Original Article

Can Serious Games Assess Decision-Making Biases?

Comparing Gaming Performance, Questionnaires, and Interviews

Kyoungwon Seo, Hokyoung Ryu, and Jieun Kim

Imagine X Lab, Hanyang University, Seoul, Republic of Korea

Abstract: The limitations of self-report questionnaires and interview methods for assessing individual differences in human cognitive biases have become increasingly apparent. These limitations have led to a renewed interest in alternative modes of assessment, including for implicit and explicit aspects of human behavior (i.e., dual-process theory). Acknowledging this, the present study was conducted to develop and validate a serious game, "Don Quixote," for measuring specific cognitive biases: the bandwagon effect and optimism bias. We hypothesized that the implicit and explicit game data would mirror the results from an interview and questionnaire, respectively. To examine this hypothesis, participants (*n* = 135) played the serious game and completed a questionnaire and interview in a random order for cross-validation. The results demonstrated that the implicit game data (e.g., response time) were highly correlated with the interview data. On the contrary, the explicit game data (e.g., game score) were comparable to the results from the questionnaire. These findings suggest that the serious game and the underlying intrinsic nature of its game mechanics (i.e., evoking instant responses under time pressure) are of importance for the further development of cognitive bias measures in both academia and practice.

Keywords: assessment, serious game, dual-process theory, cognitive bias

Cognitive bias refers to a systematic pattern of deviations in judgment and decision-making, resulting from a lack of appropriate information acquisition or a limited information processing capacity (Haselton, Nettle, & Murray, 2005; Reece & Matthews, 1993). Such biases may enable faster decisions when timeliness is more valuable than accuracy; however, sometimes they introduce severe and systematic errors.

The most well-known approach to assess the individual differences in human cognitive biases constitutes self-report questionnaires and interviews (Ariely, 2008; Hilbert, 2012). However, these conventional methods have come under renewed scrutiny in the last decades. In a review of 19 questionnaire-interview comparison studies (Harris & Brown, 2010), researchers confirmed a discrepancy between self-report and interview outcomes.

Dual-process theory provides a theoretical rationale for this measurement discrepancy by positing that two distinct mental processes exist that underlie behavioral responses: the implicit process and explicit process (Evans & Stanovich, 2013; Kahneman, 2011). An implicit process is an unintentional, effortless, uncontrollable, or unconscious process that is assumed to yield our automatic default responses (Gawronski & Creighton, 2013). In comparison, an explicit process supports our controlled hypothetical thinking that is characterized by an intentional, effortful, controllable, or conscious process (Evans & Stanovich, 2013).

In an interview, the interviewer takes a third-person perspective and they are much more focused on the implicit, internalized, often unconscious process, which is not open to introspection (Furman & Flanagan, 1997). On the contrary, a questionnaire is an explicit measure that evaluates people's analytic and controlled responses (Schaeffer, 2000). Correlational studies show that each implicit and explicit measure has causal connections with different aspects of behavior (Petty, Fazio, & Briñol, 2012; Wittenbrink & Schwarz, 2007). Explicit measures have been shown to have better correlations with actual behaviors, whereas implicit measures have shown strength in incremental validity for behavior; that is, explaining variance in a behavior over and above what is explained by explicit measures (Richetin, Perugini, Prestwich, & O'Gorman, 2007). In this context, measuring both the implicit and

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explicit aspects of cognitive bias is crucial for a comprehensive understanding of the phenomenon.

Rise of the Serious Game as a New Assessment Paradigm

Attempts at developing a new method to assess cognitive biases have been made recently (Jasper & Ortner, 2015). Serious game studies offer novel and interesting ways to comprehensively assess cognitive biases (Choliz, 2010; Peng, Liu, & Mou, 2008). Note that a serious game is a game designed for a primary purpose other than pure entertainment, such as learning or training (Cowley, Fantato, Jennett, Ruskov, & Ravaja, 2014). For instance, Van Herpen, Pieters, and Zeelenberg (2009) have developed a shopping game and examined the player's response time latency while shopping (e.g., time spent examining the shelf tags). A response time revealed the strength of association between the player's implicit bias and presented stimuli (see Implicit Association Test in Greenwald, Nosek, & Banaji, 2003). Lejuez and colleagues (2002) examined a rather different aspect of the game. They developed a balloon popping game and analyzed a score when players stop pumping up the balloon. If players stopped pumping up the balloon when a game score was high, their self-reported bias was higher accordingly. These controlled action choices in response to visual elements during the game (e.g., score) are more related with the explicit aspects of cognitive bias.

