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Investigating the relationship between luck beliefs causal attributions and well-being through a card game experiment

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This study investigated the relationship between luck beliefs, causal attribution, and well-being through a card game experiment. Building on the two-factor model of luck beliefs–general belief in luck (Belief in Luck) and personal luck (Personal Luckiness)–this study explored how these beliefs influenced subjective well-being and causal attributions to luck or ability. Participants (N = 441) played a concentration card game against a computer agent with varying memory capacities while evaluating whether their success was attributable to luck or ability. The results supported three key hypotheses: (1) Belief in luck was negatively associated with cognitive well-being, whereas Personal Luckiness positively correlated with both cognitive and affective well-being; (2) Belief in luck predicted higher attribution to luck, whereas Personal Luckiness correlated with both luck and ability attributions; and (3) no consistent relationships between causal attributions and well-being were found. These findings highlight the complex psychological mechanisms that link luck beliefs, causal attribution, and well-being.

Human perception of luck has been studied from various philosophical and psychological perspectives. First, there are studies that question the existence of luck as an objective phenomenon, with the aim of exposing the irrationality of the human concept of luck[1]. This was the starting point for the study of luck. Next, there are types of studies that attempt to identify heuristics or biases in human perception of luck in a descriptive manner. These include several well-known heuristics, such as the availability heuristic, confirmation bias, and illusory correlation[2]. A third type of research focuses on understanding the psychological and neurological mechanisms underlying the perception of luck[3]. It seeks to clarify the mechanisms of luck perception by investigating why humans acquired the concept of luck during evolution[4].

Sub-structure of luck beliefs

As the earliest effort to identify the structure of luck beliefs and measure these beliefs, Darke and Freedman (1997) conceptualized irrational luck beliefs in a unidimensional way[5]. Specifically, they developed the Belief in Good Luck Scale (BIGL), which measures on a single dimension the belief that luck deterministically favors certain people versus the view that luck is simply a random phenomenon. This pioneering work laid the groundwork for subsequent research examining more nuanced perspectives on luck beliefs. Subsequent studies have suggested that luck beliefs are more complex than Darke and Freedman's unidimensional conceptualization. For instance, Andre[6], after positing six subfactors, identified four in his factor analysis. Maltby et al.[7] found a structure consisting of four dimensions; however, the factors were not necessarily consistent with each other. These findings collectively point to the possibility of multiple facets underpinning luck beliefs, indicating that individuals' perceptions of luck may not be reducible to a single factor.

Building on these mixed results, Prendergast and Thompson[8] found two subfactors of luck beliefs: general beliefs in luck and the belief that one is lucky. There was no correlation between these two factors. They elaborated on the two-dimensional structure of luck beliefs and developed the Belief in Luck and Luckiness Scale (BILLS) to measure them[9]. BILLS distinguishes between a general belief or disbelief in luck as a definitive phenomenon (hereafter, Belief in Luck) and whether one is personally lucky or unfortunate (hereafter, Personal Luckiness). Given these developments in the field, the present study adopts the two-factor model of luck beliefs and uses BILLS as its primary assessment tool. This approach ensures a more nuanced examination of how people's attributions regarding luck relate to broader aspects of their well-being.

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Luck beliefs and well-being

Luck beliefs are known to affect the quality of life. For example, studies using the one-dimensional BIGL have shown that belief scores in luck are negatively correlated with anxiety and depression tendencies[10,11]. However, the two-factor model of luck beliefs showed that the two subfactors of luck beliefs had opposite relations on well-being[9]. First, general luck beliefs, as measured by Belief in Luck, were negatively correlated with life satisfaction. A negative correlation between general luck beliefs and well-being has been confirmed in surveys conducted in the United States, Lithuania, India, China, and Mongolia, where life satisfaction was lower among those who believed luck determined their lives[12]. In contrast, Personal Luckiness was positively correlated with life satisfaction. This study focused on the duality of luck beliefs in predicting well-being.

The initial aim of this study was to provide more robust evidence for the relationship between luck beliefs and well-being, as identified in the two-factor model of luck beliefs. Various factors are thought to influence well-being levels. Positive psychology research typically controls for these variables and examines whether the factors of interest affect well-being. However, previous studies controlled only for sex and age; they did not eliminate the influence of other factors. Therefore, the first objective of this study was to test the following hypothesis:

- **Hypothesis 1**: Even after controlling for demographic variables known to have a significant impact on levels of well-being as well as factors such as health status and friendships, general beliefs in luck (Belief in Luck) are negatively related to well-being, whereas beliefs about one's own luck (Personal Luckiness) are positively related.

In positive psychology, well-being is typically assessed using two key dimensions: cognitive and affective well-being[13,14]. These dimensions reflect how people evaluate their lives and experience emotions. Cognitive well-being refers to an individual's evaluation of their overall quality of life. It is based on rational, rather than momentary, emotions. On the other hand, affective well-being focuses on emotional experiences and is measured by assessing how frequently people experience positive and negative emotions. This study measured the level of well-being using this subjective well-being framework.

Luck beliefs and causal attribution

Thompson et al.[15] examined personality traits as factors explaining the different directions in which these two types of luck belief affect life satisfaction. Specifically, people who held strong general luck beliefs (Belief in Luck) also tended to have high neurotic tendencies, which in turn reduced their happiness. On the other hand, Personal Luckiness was positively associated with life satisfaction and positive affect but negatively with negative affect. However, personality traits do not fully mediate these relationships.

In this study, we focused on the relationship between luck beliefs and causal attribution for explaining how the two types of beliefs in the two-factor model of luck beliefs affect levels of well-being in different directions. Weiner proposed a theory of causal attribution by combining the Stable and Unstable dimension and the Internal and External dimension[16,17]. According to this theory, luck is the typical causal attribute of the External and Unstable. On the other hand, the representative causal attribution of Internal and Stable, which is the opposite, is attributed to ability. In the former, the cause of the phenomenon was sought in terms of environmental and contingent factors. In the latter case, the cause is one's own characteristics, such as abilities, skills, and personality.

