward 1 hour ago
Received ¥100000 reward 30 days ago	<input type="radio"/>	<input type="radio"/>	Received ¥40000 reward 1 hour ago
Received ¥100000 reward 30 days ago	<input type="radio"/>	<input type="radio"/>	Received ¥30000 reward 1 hour ago
Received ¥100000 reward 30 days ago	<input type="radio"/>	<input type="radio"/>	Received ¥20000 reward 1 hour ago
Received ¥100000 reward 30 days ago	<input type="radio"/>	<input type="radio"/>	Received ¥10000 reward 1 hour ago

Figure 1: Binary choice task: past scenario

Which option would you prefer?

Receive ¥100000 reward in 30 days	<input type="radio"/>	<input type="radio"/>	Receive ¥100000 reward in 1 hour
Receive ¥100000 reward in 30 days	<input type="radio"/>	<input type="radio"/>	Receive ¥90000 reward in 1 hour
Receive ¥100000 reward in 30 days	<input type="radio"/>	<input type="radio"/>	Receive ¥80000 reward in 1 hour
Receive ¥100000 reward in 30 days	<input type="radio"/>	<input type="radio"/>	Receive ¥70000 reward in 1 hour
Receive ¥100000 reward in 30 days	<input type="radio"/>	<input type="radio"/>	Receive ¥60000 reward in 1 hour
Receive ¥100000 reward in 30 days	<input type="radio"/>	<input type="radio"/>	Receive ¥50000 reward in 1 hour
Receive ¥100000 reward in 30 days	<input type="radio"/>	<input type="radio"/>	Receive ¥40000 reward in 1 hour
Receive ¥100000 reward in 30 days	<input type="radio"/>	<input type="radio"/>	Receive ¥30000 reward in 1 hour
Receive ¥100000 reward in 30 days	<input type="radio"/>	<input type="radio"/>	Receive ¥20000 reward in 1 hour
Receive ¥100000 reward in 30 days	<input type="radio"/>	<input type="radio"/>	Receive ¥10000 reward in 1 hour

Figure 2: Binary choice task: future scenario

## Results

### General tendency

Based on participants' answers in the discounting task, we identified the points where the immediate reward of ¥100,000 was equivalent to the amount at temporal distances of 1, 7, 30, 90, 180, 365 days in the past as well as in the future scenario for each participant.

Then, we calculated the indifference points by averaging the equivalent amounts for each temporal distance and plotted them. We fitted the four models to data and chose the best one based on Akaike information criterion (AIC). AIC for each model is summarized in Table 2. It was found that q-exponential was the best model for both past and future discounting. Thus, we analyzed the data based on the q-exponential model.

Figure 3 showed the indifference points plot and q-exponential model for past and future discounting. Overall, as predicted, Japanese speakers discounted past gains ( $k_{past}=0.480$ ) more heavily than future gains ( $k_{future}=0.229$ ).

We also used the indicator of (Area Under the Curve) to evaluate the temporal discount. We standardize the area to restrict the value from 0 to 1. The average AUC of past gains ( $MAUC_{past}=0.547$ ) is significantly smaller than that of future gains ( $MAUC_{future}=0.624$ ,  $t(504) = 6.843$ ,  $p < .001$ ,  $d = 0.305$ ), suggesting that the value of past is more sensitive to time transition.

Figure 4 shows the discounting rates for each temporal distance (1, 7, 30, 90, 180, and 365 days) in past and future scenarios, with significant differences between the two scenarios for all temporal distances: 1d ( $t(504) = 4.770$ ,  $p < .001$ ,  $d = 0.212$ ), 7d ( $t(504) = 3.980$ ,  $p < .001$ ,  $d = 0.177$ ), 30d ( $t(504) = 5.602$ ,  $p < .001$ ,  $d = 0.249$ ), 90d ( $t(504) = 4.780$ ,  $p < .001$ ,  $d = 0.213$ ), 180d ( $t(504) = 5.503$ ,  $p < .001$ ,  $d = 0.245$ ) and 365d ( $t(504) = 5.710$ ,  $p < .001$ ,  $d = 0.254$ ).

In line with our prediction, results suggest that Japanese speakers tended to discount past gains more drastically than future gains, as indicated by data of discounting rate, AUC and q-exponential model. This finding also supported the LSH.

Table 2: AIC for the models.