In the Sirius research program, 4-year-long multidisciplinary studies were conducted to verify the effectiveness of games as a training tool for teaching about and mitigating cognitive biases (Bush, 2017). The researchers developed several game genres, including an adventure game, "MACBETH," a puzzle game, "CYCLES," a mystery game, "Missing," and a sci-fi game, "Heuristica," to investigate whether a game could be an effective mechanism for training adults to identify and mitigate their cognitive biases (Dunbar et al., 2013; Mullinix et al., 2013; Symborski et al., 2014). Other serious games, "Wasabi Waiter" and "Balloon Brigade," have shown that intuitive behaviors in games can be used to identify a player's systematic decision patterns, such as risk aversion, empathy, or responsiveness (Jacob, 2013), with the results being applied directly to the human resource division of a company for learning and the allocation of job positions. Despite the potential applications of serious games, previous studies have focused more on the effectiveness of games as a training tool, and few studies have been conducted to verify the content validity of serious game-based assessments. For the adoption of serious games for both training and assessment, it is crucial to ensure that the quality of an assessment using a serious game equals (or outperforms) that of conventional assessment methods.

The Present Study

Two cognitive biases were investigated in this study: the bandwagon effect and optimism bias. When the bandwagon effect co-occurs with the optimism bias, people easily accept risky decisions without proper consideration and precaution. The bandwagon effect makes people easily accept an unproven but popular decision without proper consideration due to sensitivity to majority or influential opinions (Bornstein & Emler, 2001). Majority opinion sensitivity is the desire to belong to the major social group (e.g., "It is important that others like the products and brands I buy"), and influential opinion sensitivity refers to how easily individuals are affected by influential people's opinions (e.g., "I often consult other people to help me choose the best alternative available from a product class"). The optimism bias leads people to exaggerate the perceived benefit and to underestimate the perceived risk of making a risky decision (Shepperd, Carroll, Grace, & Terry, 2002). Perceived benefit indicates the benefits that an individual would obtain from each situation, and perceived risk indicates how risky an individual perceives the same situation to be. People with optimism bias believe that they are at less risk of experiencing a negative event compared to others; as such, they engage in risky behaviors and do not take precautionary measures for safety.

A serious game called "Don Quixote" was designed to address and measure bandwagon effect and optimism bias (see Figure 1). The Don Quixote game was developed in app form using four basic game elements (i.e., theme, challenge, reward, and progress; Flatla, Gutwin, Nacke, Bateman, & Mandryk, 2011). The main theme was the famous novel "Don Quixote" written by Miguel de Cervantes. The game player takes the role of Don Quixote who is obsessed with chivalrous ideals and decides to bring justice to the world. Several fictive players join the game with the player. The main goal is to collect as many points as possible in two stages. Stage 1 was set to measure the bandwagon effect about the rate of uptake of beliefs through a set of "True or False Quizzes." Stage 2 was a "Scooping Water" game, which is similar to a balloon popping game, which was designed to assess the effects of optimism bias under risky situations. During the game, each player's implicit and explicit behavior data were collected. A full set of the experimental data is given in the Electronic Supplementary Material, ESM 1.

To summarize, the present study aims at developing and validating a serious game to comprehensively assess both the implicit and explicit aspects of cognitive bias.

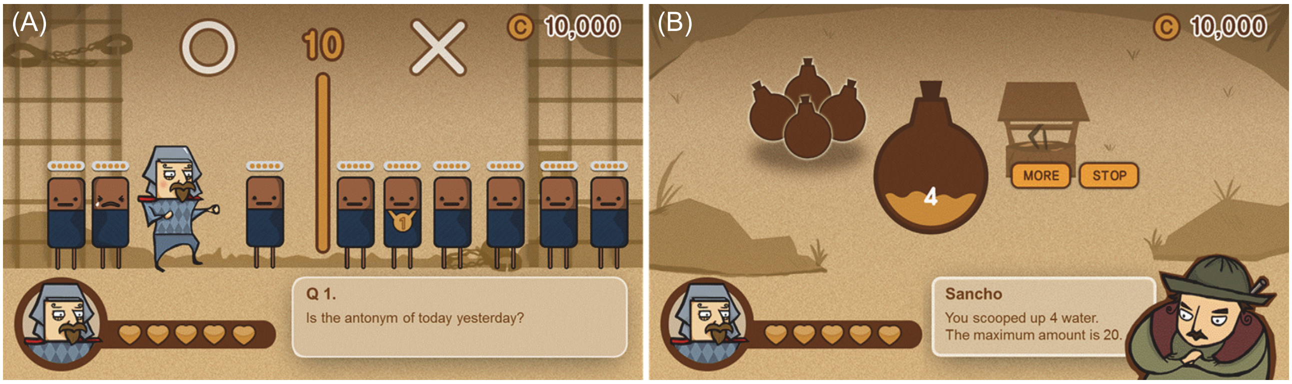

Figure 1. Screenshots of the serious game "Don Quixote." (A) Stage 1 "True or False Quizzes" for the bandwagon effect. (B) Stage 2 "Scooping Water" for the optimism bias.