As we will discuss in more detail below, causal attribution is related to the locus of control (LOC), which is known to be an important determinant of life satisfaction. Hence, the two types of luck beliefs may have different relations with life satisfaction depending on one's tendency to attribute the cause. LOC can be divided into internal LOC, the idea that one has control over events in one's life (i.e., that the occurrence of events depends on one's own behavior and internal capabilities), and external LOC, the idea that it depends on external factors[18]. Based on the nature of these two types of LOC, these beliefs are thought to be associated with the two types of causal attribution. It has been shown that internal LOC is positively correlated with attribution of cause to ability[19,20], and external LOC is positively correlated with attribution of cause to luck[20].

Luck is defined as an object that cannot be controlled. This finding suggests that luck beliefs positively correlate with external LOC. Darke and Freedman[5] showed that the BIGL is positively correlated with external LOC but not internal LOC. Similarly, two studies conducted in Italy confirmed positive correlations between the BIGL and external LOC scores[21,22]. The two types of luck beliefs we focus on in this study-Belief in Luck and Personal Luckiness-are both related to uncontrollable luck. This suggests that both Beliefs in Luck and Personal Luckiness in the two-factor model of luck beliefs are positively correlated with attribution to luck. Thus, we propose the following Hypothesis 2A.

- **Hypothesis 2A**: Both General beliefs in luck (Belief in Luck) and one's own luck (Personal Luckiness) would be positively related to attribution to luck.

In contrast, Prendergast and Thompson[9] found that general beliefs in luck were positively correlated with external LOC, whereas beliefs about personal luckiness were positively correlated with internal LOC. These results were confirmed by Thompson et al. (2022). Given that Personal Luckiness is related to internal LOC, this belief may also be positively correlated with attributions to ability. In fact, we have naïve intuition that perceives luck as a type of ability. For example, we have naïve notions such as the "law of attraction," which means that we can attract luckiness[23,24]. Additionally, aphorisms such as "Chance favors a prepared mind"[25] indicate that people have the idea that we can control luck to some degree. Thus, we propose the following Hypothesis 2B.

- **Hypothesis 2B**: Beliefs in one's own luck (Personal Luckiness) would be positively related to attribution to ability.

Causal attribution and well-being

The difference in the nature of this causal attribution may explain why the two beliefs in the two-factor model of luck beliefs contribute differently to well-being levels. Specifically, it is possible that the tendency to attribute causes to luck in a general belief about luck (Belief in Luck) negatively contributes to levels of well-being. Whereas the tendency to attribute causes to ability in Personal Luckiness positively contributes to levels of well-being. This possibility can be drawn from the following findings on the relationship between the two types of LOC and levels of well-being.

Previous studies confirmed the relationship between LOC and well-being. Ng et al. (2006) conducted a meta-analysis of the relationship between LOC and a variety of work outcomes. They found that internal LOC was positively correlated with positive work outcomes, such as positive task experience, social experience, and higher work motivation[26]. Managers' internal LOC have also been shown to promote their well-being[27]. Similarly, Judge and Bono[28] conducted a detailed meta-analysis and estimated a correlation of approximately 0.32 between a sense of internal control and job satisfaction. In contrast, Cheng et al.[29] found a moderately strong relationship between external LOC and symptoms of depression and anxiety. In addition, Gore et al.[30] hypothesized that internal and external LOC uniquely predict levels of well-being, with external LOC best predicting lower levels of well-being. Thus, it is possible that the tendency to attribute causes to luck based on external LOC is negatively related to well-being levels, whereas the tendency to attribute causes to ability based on internal LOC is positively related to well-being levels. The following hypothesis 3 is drawn:

- **Hypothesis 3**: Attributing causes to luck is negatively correlated with levels of well-being, whereas attributing causes to ability is positively correlated with levels of well-being.

Experimental paradigm for measuring causal attribution

Previous studies on the relationship between luck beliefs and causal attribution have examined the relationship between luck beliefs, as measured by psychological scales such as BIGL and the BILLS and beliefs in control over life events, as measured by LOC scales[5,9,21,22]. LOC can be viewed as a generalized belief system regarding the causality of events, whereas causal attribution is often more in the nature of a psychological response to an event that has occurred.

Therefore, in this study, we conducted an experiment using a card game, specifically Concentration, to more directly examine the relationship between luck beliefs and causal attributions. Concentration is one of the most widely played card games worldwide. In this game, two cards from the face-down cards set are turned face-up and if the card symbols on the face of the cards match, the player wins the pair. Finally, the winner is determined by the number of pairs of cards acquired. It is important to note that in this type of game, getting a pair depends on both luck, such as the player accidentally turning the identical cards face up, and the player's ability to memorize[31]. In this experiment, we measure causal attribution more directly by asking participants to rate whether the acquisition of the pair was because of their own ability or luck at the time the pair was acquired during and at the end of the game.

Experiments

Participants

A total of 442 individuals recruited through a crowdsourcing service, "Crowd Works," participated in the study. One participant who scored zero on the memory test was excluded from the analysis; so data were analyzed for a total of 441 participants. Participants were paid JPY 400. There were 191 males (age: mean = 40.8, SD = 8.73) and 250 females (age: mean = 40.9, SD = 9.07).

The distribution of demographic variables is shown in Supplementary Material.

The size of the number of participants required was calculated using G*Power (version 3.1.9.6). We need a larger sample size for detecting a smaller effect size The regression analysis conducted in this study detected the explanatory effects of the two variables on luck beliefs under the eight control variables. Under this assumption, the sample size needed to ensure a significance level: $\alpha = 0.05$, effect size: $f^2 = 0.05$, and power: $1 - \beta = 0.8$ was 196.

Experimental environment

In this experiment, the game task was a game of Concentration. The experimental environment was originally designed and built by the authors, implemented with JavaScript, HTML and CSS, and run on a web browser. Figure 1 shows a screenshot of the experimental environment.

The basic procedure of the Concentration game is as follows: First, 24 face-down cards are placed on a board. When it is their turn, the participants turn over two cards. If the symbols on the cards that are turned-up match, the participants wins those cards. If the symbols on the cards are not the same, the cards are turned over and the other player's turn begins. The turns continue in this manner and the game ends when the players win all cards on the board.

In this experiment, the participants played against a game agent built on a computer. Each time a card was revealed, the agent stores its position and symbol in its memory. However, the memory capacity of the agent was limited. When the maximum number of stored cards was reached, the information on the oldest cards in the memory were deleted. In the experiment, the memory capacity of the agent was manipulated using this upper limit on the number of cards stored. Specifically, three conditions were set for the maximum number of memory cards: three, five, and seven.