	Past	Future
Linear	15.092	13.789
Exponential	28.231	25.576
Hyperbolic	26.249	23.906
Q-exponential	9.472	8.031

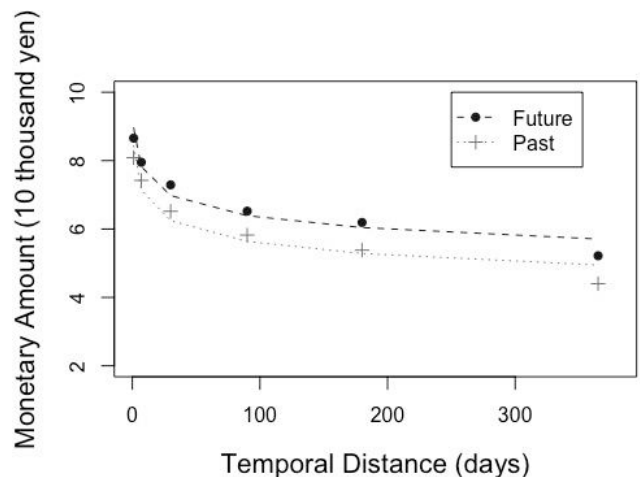
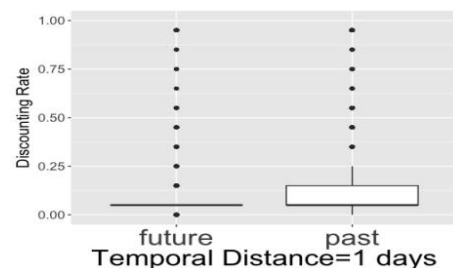


Figure 3: Q-exponential model fits for discounting results.



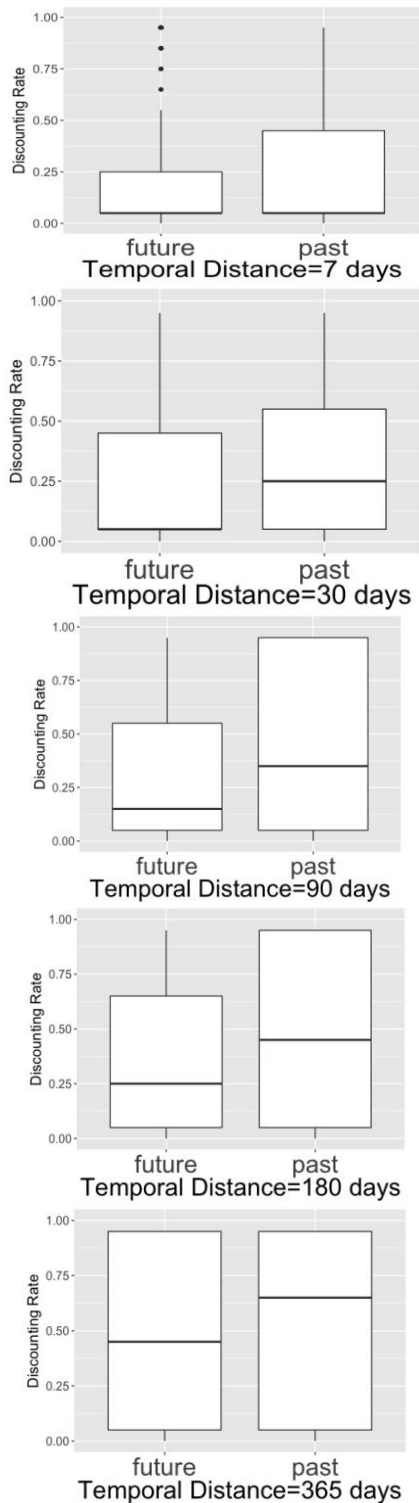


Figure 4: Discounting rate for each temporal distance.

### Individual differences and personal characteristics

To further assess individual differences and the effect of demographic factors, we fitted individual participants' data with each of the four models to decide on the best-fitting model for individuals (evaluated by AIC), as summarized in

Table 3. Although the q-exponential model was found to be the best-fitting for the overall data, the linear model explained the individual data the best. However, other models were also selected with non-negligible proportions, making it difficult to directly compare individual behaviors. Therefore, we used AUC to evaluate the discounting behavior at the individual level.

To identify the tendency of individuals, we first executed k-means clustering to categorize the AUC values obtained in past and future scenarios.

The first step is to determine the optimal number of clusters. We applied 30 indices in the R package 'NbClust' (Charrad et al., 2014) and experimented with the optimal cluster number from two to ten. Among the 30 indices, 27 returned valid results. Although two clusters were suggested by the largest number of indices (8/27), it gave much less information than three clusters, suggested by the second largest number of indices (6/27). Balance between parsimony and informativeness, we decided on three as the optimal number of clusters as shown in Figure 5. Each dot displays data for one individual, and the triangles represent the center of each cluster.

Figure 5 showcases the plausible clustering of participants' discounting behavior into three groups, i.e. high discounting group (green dots,  $n=136$ ), middle discounting group (blue dots,  $n=183$ ) and low discounting group (red dots,  $n=186$ ). The diagonal line represents identical discounting rate of past and future gains. The dots above the line are individuals who discounted the value of future gains more, while those below the line denote individuals who discounted the value of past gains more.

