THE COMPARISON OF INDUCTIVE REASONING UNDER RISK CONDITIONS BETWEEN CHINESE AND JAPANESE BASED ON COMPUTATIONAL MODELS: TOWARD THE APPLICATION TO CAE FOR FOREIGN LANGUAGE

Yujie Zhang, Asuka Terai and Masanori Nakagawa
Tokyo Institute of Technology

ABSTRACT

Inductive reasoning under risk conditions is an important thinking process not only for sciences but also in our daily life. From this viewpoint, it is very useful for language learning to construct computational models of inductive reasoning which realize the CAE for foreign languages. This study proposes the comparison of inductive reasoning under risk conditions between Chinese and Japanese based on computational models. The results suggest that risk conditions (quantitative conditions) have a significant effect on inductive reasoning in Japanese, while those conditions have no effect in Chinese. On the contrary, argument conditions (qualitative conditions) have a significant effect on inductive reasoning in Chinese, while those conditions have an only partial effect in Japanese. More research is needed to find the essential reason for this contrast, for example differences between cultural or social systems. However, it is important to consider this contrast when the present models of inductive reasoning are applied to CAE for Chinese and Japanese.

KEYWORDS

Inductive reasoning, risk conditions, Chinese, Japanese, computational models, CAE

1. INTRODUCTION

Inductive reasoning is an important thinking process not only for sciences but also in our daily life. From this viewpoint, it is very useful for language learning to construct computational models of inductive reasoning which realize the CAE for foreign languages. Additionally, there are many kinds of risks that affect the inductive reasoning in various situations. Therefore, the computational model has to include the adaptive mechanism for those kinds of risk situations. We have already constructed computational models in Chinese and Japanese which include such an adaptive mechanism (Zhang, Terai, Dong, Wang, Nakagawa, in press). However, for effective usage of those models in practical education, that mechanism has to process the naive differences between languages, for example, Chinese and Japanese. Therefore, it is important to compare the effects of risk context on inductive reasoning between languages, for example, Chinese and Japanese. This study proposes the comparison of inductive reasoning under risk conditions between Chinese and Japanese based on computational models.

At first, this study deals with one kind of inductive reasoning argument (e.g., Rips, 1975; Osherson, Smith, Wilkie, Lopez, and Shafir,1990), such as:

The person likes steak.
The person doesn’t like noodles.
The person likes pasta.

In this type of argument, its strength (the likelihood of the conclusion below the line given the premises above the line) depends mainly on the entities in each sentence (e.g., “steak” (the positive entity) , “noodles” (the negative entity) , “pasta” (the conclusion)) since these sentences share the same basic predicate (e.g., “The person likes~.” and “The person doesn’t like ~.”).

However in real-world situations, even reasoning-based behavior that involves such a simple argument evaluation can entail some element of risk context. For example, the relatively straightforward situation of inviting somebody to dinner involves some risk. Even if you know that the person in question likes steak but not noodles, can you reasonably infer their reaction to pasta? If the person were a close friend, they would be likely to go to any type of restaurant with you. Therefore, in this situation, you would be fairly safe in inferring that the person "probably" likes pasta. On the other hand, when faced with the risk of inviting your boss, which could have more serious consequences, you might make a different inference, telling yourself how "unlikely" it is that the boss likes pasta. In these different risk contexts, the argument strength should be evaluated differently, which means that human ratings of the argument strength are by nature context-dependent. There is a study which discusses the risk effect on inductive reasoning in Japanese (Sakamoto, Nakagawa, 2007). However, the difference between different cultures in the reaction of risk context on inductive reasoning is not discussed in previous studies.

This study examines the impact of risk context on inductive reasoning in Japanese and Chinese. The outline of this study is as follows: At first, we conduct psychological experiments of inductive reasoning under two different risk conditions in Chinese, and then did the same experiments in Japanese. Secondly, parameters of computational models of inductive reasoning are estimated using the results of each experiment in Chinese and Japanese. Finally, we compare the effects of risk conditions between Chinese and Japanese based on the difference between parameters.