The computer agent uses the following strategy to play the game. This is a common normative strategy for playing against each other in Concentration[32]. When it is the agent's turn, it first searches its memory for information on the cards. If there are two cards in memory with matching symbols, they are turned over and

Fig. 1. Screenshot of the experimental environment. When participants win a card pair, they are asked "Getting the card pair is because of luck" or 'Getting the card pair is because of ability," and respond to the question on a 5-point scale from "strongly disagree" to "strongly agree" in the window below.

taken. If there are no matching cards in memory, the first card is randomly turned up. Then, it searches its memory again, and if there is a card in the memory whose symbol matches the first card, that card is turned up and taken. If there is no matching card in memory, the second card is randomly turned over.

Measurement of participants' memory capability

Participants' memory capabilities were measured using the method of limit. First, 24 cards were displayed face down, similar to the Concentration game. The participants were randomly presented with n cards, one at a time, and faced up. The participants were asked to memorize the cards, and recall the order in which the cards were presented. If the order was played correctly, n + 1 card presentations were tested in the next session (ascending series). If they failed, n–1 card presentations were tested (descending series).

The test was terminated after 10 reversals, and the average number of cards in the card series at the time of the 10 reversals was considered as the participant's memory capacity. This test was performed in the test environment implemented on a computer.

Measures

BILLS

For luck beliefs, we used the Belief in Luck and Luckiness Scale (BILLS) as a psychological scale designed to measure two-dimensional luck beliefs[9].

The scale is based on a bidimensional model, which includes two main aspects: Belief in Luck and Personal Luckiness. It comprises 12 items, six of which are Belief in Luck items such as "I believe in good luck and bad luck," and six of which are Personal Luckiness items such as "I generally have good luck," and uses a Likert-scale format from 1 (strongly disagree) to 5 (strongly agree). See Supplementary Material for specific items. This study used the Japanese version of BILLS, which was translated by the authors. The standard method of repeatedly translating into English and Japanese, and then having several experts, including native English speakers, check the translation was adopted.

The Belief in Luck and Personal Luckiness score was calculated as the sum of the ratings for the 6 items included in that sub-scale.

SWLS

Subjective well-being includes two aspects: cognitive and affective[13,14]. We used the Satisfaction with Life Scale (SWLS), a widely used self-report instrument to measure the cognitive aspect of subjective well-being[33].

This scale consists of five statements such as "In most ways my life is close to my ideal," which individuals rate on a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree). See Supplementary Material for specific items. In this study, the Japanese version of SWLS was used[34].

The SWLS score was calculated as the sum of the rating scores for the five items.

SPANE

For the affective aspect, we used the Scale of Positive and Negative Experience (SPANE)[35]. The SPANE is a self-report measure designed to assess emotional aspects of well-being. This scale aims to capture both the frequency and intensity of positive and negative emotions experienced by individuals.

The SPANE consists of 12 items such as "pleasant and unpleasant, joyful and afraid," with participants rating each item on a 5-point Likert scale, ranging from 1 (very rarely or never) to 5 (very often or always). See Supplementary Material for specific items.

Each positive and negative score was calculated as the sum of the rating scores for the six items in each of the positive and negative items.

For the above variables, we confirmed a two-factor structure of the BILLS and a single-factor structure of the SWLS, SPANE (positive), and SPANE (negative) using factor analysis. The scree plots and the factor structures are presented in Supplementary Material.

The Cronbach's alpha coefficients for Belief in Luck, Personal Luckiness, SWLS, SPANE(P), and SPANE(N) were 0.80, 0.94, 0.91, 0.94, and 0.88,respectively.

Control variables

We measured the following five demographic variables as control variables: gender, age, household income, highest level of education, and marital status, along with two additional variables, namely, the number of friends and health status. For marital status, three responses were recorded: unmarried, married, other (i.e., divorced, widowed, and separated). The analysis was performed using unmarried as the reference level.

Measures for causal attribution

In a game, participants responded on a 5-point scale from "strongly disagree" to "strongly agree" to the question "Getting the card pair is due to luck (or ability)" each time they won a card pair. The score for attribution to luck (or ability) during the game was the average of their rating scores.

At the end of the game, they also responded on a 5-point scale from "strongly disagree" to "strongly agree" to the question, "The overall outcome of this game was due to luck (or ability)." The score for attribution to luck (or ability) at the end of the game was the rating score.

Procedures

Informed consent was obtained from all the participants involved in our study. Prior to participation, they were fully informed about the nature and objectives of the research, as well as the procedures involved, and consent was documented in accordance with the ethical guidelines and requirements set by our institutional review board. All personal identifiers were removed or masked to protect participants' privacy and confidentiality.

A total of 442 participants were randomly assigned to play against an agent with one of the three abilities. As a result, 162, 117, and 163 participants played against agents who can memorize the three, five, and seven cards, respectively. The assignment of participants to each condition was done by the program each time. Due to a technical problem with the program, there were unexpected small differences in the number of participants between the conditions. One participant in the seven-card condition was excluded from the analysis because his/her memory test score was zero.

Participants entered the experiment by clicking on the provided URL. The experiment ran automatically, and participants went through the series of stages from start to finish in one go. Participants first responded to the BILLS scale. Next, they participated in the test to measure their memory performance. They then participated in two games. At the end of the first game, the 24 cards were turned face down again and the second game began. In one game, the participants responded to the attribution to luck; in the other, they responded on the attribution to ability. The order in which the games tested luck and testing ability was counterbalanced. After completing the two games, participants responded to the SWLS scale, the SPANE scale, and finally a questionnaire with demographic variables.

Results

Descriptive statistics

Table 1 shows the descriptive statistics for the representative variables and the correlations between the variables.

Memory ability and game performance

This experiment measured the participants' memory capacity, and manipulated the memory capacity of the opposing computer agent. Higher memory capacity predicts higher game performance, in this case the number of card pairs won. Before starting the main analysis, we check whether the game performance is predicted by these two factors as expected.

The analysis was performed using a linear mixed model, where the performance (i.e., the number of pairs of cards won) was regressed on the participant's memory ability, the computer agent's memory ability, and game variation. Each participant played two games, one in which attribution to luck was rated and the other in which attribution to ability was rated. In this model, the participants were included as random effects. Table 2 shows the result of analysis. The results of the analysis confirmed this prediction, showing that the higher the ability of the participant and the lower the ability of the computer agent, the greater the number of pairs of cards acquired.