We hypothesized that (1) the implicit game data (e.g., a response time) would correlate with the interview outcomes and (2) the explicit game data, which are visual elements in game, like score, number of players, would correlate with the results from questionnaires. To investigate this, a comparative study of gaming performance, questionnaires, and interviews were conducted. Both implicit and explicit game data were compared to the questionnaire and the interview and verify the validity of the serious game as an assessment of cognitive biases.

The questionnaire was administrated by one researcher with more than 10 years of experience in psychology. In the interview session, two independent interviewers with 13 and 17 years of experience in psychometrics were recruited. The Don Quixote game contains two stages: Stage 1 True or False Quizzes (bandwagon effect) and Stage 2 Scooping Water (optimism bias). The mechanics in the game (e.g., time pressure) motivated participants to focus solely on the game with no distractions. The game data (e.g., clicks, response time) were computerized and collected during the game play.

Materials and Methods

Participants

The participants were 135 college students (65 men and 70 women) between the age of 22 and 28 years (M = 25.55; SD = 2.11). They were recruited from two departments – Industrial Engineering and Applied Systems – of Hanyang University. The participants were taking human-computer interaction classes and were selected randomly to take part in the study as a course assignment. All participants received course credits for taking part in the experiment. Upon completion, all participants were given a gift voucher as a reward.

Procedure

All participants were introduced to the experimental procedure and completed consent forms. Two experiments were conducted with the three measures in a random order: (i) a self-report questionnaire (about 10 min), (ii) the Don Quixote serious game (about 10 min), and (iii) an interview (about 40 min) with 5 min rest pause between the measures.

Experiment 1: Bandwagon Effect

Self-Report Questionnaire

A self-report questionnaire for the bandwagon effect was administered, which consists of 12 items with a 7-point scale ranging from 1 (= *not at all*) to 7 (= *very much so*) (Bearden, Netemeyer, & Teel, 1989). Two bandwagon effect variables, majority opinion sensitivity and influential opinion sensitivity, were assessed. The internal consistency was found to be 0.85 (Cronbach's α).

Game: True or False Quizzes (Stage 1)

A game stage for the bandwagon effect was designed as shown in Table A1 of the Appendix. The game is True or false quizzes with 10 trivia questions. The player has to solve each question in 10 s. The correct answer earns 1,000 points. We intentionally inserted several fictive players into the game and examined how the majority opinion of the fictive players (number of players on each side) and the influential opinion (top-scoring player) affected the player's answers.

The explicit game data were the "number of fictive players involved in the majority opinion when changing answer" and the "number of changes due to the influential opinion." The implicit game data collected were the "time taken to change answer via the majority opinion" and the "time taken to change answer via influential opinion." The retest reliability was 0.82 (Pearson's *r*).

Interview

First, one interviewer carried out a semi-structured interview to examine a participant's bandwagon effect with various hypothetical situations. Questions included, for example, "how much are you concerned about others' preferences when dining out?". Using these projected hypothetical scenarios, the interviewer rated the level of bandwagon effect with a 7-point scale ranging from 1 (= *not at all*) to 7 (= *very much so*). All interviews were video-recorded. The next day, the other interviewer visited the experimental room and independently rated the level of bandwagon effect of each participant with a 7-point scale from the video-recording obtained during the experiment. The inter-rater agreement was found to be 0.77 (Cohen's κ).

Experiment 2: Optimism Bias

Self-Report Questionnaire

Optimism bias was surveyed using eight items with a 5-point scale ranging from 1 (= *not at all*) to 5 (= *very much so*) (Weber, Blais, & Betz, 2002). Two optimism bias variables, perceived benefit and perceived risk, were assessed by the questionnaire. The internal consistency was found to be 0.88 (Cronbach's α).

Game: Scooping Water (Stage 2)

The scooping water game is formed in five rounds for assessing the optimism bias. The goal is to fill as much water as possible in a 20 L pot. The player could accumulate points as the level of water takes up. In game, each scoop was randomized from 1 L to 5 L. If the water exceeds the 20 L, the water pot will be cracked and the player will lose all. There is a trade-off between the water level and the point to be collected. The return of point reward rises with an increase of water level in risk (Scoreboard: 1 L = 100 points, 15 L = 1,500 points, and 20 L = 20,000 points). The more details are in Table A2 of the Appendix.

The player's decision-making patterns in regard to optimism bias were examined to assess how perceived benefit and perceived risk about each situation affected the player's decisions. The implicit game data were the "time taken to decide to do further scooping" and the "time taken to decide to do no more scooping." The explicit game data were the "water level when the participant stopped scooping" and the "number of decision changes via a confirmation check." The retest reliability was 0.73 (Pearson's *r*).