2. MODEL

We have already constructed the model based on Gaussian kernel functions, which produces the likelihood of a conclusion N_i^c, denoted as $v(N_i^c)$ represented as follows:

$$v(N_i^c) = a\mathrm{SIM}_+(N_i^c) + b\mathrm{SIM}_-(N_i^c)$$

$$\mathrm{SIM}_+(N_i^c) = \sum_j^{n^+} e^{-\beta d_{ij}^+}$$

$$\mathrm{SIM}_-(N_i^c) = \sum_j^{n^-} e^{-\beta d_{ij}^-}$$

$$d_{ij}^+ = \sqrt{\sum_k^m (P(c_k|N_i^c) - P(c_k|N_j^+))^2}$$

$$d_{ij}^- = \sqrt{\sum_k^m (P(c_k|N_i^c) - P(c_k|N_j^-))^2}$$

, where d_{ij}^+ and d_{ij}^- are word-distance functions based on the latent classes (denoted as c_k). d_{ij}^+ represents the distance between the conclusion entity N_i^c and the positive premise entity N_j^+, while d_{ij}^- represents the distance between the conclusion entity N_i^c and the negative premise entity N_j^-.

$P(c_k|N_i^c)$, $P(c_k|N_j^+)$, $P(c_k|N_j^-)$ represents the conditional probability of C_k, given N_i^c, N_j^+, N_j^-, respectively, estimated from a large scale language data in Chinese and Japanese. Each word distance function constructs Gaussian kernel functions, such as $\mathrm{SIM}_{+}(\mathrm{N}_i^c)$ and $\mathrm{SIM}_{-}(\mathrm{N}_i^c)$, when combined with nonlinear exponential functions and a parameter β. In this study, these Gaussian kernel functions are regarded as nonlinear similarity functions that reflect the retrieval assumption. $\mathrm{SIM}_{+}(\mathrm{N}_i^c)$ represents the similarities between the conclusion entity N_i^c and the positive premise entities, while $\mathrm{SIM}_{-}(\mathrm{N}_i^c)$ denotes the similarities between N_i^c and the negative premise entities. In the present model, parameter *a* means the strength of positive entity effect, while *b* indicates the strength of negative entity effect.

In this study, we consider the following hypotheses according to the present model and experiments. If participants are affected by each risk condition, in the over-estimated risk condition, they will emphasize the negative entity and parameter *b* will become bigger than parameter *a*, that is the index $|b/a| > 1$, while in the under-estimated risk condition, they will emphasize the positive entity and parameter *a* will become bigger than parameter *b*, that is $|b/a| < 1$. Totally, if the participants are affected by each risk condition, there will be a significant difference of the index $|b/a|$ between the two risk conditions.

3. EXPERIMENT

An experiment was designed like a game and played on the internet. We designed the same experiment in Chinese and Japanese and compared the effect of an over-estimated risk condition and an under-estimated risk condition.

3.1 Method

In the Japanese experiment, 38 Japanese undergraduate and graduate students participated, of which 20 were assigned to the over-estimated risk condition, with the remaining 18 being assigned to the under-estimated risk condition. While in the Chinese experiment, 33 Chinese undergraduate and graduate students participated, of which 18 were assigned to the over-estimated risk condition, with the remaining 15 being assigned to the under-estimated risk condition.

3.1.1 Task and Condition

Participants were told a cover story and were to suppose they were new employees of a consulting company and were participating in the company's new employee training. The experimental task was judging the preference of customers from the perspective of a new employee in the company. The game consisted of three parts. The first part was a practice session about judging the preference of customer A. The customer's preference was expressed by 26 inductive reasoning arguments and was rated on a 7-point scale. Unlike the usual inductive reasoning task, the money you gained or lost was according to the variation from the 'concocted' right answer from the previous experimental study. If a rating corresponded to this right answer, the participant received money. The right answer appeared in all three sessions. In the over-estimated risk condition, as the likelihood rating increased relative to the right answer, the reduction of money also increased. Conversely, in the under-estimated risk condition, as the rating decreased relative to the right answer, the reduction of money also increased. Money allocations for each condition are shown in Table 1.