As the figure illustrates, individuals of the three clusters show very different tendencies. On average, the discounting rate for past and future gains is very close in both high ( $M_{AUC_{past}}=0.205$ ,  $M_{AUC_{future}}=0.200$ ) and low ( $M_{AUC_{past}}=0.905$ ,  $M_{AUC_{future}}=0.883$ ) discounting group. However, it is obvious that participants in the middle discounting group discount the value of past gains much more heavily than that of future gains ( $M_{AUC_{past}}=0.436$ ,  $M_{AUC_{future}}=0.676$ ). Thus, although the LSH well predicted the general tendency of the participants' discounting behaviors, it failed to capture the specificity at the individual level as it was found to have explained individuals with middle level discounting behaviors better than on average.

We then conducted multiple regression analysis to identify individual characteristics that have influenced discounting behavior. To reveal a full picture, we included age, impulsiveness (measured by BIS-11 questionnaire), language ability (in English, Mandarin and French) as numerical independent variables, and sex (male = 1, female = 0) and tense (past = 1, future = 0) as dummy independent variables, to predict AUC. Since we have confirmed that all participants reported that Japanese is their native language, we excluded the variable of Japanese skill. We also confirmed that correlations between every two variables were low ( $cor < .2$ ).

As multiple regression results (Table 4) show, among all variables, tense (past or future) and impulsiveness had

significant influences on discounting behaviors ( $p < .01$ ). The significant effect of tense is consistent with our major finding that people have the tendency to discount the value of past gains more strongly than that of future gains. With regard to impulsiveness, participants who scored high in the BIS-11 questionnaire tended to have stronger discounting behaviors than those with lower scores in the measurement. This result is consistent with that in the previous study, suggesting that in general impulsive individuals tend to showcase more drastic discounting behaviors (Bickel et al., 2008). No significant influence was found for the other variables. These results indicated that the difference of discounting behavior was explained more in terms of impulsiveness than other demographic factors such as age and sex. Besides, we tried to include the interaction factor of tense and impulsiveness in the model and found there was no significant interaction between tense and impulsiveness ( $p > .1$ ). The result implied that impulsiveness and tense functions on temporal discounting separately.

Table 3: Individual best model percentage.

	Past	Future
Linear	264 (52.3%)	286 (56.6%)
Exponential	90 (17.8%)	78 (15.5%)
Hyperbolic	80 (15.8%)	59 (11.7%)
Q-exponential	71 (14.1%)	82 (16.2%)

Table 4: Multiple regression results for AUC values.

	Est.	SE	p
<b>Tense</b>	<b>-0.077</b>	<b>0.020</b>	<b><math>p &lt; .001</math></b>
Age	0.000	0.001	$p = .966$
Sex	0.008	0.020	$p = .683$
English Skill	-0.001	0.001	$p = .375$
Mandarin Skill	-0.001	0.001	$p = .320$
French Skill	0.002	0.002	$p = .373$
<b>Impulsiveness</b>	<b>-0.005</b>	<b>0.001</b>	<b><math>p &lt; .001</math></b>

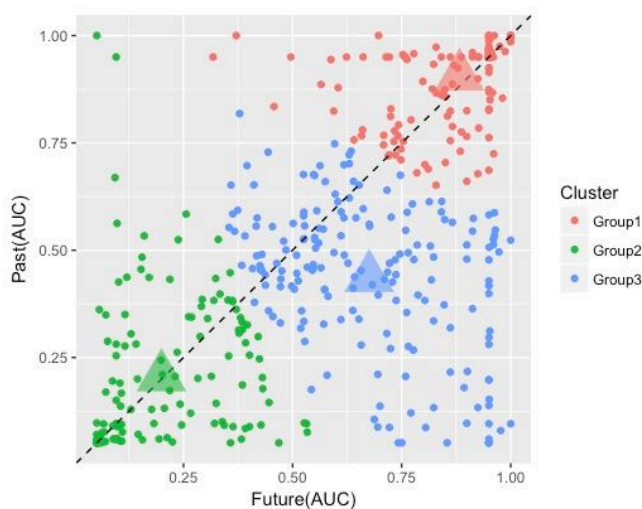


Figure 5: Cluster analysis result of AUC values.

## Discussion

The present study examined the LSH by comparing past and future discounting behaviors of individual Japanese speakers to eliminate the influence of potent factors such as culture. We found that Japanese speakers discounted the value of past gains more than that of future gains. This pattern was consistent with the prediction based on the asymmetric grammatical marking of tense in Japanese as there is grammatically marked past tense but no future tense. Thus, our results supported the LSH.

Moreover, detailed analysis of individual characteristics revealed that although the theory could explain the general tendency of discounting behavior, remarkable individual differences remained unexplained. Furthermore, our results suggested that the difference in discounting behavior was explained more in terms of impulsiveness than in terms of demographic characteristics.

Finally, we need to acknowledge that our study focused only on Japanese speakers. Even though there were several previous studies on native English speakers in the U.S. and found they discounted the value of future and past gains in a symmetrical way, we haven't replicated this result and executed the direct comparative analysis by far. This may cause some doubt and alternative explanations here. Our next step is to collect data from native speakers of English and Mandarin for comparative studies to strengthen and broaden our conclusion.

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