Interview

The process of the interview was the same as in Experiment 1. The first interviewer carried out a semi-structured interview with hypothetical questions, such as "how much do you prefer to invest for high risk and high return in China's stock-exchange market?". Interviewers rated the level of optimism bias on a 5-point scale ranging from 1 (= *not at all*) to 5 (= *very much so*). The inter-rater agreement was found to be 0.74 (Cohen's κ).

Analysis

In order to examine the validity of the game as an evaluation method for cognitive biases, a Pearson correlation analysis was applied using a statistical software package (SPSS Statistics 21). In both experiments, a comparison was made between the results of the questionnaire, the game, and the interview. The overall descriptive and correlation results are provided in Tables A3 and A4 of the Appendix.

Results

Results of Experiment 1: Bandwagon Effect

Table 1 shows that the game data selectively corresponded with the bandwagon effect assessed by either the self-report questionnaire or the interview. The implicit game data, such as the "time taken to change answer via the majority opinion" and the "time taken to change answer via influential opinion" were significantly associated with the results from the interview. The participants with a strong bandwagon effect in the interview demonstrated taking less time to change their answer via the majority or influential opinion. In the case of the explicit game data, the "number of fictive players involved in the majority opinion when changing answer" was negatively correlated with majority opinion sensitivity from the questionnaire, and the "number of changes due to the influential opinion" was positively related with influential opinion sensitivity. The participants with strong majority opinion sensitivity changed their answer with a lower number of fictive players involved in the majority opinion. In addition, the participants with strong influential opinion sensitivity changed more answers due to the influential leaders. There was no association between the results from the questionnaire and the interview.

Results of Experiment 2: Optimism Bias

Table 2 also shows that there was no association between the questionnaire and the interview. Furthermore, the

Table 1. Comparison between the questionnaire, the game, and the interview to assess the bandwagon effect (n = 135)

	Questionnaire		Interview
Measures	Majority opinion sensitivity	Influential opinion sensitivity	Bandwagon effect interview
Questionnaire			
Majority opinion sensitivity	1.00		
Influential opinion sensitivity	0.24	1.00	
Game data			
(Implicit) Time taken to change answer via the majority opinion	−0.13	0.10	**−0.91***
(Implicit) Time taken to change answer via influential opinion	0.23	0.02	**−0.85***
(Explicit) Number of fictive players involved in the majority opinion when changing answer	**−0.66***	−0.16	−0.39
(Explicit) Number of changes due to the influential opinion	0.24	**0.68***	0.30
Interview			
Bandwagon effect interview	0.14	−0.05	1.00

Note. *p < 0.01**.** The significant correlations are shown in bold.

Table 2. Comparison between the questionnaire, the game, and the interview to assess the optimism bias (n = 135)

	Questionnaire		Interview
Measures	Perceived benefit	Perceived risk	Optimism bias interview
Questionnaire			
Perceived benefit	1.00		
Perceived risk	**−0.81***	1.00	
Game data			
(Implicit) Time taken to decide to do further scooping	0.03	−0.01	**−0.65***
(Implicit) Time taken to decide to do no more scooping	0.17	−0.19	**0.76***
(Explicit) Water level when the participant stopped scooping	**0.78***	**−0.64***	−0.08
(Explicit) Number of decision changes via a confirmation check	0.15	0.03	−0.07
Interview			
Optimism bias interview	0.07	−0.12	1.00

Note. *p < 0.01. The significant correlations are shown in bold.

implicit game data, such as the "time taken to decide to do further scooping" and the "time taken to decide to do no more scooping," were significantly associated with the results from the interview. The participants with strong optimism bias in the interview demonstrated taking less time to decide to do further scooping and more time to decide to do no more scooping. The explicit game data of the "water level when the participant stopped scooping" were significantly associated with perceived benefit and perceived risk from the questionnaire. When the perceived benefit was high, the participants scooped up water until a high water level. On the contrary, when the perceived risk was high, the participants stopped scooping up water even with a low water level. Another type of explicit game data, the "number of decision changes via a confirmation check," showed no relationship with conventional methods. The two measures in the questionnaire were negatively correlated with one another, meaning that one's perceived benefit in a risky activity and one's assessment of the riskiness of the same situation are inversely proportional.

Discussion and Conclusions

Discrepancy of Self-Reported Outcome With Interview

Tables 1 and 2 show that there was a discrepancy between the self-report questionnaire and the interview. Dual-process theory can provide a theoretical rationale for this measurement discrepancy by dividing the realm of mental processes into two general categories depending on whether they operate automatically or in a controlled fashion (i.e., an implicit and explicit process; Evans & Stanovich, 2013; Kahneman, 2011). Waehrens, Bliddal, Danneskiold-Samsøe, Lund, and Fisher (2012) showed that a self-report questionnaire, an expert interview, and behavior observations yielded rather different results because people respond differently according to the characteristics of each measure. While responding to the self-report questionnaire, participants carefully processed the questions before making an answer by using their explicit process (Schaeffer, 2000). On the contrary, the interview evoked an implicit process; as such, participants were more likely to present immediate and automatic responses (Kahneman, 2011). The correlation between implicit and explicit measures varies widely across studies (Ajzen, 2001; Hofmann, Gawronski, Gschwendner, Le, & Schmitt, 2005; Nosek, 2005). In our serious game, the player's behavior data could be used to comprehensively assess both implicit and explicit processes.