Table 1. Allocation of Money in Each Risk Condition

		Over-estimation by 3 or more points	Over-estimation by 2 points	Over-estimation by 1 point	Corresponds to the right answer
Over	Japanese	-20000 yen	-15000 yen	-10000 yen	10000 yen
	Chinese	-2000 yuan	-1500 yuan	-1000 yuan	1000 yuan
Under	Japanese	0 yen	5000 yen	10000 yen	10000 yen
	Chinese	0 yuan	500 yuan	1000 yuan	1000 yuan

		Under-estimation by 1 point	Under-estimation by 2 points	Under-estimation by 3 or more points
Over	Japanese	10000 yen	5000 yen	0 yen
	Chinese	1000 yuan	500 yuan	0 yuan
Under	Japanese	-10000 yen	-15000 yen	-20000 yen
	Chinese	-1000 yuan	-1500 yuan	-2000 yuan

Each inductive reasoning argument has its correct answer, the condition of the money you gained or lost was shown on the screen as feedback according to the answer given by each participant. In the end of the practice session, the participant's total money was shown on the screen. The next two parts, formal session 1 and formal session 2, were the same as the practice session except for the inductive reasoning arguments about the preference of costumer B and costumer C.

3.1.2 Materials

The premise and conclusion statements all consisted of a combination of a predicate (Customer A likes '~') and an entity (e.g. basketball), such as "Customer A likes basketball." In the case of negative premises, the predicate involved a negative verbal form, such as "Customer A doesn't like Sociology." The positive and negative premise entities and the conclusion entities in each argument set were selected from the previous study, and the Japanese words were translated from Chinese words.

3.1.3 Procedure

We compare participants' reactions under two distinct risk conditions: in the over-estimated risk condition, the over-estimation of the ratings of customers' preference entail a money-decreasing risk, while in the under-estimated risk condition, the under-estimation of the ratings also entail a money-decreasing risk. Moreover, in order to compare the effect of the two risk conditions more deeply, each participant participated in both of the risk conditions. A participant assigned to the over-estimated risk condition participated in the under-estimated risk condition when the experiment of the over-estimated risk condition finished, and vice versa for a participant of the under-estimated risk condition. The same experiments were conducted in Japanese and Chinese on the internet.

3.2 Result and Discussion

The parameters *a*, *b*, and the index $|b/a|$ were estimated in each risk condition in Japanese and Chinese. In both experiments of Japanese, a significant difference is observed in the average of $|b/a|$ between two risk conditions ($p<0.01$). On the other hand, in both experiments of Chinese, no significant difference is observed in the average of $|b/a|$ between the two risk conditions.

Table 2. The Average of Parameters and the t-test between Japanese and Chinese (Exp is represent Experiment)

	Japanese						
	Over			Under			
	a	b	|b/a|	a	b	|b/a|	p-value from t-test
Exp1	2.601	-4.075	1.584	3.556	-3.177	0.915	0.0000
Exp2	2.665	-4.184	1.642	3.493	-3.128	0.906	0.0000

Chinese						
Over			Under			
a	b	|b/a|	a	b	|b/a|	p-value from t-test
2.242	-1.278	0.565	2.753	-1.298	0.476	0.020
2.475	-1.330	0.547	2.505	-1.239	0.490	0.146

Table 3. The Average of |b/a| and the t-test between Session 1 and Session 2 in Every Risk Condition between Japanese and Chinese (Exp is represent Experiment)

Japanese				Chinese		
		OVER	UNDER		OVER	UNDER
Exp1	Session1	1.765	0.920	Session1	0.794	0.680
	Session2	1.476	0.965	Session2	0.354	0.306
	p-value from t-test	0.031	0.393	p-value from t-test	0.0000	0.0000
Exp2	Session1	1.685	0.905	Session1	0.740	0.760
	Session2	1.404	0.971	Session2	0.365	0.308
	p-value from t-test	0.001	0.068	p-value from t-test	0.0000	0.0000

Additionally, we compared the difference between session 1 and session 2 in every risk condition. The parameters |b/a| of session 1 and session 2 were estimated in each risk condition of Japanese and Chinese. In both experiments of Japanese, no significant difference is observed in the average of |b/a| between the two sessions in under risk condition. On the other hand, in both experiments of Chinese, a significant difference is observed in the average of |b/a| between the two sessions in each risk condition ($p<0.01$).

Totally, there are very interesting contrasting effects of conditions in inductive reasoning between Chinese and Japanese. Risk conditions (quantitative conditions) have a significant effect on inductive reasoning in Japanese, while those conditions have no effect in Chinese. On the contrary, argument conditions (qualitative conditions) have a significant effect on inductive reasoning in Chinese, while those conditions have an only partial effect on inductive reasoning in Japanese. More research is needed to find the essential reason for this contrast, for example, differences between cultural or social systems. However, it is important to consider this contrast when the present models of inductive reasoning are applied to CAE for Chinese and Japanese.

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