

Causal Strength and Reliability: Two Processes in Causal Reasoning

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Abstract

The purpose of this study is to examine whether reasoners have two cognitive processes, the causal strength and the reliability, and how the processes work in causal judgments. In an experiment, participants' causal judgments were varied depending on the conditions, which were introduced to activate either one of the two processes, as well as on the cell configurations between causes and effects. The results suggested the two different cognitive processes were involved in causal judgments and their interaction occurred in case a higher accuracy is needed. It is proposed that theories on causal reasoning should give regards to the reliability of data.

Introduction

Causal knowledge is important for us because it enables us to predict the future. On the one hand, if there is a strong causal relationship between events, the occurrence of the cause entails the occurrence of the effect. Knowledge of a strong causal relationship brings us the advantage of precise predictions. On the other hand, as long as we induce causal relationship from instances, we always have a risk of forming a wrong causal knowledge. Credible causal knowledge is important as well for our confident expectation.

Correspondingly, there have been two lines of research on causal induction: cognitive judgment vs. learning. For some researchers, discovering a causal relationship can be regarded as a kind of covariation detection, which is a form of judgment on a sample (e.g., Cheng, 1997; Hattori, 2003). For the other researchers, however, causal induction is a form of learning through a sequential sampling (e.g., Rescorla & Wagner, 1972). The issues on sample size have emerged from debates between the two camps (e.g., Anderson & Sheu, 1995). Reliability of the causal knowledge is tightly connected with the sample size. As the number of instances increases, the induced causal relationship can be strengthened.

From the viewpoint of covariation detection, it is difficult to account for the variation of the reliability of data caused by the sample size. On the other hand, the learning view has the advantage in the influence of the sample size, which is explained by the change of the associative strength of the cause and effect. However, it is not clear how the reliability affects the participants' judgments on causality. Therefore, we investigated how the reliability of data, as well as the causal strength, affects judgments of causality. It was examined whether the need for the accuracy of judgments alter par-

ticipants' causal judgments, which has hardly been explored so far.

Method

Materials and Procedure

In order to investigate the influence of the two processes in various relations of the causal strength and the reliability, five types of the combinations between the causal strength and the reliability were prepared (see, Table 1), based on the level in the causal strength and the reliability (i.e., high / medium / low). Causal strength was calculated according to H (Hattori, 2003), Power PC theory (PW) (Cheng, 1997) and ΔP . Reliability was defined by an index, which we call effective sample size (ESS): $ESS = (a + b)d / (c + d)$, where a , b , c , and d indicate cell frequencies. Cell frequencies are defined by 4 possible states of the relation between a cause and an effect: a (cause is present and effect is present), b (cause present and effect absent), c (cause absent and effect present), and d (cause absent and effect absent). In Type, EE denotes that the two options, the player A and B (detailed below), are equal both in strength and reliability. UE and EU represent A and B are unequal in strength and reliability, respectively. UUc and UUu indicate both the measurements are different in the coincident direction and in the uncoincident direction, respectively.

A cover story about a fictitious baseball league was used. Participants were given a pair of the score information of the two players (i.e., Player A and B), who played at different regional division teams and whose teams never played against each other. Participants' task was to select either Player A or B to give some advice to a team. In order to lead participants' attention into the causal strength or the reliability, two conditions were prepared: Causality Condition and Reliability Condition. In Causality Condition, participants answered which player had had the stronger influence on the performance of the team. In Reliability Condition, participants were asked to advise either one of the two teams. The advice was either to keep or to stop recruiting the player concerned in the rest half-term in this season. It was emphasized that participants should have given an advice only when they were confident their assessments of the player's impact on the team's performance because a wrong judgment could cause losing their job (i.e., a great loss).

Table 1: Combination between Causal Strength and Reliability Used in the Task and Results

Type	Str.	Rel.	Config.	Player A				Player B				Prop. of A		
				H	PW	ΔP	EES	Config.	H	PW	ΔP	EES	CA	RE
EE	A = B	A = B	7,5,3,9	.64	.44	.33	9	9,3,5,7	.69	.57	.33	7	.40	.51
	A = B	A = B	3,9,3,9	.35	.00	.00	9	4,8,4,8	.41	.00	.00	8		
UE	A > B	A = B	12,0,5,7	.84	1.00	.58	7	5,7,5,7	.46	.00	.00	7	.95	.59
	A > B	A = B	12,0,1,11	.96	1.00	.92	11	1,11,1,11	.20	.00	.00	11		
EU	A = B	A > B	6,6,0,12	.71	.50	.50	12	11,1,9,3	.71	.67	.17	3	.49	.65
	A = B	A > B	10,2,7,5	.70	.60	.25	5	8,4,2,10	.73	.60	.50	10		
	A = B	A > B	5,7,1,11	.59	.36	.33	11	10,2,6,6	.72	.67	.33	6		
UUu	A < B	A > B	2,10,2,10	.29	.00	.00	10	11,1,8,4	.73	.75	.25	4	.10	.43
	A < B	A > B	1,11,1,11	.20	.00	.00	11	11,1,7,5	.75	.80	.33	5		
UUC	A > B	A > B	12,0,0,12	1.00	1.00	1.00	12	6,6,6,6	.50	.00	.00	6	.84	.65
	A > B	A > B	11,1,0,12	.96	.92	.92	12	11,1,10,2	.69	.50	.08	2		

Note: Config. denotes the cell configuration of two options, Player A and B, in the task. Its numbers indicate the frequencies of the cell a, b, c and d in the order. Str. and Rel. indicate the combination between A and B in strength and in reliability, respectively. Prop. of A notes the proportion of which participants selected A in the experiment. CA and RE represent Causality Condition and Reliability Condition, respectively.

Participants and design

Four hundred and thirty two undergraduates from Kyoto Sangyo University participated in the experiment. They were divided into 22 groups: 2 Conditions (Causal / Reliability) \times 11 stimuli (see, Table 1).

Results

Table 1 shows the proportions of participants who selected one of the two options (i.e., Player A or B) in each of the five types of the combination of the cell configurations. Although the cell configurations in both conditions were identical, there were significant differences in the participants' judgments between the two conditions in some types: UE ($\chi^2(1, N = 78) = 14.2, p < .01$), UUu ($\chi^2(1, N = 84) = 11.6, p < .01$) and UUC ($\chi^2(1, N = 86) = 3.9, p < .05$). EU also showed the similar tendency ($\chi^2(1, N = 103) = 2.8, p = .09$). There were no significant effects in EE ($\chi^2(1, N = 81) = 1.0, p = .31$).

Discussion

The results suggest that the two processes are involved in causal judgment: the causal strength process by which reasoners estimate the causal relations between events and the reliability process by which reasoners assess whether it is reasonable to make any causal judgments. Although the causal strength may usually play a central part in causal judgments, the reliability can alter the judgment under some situations in which a prudent decision is required. Participants' judgments were varied between the two conditions, when the assessments of Player A and B were different either in causal strength or in reliability, or in both. Specifically, the proportion of which participants selected A in Reliability Condition tended to be influenced by the assessment of the reliability. The selection in Reliability Condition, however, did not accord with a simple assessment of reliability. The proportion of the selection seems to reflect the causal strength more or less in both conditions.

It is therefore suggested that there is an interaction between causal strength and reliability in the condition in which the possibility of a risk is emphasized. Although some existing models can treat effects of the sample size, it would be difficult to explain the variation caused by participants' attention to reliability. The causal reasoning theories should take into account reliability as well as causal strength.

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