Implicit and Explicit Game Data for Evaluating Cognitive Biases

In the serious game, the implicit game data represent automatic and unconscious behaviors, such as the time taken to make a decision. The implicit behavior sufficiently accounted for the player's cognitive biases in a similar manner to the interview. In the bandwagon effect stage, if players took less time to change their answers due to the opinion of the majority, their interviewed bandwagon effect was higher. Similarly, if players took less time to change their answers due to the top-scoring player's choice, their interviewed bandwagon effect was also higher. In the optimism bias stage, if players took less time to decide to scoop up the water, their optimism bias was higher, whereas if players took more time to decide to stop scooping up the water (i.e., hesitate to stop), their optimism bias was also higher. These high correlations are in line with previous studies which have supported the existence of the links between an individual's response times and their implicit process (Greenwald et al., 2003; Van Herpen et al., 2009). The serious game and the underlying mechanics (i.e., evoking instant responses under time pressure) may contribute to these high correlations (Bush, 2017). In essence, the current study demonstrated that the implicit response time from the serious game could be applicable to revealing the implicit aspect of an individual's cognitive biases.

Unlike the implicit game data, the explicit game data indicate controlled and conscious decision-making outcomes in accordance with the visual elements during the game, which is similar to the self-report questionnaire results (Asendorpf, Banse, & Mücke, 2002; Dovidio, Kawakami, Johnson, Johnson, & Howard, 1997). Note that the explicit game data represent the number of visual elements when changing decisions, count of decision changes, and total number of clicks. In the bandwagon effect stage, if players changed their answers when a smaller number of fictive players was on the opposite side (i.e., visual elements), their self-reported bandwagon effect was higher accordingly. In addition, when players changed their answers more often due to the top-scoring influential player's choice (i.e., count of decision changes), their bandwagon effect was higher. In the optimism bias stage, when the current water level was close to the limit (e.g., 19 L; maximum = 20 L), and the players decided to continue to scoop up water, their optimism bias levels were very high.

In this regard, our serious game, Don Quixote, might be of value for interpreting both implicit and explicit behaviors, that is, the dual-process of decision-making. Evans and Stanovich (2013) proposed an integrative way to understand both implicit and explicit outcomes by considering the role of working memory. For example, decisions made about problematic behaviors were better predicted by explicit measures when conscious control resources from working memory were available, but were better predicted by implicit measures when control resources had been experimentally depleted (Friese, Hofmann, & Wänke, 2008; see Experiment 2 in Gibson, 2008). The integrative understanding of both implicit and explicit measures can support a holistic evaluation of the manifestation of cognitive biases.

Implications and Future Research

Multiple aspects of gaming performance (e.g., response times, decision-making patterns, reactions to visual elements) can be employed to interpret an individual's psychological biases. From the perspective of assessment, having a comprehensive understanding of implicit and explicit behavior data from games can expand our knowledge about dual-process mechanisms in various decision-making process, such as the racial prejudice in presidential elections (Payne et al., 2010); the relationship of self-esteem with depression and loneliness (Creemers, Scholte, Engels, Prinstein, & Wiers, 2012); and the role of motivation in health-related behaviors (Keatley, Clarke, & Hagger, 2012). Don Quixote is a specific genre of serious game that deals only with cognitive biases. Additional replications in other research areas would help to establish the generalizability of the game-based assessment method. It is hoped that by applying this assessment method to other conditions and contexts, researchers can gain the insights needed to make their understanding more fruitful.

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Electronic Supplementary Material

The electronic supplementary material is available with the online version of the article at https://doi.org/10.1027/1015-5759/a000485

ESM 1. Syntax (.xlsx)
Experimental data.