Luck beliefs and well-being

A hierarchical regression analysis was used to identify the unique contribution of specific variables in predicting the target variable. First, to test Hypothesis 1, we examined three models that predicted the three well-being scores. Table 3 shows how each model predicted life satisfaction (SWLS score) and the emotional status of well-being (SPANE (positive) and SPANE (negative) scores). First, we entered the demographic variables into the model (1st step). Next, we entered the BILLS scores into the model to assess their effects on the well-being scores (step 2).

In Step 2, adding the luck beliefs scores explained 15.3%, 13.2%, and 7.7% of the variance in life satisfaction, positive emotions, and negative emotions, respectively. The results also indicated that Belief in Luck was negatively correlated with life satisfaction only; however, Personal Luckiness was positively correlated with life satisfaction and positive emotions and negatively correlated with negative emotions.

	BinL	PL	LS	PE	NE	MA	ALd	ALe	AAd	AAe
BinL	—									
PL	-0.102^{*}	—								
LS	-0.131^{**}	0.626^{***}	—							
PE	-0.061	0.589^{***}	0.718^{***}	—						
NE	0.096^{*}	-0.435^{***}	-0.381^{***}	-0.412^{***}	—					
MA	0.065	-0.022	-0.019	-0.026	-0.076	—				
ALd	0.166^{***}	0.115^{*}	0.040	0.037	0.122^{*}	-0.127^{**}	—			
ALe	0.184^{***}	0.096^{*}	0.091	0.056	0.052	-0.061	0.684^{***}	—		
AAd	-0.065	0.112^{*}	0.120^{*}	0.083	-0.113^{*}	-0.036	-0.104^{*}	-0.088	—	
AAe	-0.007	0.093^{*}	0.126^{**}	0.078	-0.133^{**}	0.067	-0.105^{*}	-0.116^{*}	0.591^{***}	—
Mean	22.118	17.333	16.524	17.392	15.918	5.523	3.489	3.304	3.332	3.356
SD	3.630	5.645	6.831	5.366	5.463	1.021	0.949	1.121	0.884	1.076
Min	6.000	6.000	5.000	6.000	6.000	1.286	1.000	1.000	1.000	1.000
Max	30.000	30.000	34.000	30.000	30.000	9.714	5.000	5.000	5.000	5.000
Skewness	− 0.720	− 0.106	0.263	0.159	0.345	− 0.030	− 0.692	− 0.414	− 0.248	− 0.502
Kurtosis	4.428	2.278	2.252	2.523	2.442	4.255	2.947	2.224	2.805	2.467

Table 1. Correlations and descriptive statistics for representative variables. BinL: Belief in Luck, PL: Personal Luckiness, LS: SWLS, PE: SPANE(P), NE: SPANE(N). MA: Memory Ability, ALd: Attribution to Luck during game, ALe: Attribution to Luck at the end. AAd: Attribution to Ability during game, AAe: Attribution to Ability at the end. $p < 0.05^{*}$, $p < 0.01^{**}$, $p < 0.001^{***}$.

Fixed Effects	Estimate (β)	Std. Error	t value	Pr(>|t|)	2.5%	97.5%
(Intercept)	8.783	0.369	23.800	< 2e−16 ***	8.058	9.509
Memory ability	0.358	0.058	6.142	1.31e−09 ***	0.244	0.473
Ability of agent	− 0.819	0.035	− 23.577	2e−16 ***	− 0.887	−0.750
Game	0.016	0.105	0.152	0.879	−0.190	0.221
Random effects		**Variance**		**Std. Dev.**		
Participant (Intercept)		0.352		0.593		
Residual		2.417		1.555		

Table 2. Regression of game performance (# of card pairs won) on memory abilities of participant and computer agent. $p < 0.05^{*}$, $p < 0.01^{**}$, $p < 0.001^{***}$.

Hypothesis 1 predicted that, even after controlling for demographic variables, Belief in Luck would be negatively correlated with well-being, whereas Personal Luckiness would be positively correlated. These results are consistent with the predictions of Hypothesis 1.

Luck beliefs and causal attribution

To capture the relationship between luck beliefs and causal attributions, we conducted regression analyses in which causal attributions were regressed on Belief in Luck and Personal Luckiness. Table 4 shows the result of the regression of the attribution to luck, and Table 5 shows the result of the regression of the attribution to ability. We included the memory capability of participants (Memory Ability) and the ability of the opposing computer agents (Ability of Agent) as control variables, as well as the game performance (# of Pairs Won) because these were expected to have significant effects on the causal attribution of the game events of winning cards. The upper panel of the tables shows the regression when using a measure of causal attribution at the end of the game, and the lower panel shows the regression when using a measure of causal attribution during the game as the dependent variable. For the in-game model in the lower panel, the game performance variable was excluded from the model because the number of cards won was not fixed until the end of the game.

Hypothesis 2A predicts that both Belief in Luck and Personal Luckiness would be positively related to attribution to luck; and Hypothesis 2B predicts that Personal Luckiness would be positively related to attribution to ability. The results were consistent with the predictions of these hypotheses.

However, the positive relationship between Personal Luckiness and attribution to ability should be noted. This relationship has a significant partial regression coefficient, but its effect size was small. Additionally, the R^2 values were 0.015 and 0.017 for the indices at the end and during the game, respectively, and the adjusted R^2 values were 0.004 and 0.008, respectively, which were not statistically significant.