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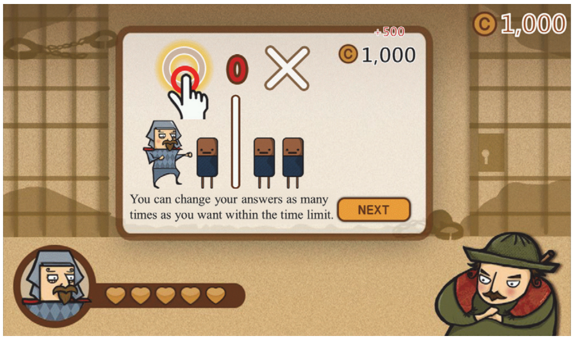
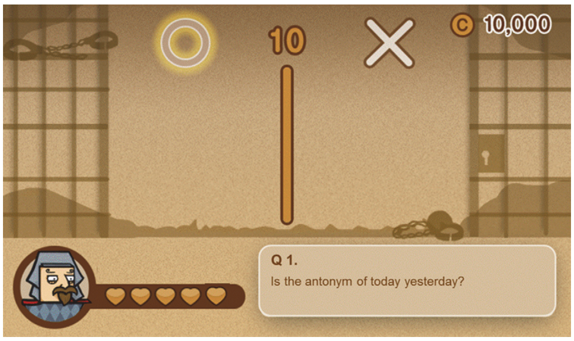
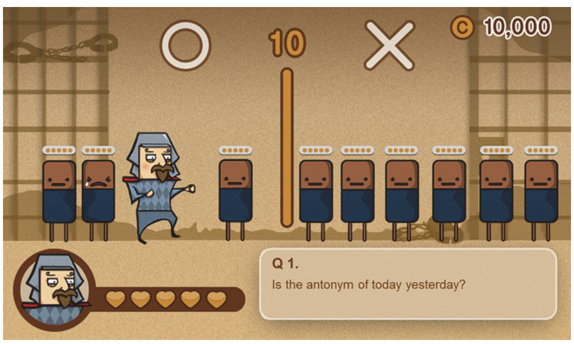
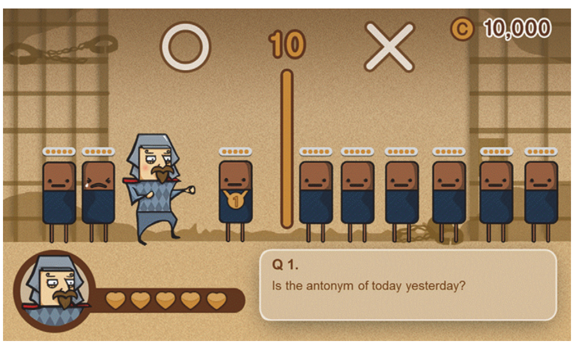
Jieun Kim
Imagine X Lab
Hanyang University
701 ho, Multidisciplinary Lecture Hall
222 Wangsimni-ro, Seongdong-gu
Seoul 04763
Republic of Korea
jkim2@hanyang.ac.kr

Appendix

Detailed Information of the Serious Game "Don Quixote"

Table A1. Stage 1 – True or False Quizzes (bandwagon effect)

		Data collected	
Screenshot	Descriptions/Measure	Implicit	Explicit
	A tutorial for the stage is provided.		
	A set of trivia quiz questions is given. A player had 10 s to answer and could change their answers as many times as they want within the time limit.		
	Once the player makes an initial answer, fictive players are progressively shown on the opposite side from the player. The movement of fictive players who seem to be virtual competitors in the game may influence the player's initial belief. In order to assess this majority opinion sensitivity, the "time taken to change answer via the majority opinion" (implicit data) and the "number of fictive players involved in the majority opinion when changing answer" (explicit data) were recorded.	X	X
	The player's influential opinion sensitivity was measured when one fictive top-scoring player with a badge appears in the game. We measured the "time taken to change answer via influential opinion" (implicit data) and the "number of changes due to the influential opinion" (explicit data).	X	X

(Continued on next page)

Table A1. (Continued)