	Life satisfaction		Positive emotions		Negative emotions	
	1st step	2nd step	1st step	2nd step	1st step	2nd step
Gender reference = male	1.178*	0.061	1.168*	0.319	0.502	1.148*
Age	− 0.038	− 0.057*	− 0.023	− 0.041	− 0.060*	− 0.049
Education	0.222	0.196	− 0.080	− 0.126	0.424	0.439
Household income	0.357**	0.239*	0.198*	0.106	− 0.134	− 0.066
Marriage	3.072***	3.236***	2.013***	2.140***	0.847	0.752
Marriage (other) reference = unmarried	1.559	2.243	0.826	1.378	0.601	0.205
Relationship	0.580***	0.362***	0.381***	0.225**	− 0.385***	− 0.259**
Health	1.633***	0.715***	1.388***	0.708***	− 1.443***	− 0.914***
Belief in luck		− 0.135*		− 0.002		0.076
Personal luckiness		0.542***		0.407***		− 0.313***
R^2	0.385	0.539	0.323	0.453	0.191	0.271
ΔR^2		0.154***		0.130***		0.080***
Adj R^2	0.374	0.528	0.310	0.440	0.176	0.254
F-statistics	33.83***	50.22***	25.70***	35.62***	12.75***	15.97***

Table 3. Results of hierarchical regression analysis for Life satisfaction, positive emotions, and negative emotions. Scores are partial regression coefficients β(not standardized). Gender: categorical, Age: continuous. Education: 1 = junior high school, 2 = high school, 3 = junior college, 4 = university, 5 = graduate school. Household income: 1 = less than 100M Yen, 2 = 100M–200M Yen, 3 = 200M–300M Yen, 4 = 300M–400M Yen, 5 = 400M–500M Yen, 6 = 500M–600M Yen, 7=600M–700M Yen, 8 = 700M–800M Yen, 9 = 800M–900M Yen, 10 = 900M–1000M Yen, 11 = 1000M–1500M Yen, 12 = 1500M–2000M Yen, 13 = more than 2000M Yen. Marriage: categorical ("others" mean divorced, widowed, separated). Relationship: continuous (number of friends or social connections). Health status: 1 = very poor, 2 = fairly poor, 3 = somewhat poor, 4 = natural, 5 = somewhat good, 6 = fairly good, 7 = very good. $p < 0.05^{*}$, $p < 0.01^{**}$, $p < 0.001^{***}$.

Variable	Estimate (β)	Std. error	t value	Pr($>\|t\|$)	2.5%	97.5%
At the end of the game						
(Intercept)	1.254	0.541	2.319	0.021 *	0.191	2.318
Belief in luck	0.062	0.014	4.381	1.48×10^{-5} ***	0.034	0.090
Personal luckiness	0.025	0.009	2.791	0.005 **	0.008	0.043
Memory ability	− 0.116	0.051	− 2.250	0.025 *	− 0.217	− 0.015
Ability of agent	0.020	0.040	0.492	0.623	− 0.059	0.098
# of Pairs Won	0.116	0.031	3.678	0.000 ***	0.054	0.177
During the game						
(Intercept)	2.840	0.399	7.113	4.67×10^{-12} ***	2.055	3.625
Belief in luck	0.050	0.012	4.101	4.91×10^{-5} ***	0.026	0.074
Personal luckiness	0.023	0.008	2.886	0.004 **	0.007	0.038
Memory ability	− 0.125	0.043	− 2.895	0.004 **	− 0.209	− 0.040
Ability of agent	− 0.032	0.026	− 1.248	0.213	− 0.082	0.018

Table 4. Regression analysis for attribution to luck. R^2 = 0.094, Adj R^2 = 0.084, F(5, 435) = 9.053*** at the end of game. R^2 = 0.067, Adj R^2 = 0.058, F(4, 436) = 7.821*** during the game. $p < 0.05^{*}$, $p < 0.01^{**}$, $p < 0.001^{***}$.

Causal attribution and well-being

To capture the relationship between causal attributions and well-being, we conducted regression analyses in which variables related to well-being were regressed on causal attributions. Tables 6, 7, and 8 show the regression results for life satisfaction (SWLS), positive emotions (SPANE (positive)), and negative emotions (SPANE (negative)). We included participants' memory capability (Memory Ability) as a control variable. Similar to previous analyses, the upper and lower panels of the tables show the regressions when using a measure of causal attribution at the end of the game and during the game, respectively.

Hypothesis 3 predicts a negative relationship between the attribution to luck and the levels of well-being, and a positive relationship between the attribution to ability and the levels of well-being.

Variable	Estimate (β)	Std. error	t value	Pr($>\|t\|$)	2.5%	97.5%
At the end of the game						
(Intercept)	2.892	0.543	5.329	1.590×10^{-7} ***	1.825	3.959
Belief in luck	− 0.001	0.014	− 0.100	0.920	− 0.029	0.027
Personal luckiness	0.018	0.009	2.015	0.045 *	0.000	0.036
Memory ability	0.082	0.051	1.599	0.111	− 0.019	0.183
Ability of agent	− 0.022	0.039	− 0.561	0.575	− 0.097	0.054
# of Pairs won	− 0.025	0.030	− 0.836	0.403	− 0.085	0.034
During the game						
(Intercept)	3.518	0.382	9.212	$< 2 \times 10^{-16}$ ***	2.767	4.268
Belief in luck	− 0.012	0.012	− 1.065	0.287	− 0.035	0.011
Personal luckiness	0.017	0.007	2.253	0.025 *	0.002	0.032
Memory ability	− 0.025	0.041	− 0.616	0.538	− 0.106	0.056
Ability of agent	− 0.013	0.025	− 0.517	0.605	− 0.061	0.036

Table 5. Regression analysis for attribution to ability. R^2 = 0.015, Adj R^2 = 0.004, F(5, 435) = 1.334 at the end of game R^2 = 0.017, Adj R^2 = 0.008, F(4, 436) = 1.892 during the game. $p < 0.05^{*}$, $p < 0.01^{**}$, $p < 0.001^{***}$.

Variable	Estimate (β)	Std. error	t value	Pr($>\|t\|$)	2.5%	97.5%
At the end of the game						
(Intercept)	12.216	2.300	5.311	1.740×10^{-7} ***	7.696	16.737
Attribution to ability	0.889	0.302	2.942	0.003 **	0.295	1.483
Attribution to luck	0.647	0.290	2.234	0.026 *	0.078	1.217
Memory ability	− 0.147	0.317	− 0.465	0.642	− 0.770	0.475
During the game						
(Intercept)	12.321	2.702	4.559	6.670×10^{-6} ***	7.010	17.632
Attribution to ability	0.964	0.369	2.614	0.009 **	0.239	1.689
Attribution to luck	0.370	0.346	1.069	0.286	− 0.310	1.051
vMemory ability	− 0.054	0.320	− 0.170	0.865	− 0.684	0.575

Table 6. Regression of life satisfaction on attributions to luck and ability. R^2 = 0.028, Adj R^2 = 0.021, F(5, 435) = 4.162** at the end of game. R^2 = 0.017, Adj R^2 = 0.010, F(4, 436) = 2.539 during the game. $p < 0.05^{*}$, $p < 0.01^{**}$, $p < 0.001^{***}$.

Variable	Estimate (β)	Std. Error	t value	Pr($>\|t\|$)	2.5%	97.5%
At the end of the game						
(Intercept)	15.701	1.822	8.618	$< 2 \times 10^{-16}$ ***	12.120	19.282
Attribution to ability	0.437	0.239	1.824	0.069	− 0.034	0.907
Attribution to luck	0.311	0.230	1.354	0.177	− 0.140	0.762
Memory ability	− 0.145	0.251	− 0.578	0.564	− 0.638	0.348
During the game						
(Intercept)	15.255	2.131	7.159	3.47×10^{-12} ***	11.067	19.443
Attribution to ability	0.529	0.291	1.818	0.070	− 0.043	1.100
Attribution to luck	0.249	0.273	0.912	0.362	− 0.288	0.786
Memory ability	− 0.089	0.252	− 0.353	0.724	− 0.585	0.407

Table 7. Regression of positive emotion on attributions to luck and ability. R^2 = 0.011, Adj R^2 = 0.004, F(5, 435) = 1.652 at the end of game. R^2 = 0.009, Adj R^2 = 0.003, F(4, 436) = 1.370 during the game. $p < 0.05^{*}$, $p < 0.01^{**}$, $p < 0.001^{***}$.

Variable	Estimate (β)	Std. error	t value	Pr($>\|t\|$)	2.5%	97.5%
At the end of the game						
(Intercept)	19.453	1.844	10.552	$< 2 \times 10^{-16}$ ***	15.830	23.077
Attribution to ability	− 0.636	0.242	− 2.625	0.009 **	− 1.112	− 0.160
Attribution to luck	0.164	0.232	0.707	0.480	− 0.292	0.621
Memory ability	− 0.352	0.254	− 1.387	0.166	− 0.851	0.147
During the game						
(Intercept)	18.012	2.148	8.387	6.95×10^{-16} ***	13.791	22.233
Attribution to ability	− 0.650	0.293	− 2.216	0.027 *	− 1.226	− 0.074
Attribution to luck	0.588	0.275	2.138	0.033 *	0.047	1.129
Memory ability	− 0.359	0.254	− 1.410	0.159	− 0.859	0.141

Table 8. Regression of negative emotion on attributions to luck and ability. R^2 = 0.023, Adj R^2 = 0.017, F(5, 435) = 3.504* at the end of game. R^2 = 0.029, Adj R^2 = 0.023, F(4, 436) = 4.421** during the game. $p < 0.05^*$, $p < 0.01^{**}$, $p < 0.001^{***}$.

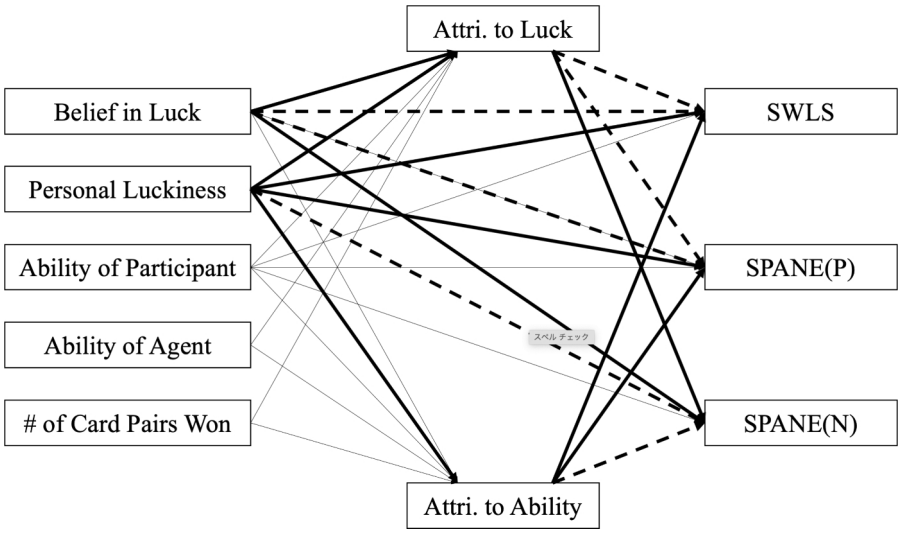

Fig. 2. Paths hypothesized by SEM analysis. Bold lines are predictions based on hypotheses. The solid line represents a positive relationship, and the dotted line represents a negative relationship.

The analyses showed inconsistent results. Specifically, for life satisfaction as a cognitive aspect of well-being, the attribution to ability was positively related to the SWLS score, but the attribution to luck was also positively related to SWLS. Regarding positive emotions as an affective aspect of well-being, there were no statistically significant relationships between the attribution scores and the SPANE (positive) score. For negative emotions the predictions of the hypothesis were basically confirmed, that is, the attribution to luck was positively related to the SPANE (negative) score, and the attribution to ability was negatively related to the SPANE (negative) score.

Analysis by SEM model

So far, we have examined three hypotheses regarding the relationship between luck beliefs, causal attributions, and levels of well-being. The three hypotheses are interrelated. Finally, we conducted an analysis using structural equation modeling to understand the overall structure of the variables included in this study. Figure 2 shows the assumed structure among the variables. Because participants' memory capability and the ability of the opposing computer agent, as well as the game performance, i.e., the number of winning cards, are expected to have significant impacts on the causal attribution of winning-card events, we included these variables in the model.

First, based on Hypothesis 1, Belief in Luck is expected to have a positive relationship with SPANE (negative) and negative relationships with SWLS and SPANE (positive), whereas Personal Luckiness is expected to have positive relationships with SWLS and SPANE (positive) and a negative relationship with SPANE (negative). Hypotheses 2A and 2B predict that both Belief in Luck and Personal Luckiness will be positively related to attribution to luck, and that Personal Luckiness will be positively related to attribution to ability. In addition, Hypothesis 3 predicts that attribution to luck is expected to have a positive relationship with SPANE (negative) and negative relationships with SWLS and SPANE (positive), whereas attribution to ability is expected to have positive relationships with SWLS and SPANE (positive) and a negative relationship with SPANE (negative).