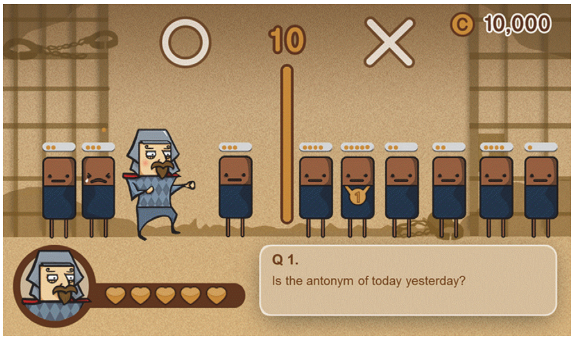
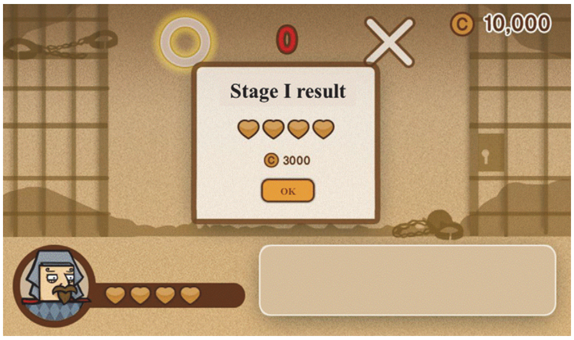
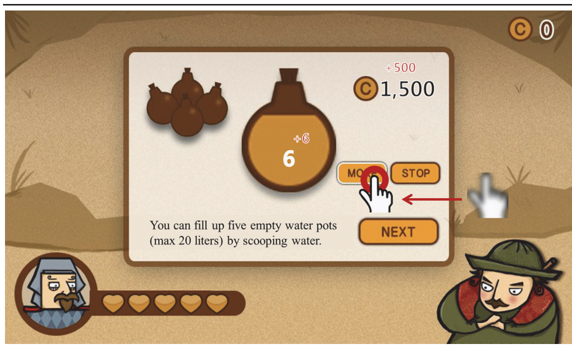
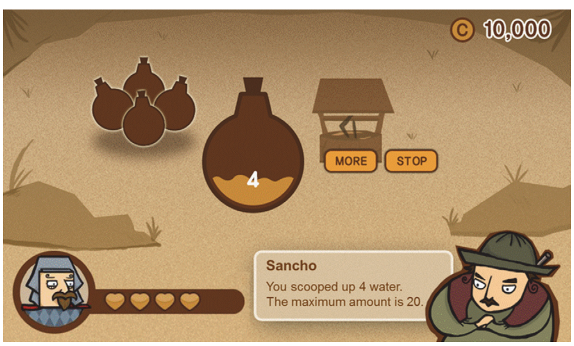
Screenshot	Descriptions/Measure	Data collected	
		Implicit	Explicit
	The player has 10 s to give his/her answer and check the correct answer. Ten rounds were played in the same manner.		
	After completing the game, a pop-up window summarized the virtual points collected. Each question offers 1,000 points if the player responds correctly.		

Table A2. Stage 2 – Scooping Water (optimism bias)

Images	Descriptions/Measure	Date collected	
		Implicit	Explicit
	A tutorial for the stage is provided.		
	The players start to fill up the water pots. The players accumulate points each time they scoop up the water, but the amount of each scoop was randomized from 1 L to 5 L. Players were informed of the cumulated current water level in the water pot.		

(Continued on next page)

Table A2. (Continued)

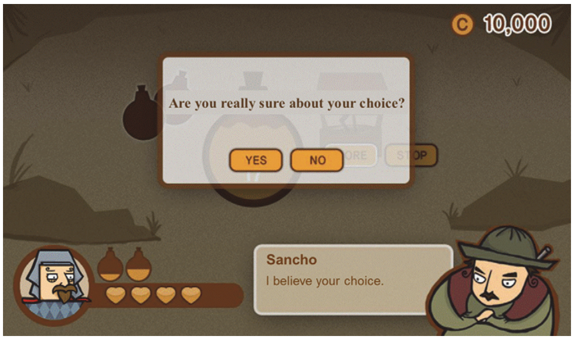
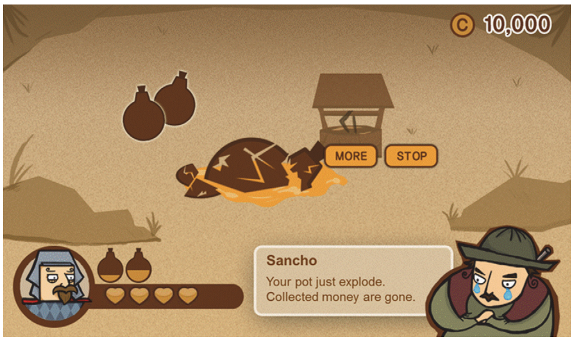
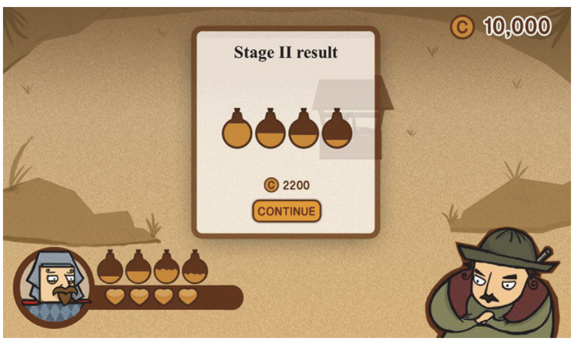
Screenshot	Descriptions/Measure	Data collected	
		Implicit	Explicit
	At each decision-making point, a pop-up window asks the player whether (s)he will continue or cease to scoop up water by clicking on the "MORE" or "STOP" button, respectively. Note that the confirmation question is asked after clicking on the "MORE" or "STOP" button when water level exceeds 16 L: "Are you really sure about your choice?" This question was used to examine the following behavior data: the "number of decision changes via a confirmation check" (explicit data).		X
	The player could collect more points when they fill up five pots with water as much as possible. Once the water level in each pot exceeded 20 L, the pot would break and all points obtained would be lost. Based on the player's perceived benefit and risk, the player decided to scoop up further or not. Player's behavior data were recorded as following: the "time taken to decide to do further scooping" (implicit data), the "time taken to decide to do no more scooping" (implicit data), and the "water level when the participant stopped scooping" (explicit data).	X	X
	After completing the game, a pop-up window summarized the virtual points collected. Each water pot offers points depending on the water level. –1 L: 100 points –. . . –15 L: 1,500 points –16 L: 2,000 points –17 L: 3,000 points –18 L: 5,000 points –19 L: 9,000 points –20 L: 20,000 points		