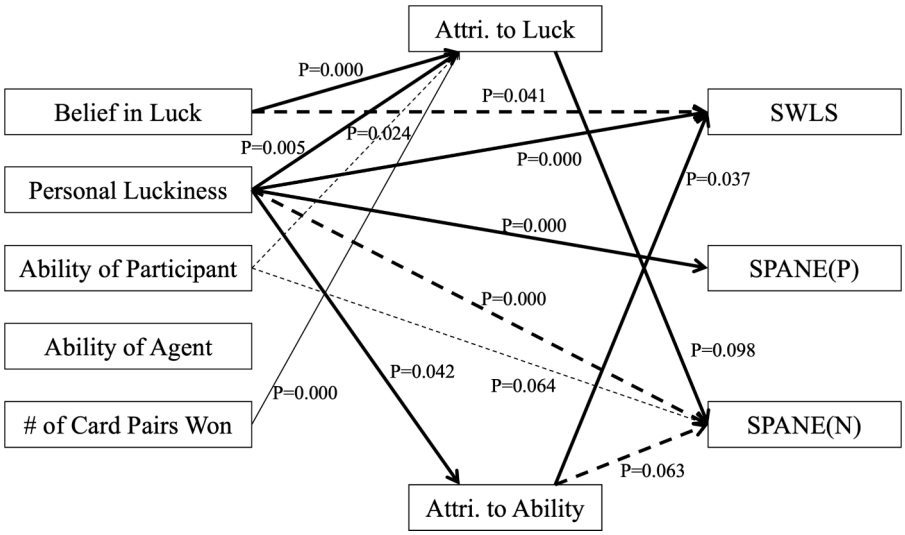

Fig. 3. Analysis results. Only significant or marginally significant paths are shown. Bold lines are predictions based on hypotheses. The solid line represents a positive relationship, and the dotted line represents a negative relationship.

χ^2	df	AIC	SRMR	RMSEA	CFI	TLI
26.965	12.000	10400.314	0.025	0.053	0.980	0.933

Table 9. Model fitting indices.

Figure 3 shows the result of the analysis. All causal attribution values are those at the end of the game. Table 9 shows the model fitting indices, indicating a good model fit. The figure shows that there are no paths that are inconsistent with the hypotheses' predictions.

The three regressions supported Hypotheses 1 and 2, but did not fully support Hypothesis 3. Consistently, the results of the SEM analysis also supported seven of the nine paths that are predicted by Hypotheses 1 and 2, but only three of the six paths that are predicted by Hypothesis 3.

Discussion and conclusions

This study tested the following three hypotheses. In this section, we summarize and discuss the results of this study through the examination of the three hypotheses.

Hypothesis 1

First, Hypothesis 1 was supported. Even after controlling for demographic variables and factors such as health status and friendships, it was confirmed that general luck beliefs were negatively related to levels of well-being; furthermore, beliefs in one's own luckiness were positively related.

However, the following points should be noted. As shown in the results, Belief in Luck showed a relationship only with the cognitive aspect of well-being, whereas Personal Luckiness showed relationships with both cognitive and affective aspects, each in a direction consistent with the prediction. In addition, even in the cognitive aspect, Personal Luckiness was more strongly related to well-being than Belief in Luck. This suggests that Personal Luckiness is more strongly related to the levels of well-being than Belief in Luck.

According to self-determination theory, people have three basic needs. One is autonomy, which is the desire to make one's own choices[36,37]. Hedonic well-being, which relates to life satisfaction and affective well-being, is closely related to the three desires. Empirical studies have confirmed that greater autonomy increases life satisfaction[38–41]. For example, in everyday contexts, Reis et al. analyzed data from 14 days of diaries submitted by college students. They found that the more autonomy they had in the activities they performed each day, the higher their daily well-being[42].

Perceived control is the belief that one can determine one's internal state and behavior, influence one's environment, and achieve desired outcomes. Several studies have suggested that increased perceived control is associated with increased well-being[43–45].

People with stronger general luck beliefs (Belief in Luck) have higher external LOC, suggesting they have a stronger sense that various events in their lives are not under their control. On the other hand, Personal Luckiness-the belief that one is personally lucky-is positively correlated with internal LOC, suggesting that people who feel fortunate have a stronger sense that their lives are under control. The fact that Hypothesis 1

is supported in the present study indicates that the result is consistent with the theoretical background of self-determination theory and perceived control.

Beliefs about luck vary across cultures[46,47]. To date, most studies of luck beliefs have been conducted in Western countries. The relationship between luck beliefs and levels of well-being has been confirmed in the West, and we believe that confirming this finding in a different culture, such as Japan, has important implications for extending its generality.

Hypotheses 2A and 2B

The study also confirmed Hypotheses 2A and 2B, showing that Belief in Luck and Personal Luckiness were positively associated with attributing causes to luck; however, Personal Luckiness was also positively associated with attributing causes to ability. Previous studies using psychological scales, such as the LOC, have not been able to directly address the relationship between luck beliefs and causal attribution. However, in this study, it was possible to do so by directly measuring the tendency toward causal attribution in a card game experiment.

This research is concerned with the two-sided nature of Personal Luckiness, namely that people who believe they are personally fortunate tend to attribute the cause of an event to both luck and their own abilities when it occurs. Specifically, in Hypothesis 2A, we predicted that Personal Luckiness would be positively related to the attribution to luck because, by definition, it is a belief component of luck beliefs. On the other hand, in Hypothesis 2B, we predicted that Personal Luckiness would be positively related to attribution to ability because it is also positively related to Internal LOC. The results confirmed both predictions, but the effect size of the relationship between Personal Luckiness and attribution to ability was relatively small compared to the relationship between Personal Luckiness and attribution to luck.

The latter finding, related to Hypothesis 2B, suggests that individuals who consider themselves fortunate are more likely to attribute their success to internal, stable factors, such as ability, preparation, or effort. This finding is consistent with the "law of attraction"[23,24] and the aphorism "Chance favors the prepared mind"[25]. It reflects the belief that personal characteristics and proactive behaviors can influence the likelihood of positive outcomes.

Weiner extended his causal attribution theory by adding a controllability dimension to the locus of control and stability dimensions. In this extended theory, luck is defined as the presence of external, unstable, or uncontrollable properties. In this framework, in which luck is seen as uncontrollable, how can the belief that one is personally fortunate be consistent with the chance-favors-prepared-mind perspective-the view that luck is controllable? These ideas actually seem to say not that luck itself can be controlled, but that one can influence how prepared one is to take advantage of opportunities that may arise. This can be viewed as an indirect method of controlling luck. It is possible that those who consider themselves personally fortunate believe they can control their luck.