Table A3. Overall descriptive statistics for the questionnaire, the game, and the interview

Measures	*M* ± *SD*	Min	Max
Experiment 1: Questionnaire			
Majority opinion sensitivity	3.4 ± 1.2	2.00	6.25
Influential opinion sensitivity	4.2 ± 1.4	2.00	6.75
Experiment 1: Game data			
(Implicit) Time taken to change answer via the majority opinion	5.7 ± 2.3	2.00	10.00
(Implicit) Time taken to change answer via influential opinion	6.1 ± 2.5	1.00	10.00
(Explicit) Number of fictive players involved in the majority opinion when changing answer	7.6 ± 1.6	4.00	10.00
(Explicit) Number of changes due to the influential opinion	2.0 ± 1.5	0.00	7.00
Experiment 1: Interview			
Bandwagon effect interview	4.5 ± 1.6	1.00	7.00
Experiment 2: Questionnaire			
Perceived benefit	2.6 ± 0.6	1.25	3.88
Perceived risk	3.5 ± 1.2	1.00	4.88
Experiment 2: Game data			
(Implicit) Time taken to decide to do further scooping	6.7 ± 2.1	1.00	10.00
(Implicit) Time taken to decide to do no more scooping	4.1 ± 2.7	0.00	10.00
(Explicit) Water level when the participant stopped scooping	18.4 ± 0.9	16.00	20.00
(Explicit) Number of decision changes via a confirmation check	1.4 ± 1.2	0.00	4.00
Experiment 2: Interview			
Optimism bias interview	3.3 ± 0.9	1.00	5.00

Table A4. Overall correlations of the questionnaire, the game, and the interview

Measures	E1-Q1	E1-Q2	E1-G1	E1-G2	E1-G3	E1-G4	E1-I	E2-Q1	E2-Q2	E2-G1	E2-G2	E2-G3	E2-G4	E2-I
Experiment 1														
E1-Q1	1.000													
E1-Q2	0.126	1.000												
E1-G1	−0.151	0.072	1.000											
E1-G2	−0.119	0.132	**0.822***	1.000										
E1-G3	−**0.659***	−0.114	0.173	0.207	1.000									
E1-G4	0.110	**0.676***	0.014	0.035	−0.104	1.000								
E1-I	0.138	−0.047	−**0.906***	−**0.849***	−0.163	−0.006	1.000							
Experiment 2														
E2-Q1	−0.019	−0.020	0.043	0.123	0.021	0.006	−0.067	1.000						
E2-Q2	0.064	0.115	−0.030	−0.108	−0.074	0.090	0.042	−**0.807***	1.000					
E2-G1	−0.115	−0.117	0.013	0.112	0.230	−0.005	−0.078	−0.024	0.095	1.000				
E2-G2	−0.043	0.147	0.005	−0.054	−0.112	0.104	0.088	0.021	−0.038	−**0.733***	1.000			
E2-G3	−0.063	0.048	0.066	0.172	0.053	0.083	−0.094	**0.781***	−**0.642***	0.014	0.002	1.000		
E2-G4	−0.025	−0.013	−0.181	−0.109	−0.084	−0.055	0.164	0.074	−0.071	0.016	0.019	0.004	1.000	
E2-I	−0.091	0.124	0.123	0.055	−0.011	0.093	−0.043	0.060	−0.089	−**0.653***	**0.763***	0.041	0.001	1.000

Notes. Values are Pearson correlation coefficient, *r*. $^{*}p < .01$. The significant correlations are shown in bold. E1-Q1: Majority opinion sensitivity questionnaire; E1-Q2: Influential opinion sensitivity questionnaire; E1-G1: (Implicit game data) Time taken to change answer via the majority opinion; E1-G2: (Implicit game data) Time taken to change answer via influential opinion; E1-G3: (Explicit game data) Number of fictive players involved in the majority opinion when changing answer; E1-G4: (Explicit game data) Number of changes due to the influential opinion; E1-I: Bandwagon effect interview; E2-Q1: Perceived benefit questionnaire; E2-Q2: Perceived risk questionnaire; E2-G1: (Implicit game data) Time taken to decide to do further scooping; E2-G2: (Implicit game data) Time taken to decide to do no more scooping; E2-G3: (Explicit game data) Water level when the participant stopped scooping; E2-G4: (Explicit game data) Number of decision changes via a confirmation check; and E2-I: Optimism bias interview.