In addition, participants' memory capacity was related to causal attribution. Specifically, a negative relationship was found between the participants' memory ability and attribution to luck. That is, those with higher abilities were less likely to attribute the acquisition of card pairs to luck. However, there was no tendency to attribute this to one's own abilities. The intersection of cause and effect is an interesting finding.

Hypothesis 3

Finally, the results for Hypothesis 3 are mixed. Regarding the cognitive aspect of well-being, attribution to ability and attribution to luck were both positively related to life satisfaction. The former result is consistent with the prediction of Hypothesis 3; however, for the latter, the hypothesis predicts a negative relationship between attribution to luck and life satisfaction.

One possible explanation for this unexpected finding is that the perception of success as a matter of luck allows individuals to maintain a sense of life satisfaction by viewing positive outcomes as a gift of chance rather than something they can control through their own efforts. Perceiving luck as a gift rather than personal entitlement may promote gratitude, a known predictor of well-being[48,49].

Another explanation is that as we experience various events in our lives, there is a possibility that a certain type of mental or cognitive buffer will improve our levels of well-being. Cognitive buffer refers to a psychological mechanism that helps individuals maintain well-being by interpreting potentially negative or uncertain situations in a more positive, manageable way. For example, self-esteem, self-control, and optimism act as mental buffers and contribute significantly to improved well-being[50]. Perceived control acts as a buffer against stress[51]. Individuals with high levels of emotional intelligence (EI) experience greater psychological well-being. One basic mechanism linking EI to these outcomes is the possibility that it acts as a stress buffer[52]. General belief in luck may serve as a cognitive buffer through which we can attribute the causes of failures and negative events to environmental factors and escape self-blame.

Regarding the affective aspect of well-being, we did not confirm a positive or negative relationship between causal attributions and positive emotions. However, we confirmed a positive relationship between attribution to luck and negative emotions, and a negative relationship between attribution to ability and negative emotions. The results for negative emotions are consistent with the predictions of Hypothesis 3. Regarding the different results of the relationship between positive and negative emotions and causal attributions, positive and negative emotions have different functions in terms of their contribution to well-being[53]. Negative emotions tend to last longer and evoke stronger emotional responses than positive emotions[54]. Negative emotions are generally believed to increase stress[55] and decrease mental and physical health[56]. Conversely, negative emotions, such as regret, have positive aspects of well-being[57,58].

Experimental paradigm using a card game

The present study examined the relationship between luck beliefs and causal attributions, which have been primarily assessed through subjective ratings using psychological measures, in an experimental paradigm using

a game. The present study provides a new perspective in the sense that it confirms the findings of previous studies by measuring causal attributions for the actual event of winning cards in a game.

In studies on luck, the relationship with games is not necessarily weak. In the past, luck beliefs have been examined in the studies of gambling behavior using games such as slot machines, roulette, and craps[59,60]. The games used in these studies were such that the win-loss performance was almost entirely determined by luck. The same is true of lotteries and sports betting, which have also been in gambling studies. These studies have consistently shown that luck beliefs have a significant impact on gambling behavior.

On the other hand, in Concentration used in this study, the event of getting card pairs depends on both luck, such as turning the cards face up by chance, and the players' memory abilities[31]. Many games are not played by chance alone; it is the right combination of ability and chance that creates allure for playing. In future, we would like to examine the potential of such games as a platform for research on the human perception of luck.

Limitations

First, the events for which causal attribution was measured were limited to positive outcomes, specifically winning card pairs. Consequently, we could not fully explore how the perceptions of luck and ability evolve in response to negative or frustrating events. In this particular game, mismatches do not necessarily represent failure-sometimes turning over a new card is simply part of the process, making it difficult to distinguish between meaningful "losses" and routine steps. Investigating how individuals' beliefs about luck or ability change with repeated mismatches could reveal important patterns of attribution, especially for those with strong luck beliefs. Future research should include both successful and unsuccessful outcomes to capture a broader range of emotional and cognitive responses.

Second, the relationships among the variables examined in this study were correlational and not causal. For example, it cannot be argued whether believing in the existence of luck lowers life satisfaction or whether people with low life satisfaction believe in the existence of luck. In this regard, it is natural to assume that the causal relationship between the two is bidirectional but should be empirically investigated.

Finally, this study examined the relationship between three variables: luck beliefs, causal attributions, and well-being. To this end, the relationships between two variables were separately analyzed: luck beliefs and well-being, luck beliefs and causal attributions, and causal attributions and well-being. Each of these relationships corresponds to the three hypotheses. The first two relationships confirmed the results predicted by the hypotheses; however, the last relationship could not be fully confirmed.

Ideally, confirming all three would have provided strong evidence that causal attributions explain the contrasting effects of general luck beliefs and personal luckiness on well-being. However, our results did not fully support the third hypothesis-that attributions to luck or ability would systematically predict well-being-despite prior research consistently linking locus of control, attribution styles, and happiness.

A central innovation in the current study lies in developing an integrated study design that captures the interplay among luck beliefs, attribution tendencies, and well-being within a single framework. We introduced a new experi- mental paradigm using a card game to measure causal attributions in response to events. This discrepancy, however, likely reflects methodological constraints. For instance, the low-stakes nature of the game may have limited participants' range of attribution styles. In real-world contexts, where outcomes can be more consequential, attributions to luck or ability may more clearly shape well-being.

Future work should address these limitations by employing multi-outcome paradigms-encompassing both successes and failures-and incorporating higher-stakes scenarios that elicit stronger affective responses. Such approaches may clarify how and when attributions mediate or moderate the well-established link between luck beliefs and subjective happiness, offering deeper insights into the psychological mechanisms involved.

Data availability

The data that support the findings of this study are openly available in the Open Science Framework at https://doi.org/10.17605/OSF.IO/ZGH8S.

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K.M.: Conceptualization, Methodology, Investigation, Writing – Original Draft, Writing – Review & Editing, Funding Acquisition, Resources, Supervision. W. Y.: Conceptualization, Methodology, Investigation. S. M.: Conceptualization, Methodology, Investigation.

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Competing interests

The authors declare no competing interests.

Ethical approval

All surveys in the present study were conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki, and were reviewed and approved by the Ethics Committee of the Department of Cognitive and Psychological Sciences, Nagoya University. The reference number is 221117-C-01-1.

Additional information

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