

# Commitment-enhancing tools in Centipede games: Evidencing European–Japanese differences in trust and cooperation

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## Abstract

Theories of trust distinguish general trust in situations of social uncertainty from assurance-based trust in committed, long-term relationships. This study investigates European-Japanese differences using the Centipede game, in which two players choose between cooperation and defection. The game models repeated reciprocal interactions, necessitating assurance-based trust to sustain cooperation. We included game conditions offering players the option of purchasing commitment-enhancing tools to increase social certainty. Japanese participants were more cooperative than Europeans, confirming higher assurance-based trust, and also purchased more commitment-enhancing tools, demonstrating their preferences for social certainty. Purchase of commitment-enhancing tools improved cooperativeness in both groups. However, if co-players refused tool purchase, the Japanese appeared to interpret this as non-cooperative intent and cooperativeness in the respective games decreased.

Keywords: centipede game; cooperation; cross-cultural differences; trust; reciprocity

## 1 Introduction

Cross-cultural differences in trust and cooperation — despite their importance for international business partnerships and global human interaction — remain to be fully understood (Krockow, Takezawa, Pulford, Colman & Kita, 2017). Of particular interest are differences between countries with comparable industrial development but contrasting cultural and religious backgrounds, such as Northern European countries compared with East Asian nations such as Japan.

Previous cross-cultural research has differentiated between *assurance-based trust* and *general trust* (Yamagishi & Yamagishi, 1994). Japanese society was suggested to be high in assurance-based trust, the type of trust necessary in relationships of high social certainty and an expectation of repeated future interactions with the same other.<sup>1</sup> Examples

include historically close family bonds, tight business groups (so-called *keiretsu*), and life-long employment with the same company (e.g., Kim, Hoskisson & Wan, 2004; Spencer & Qiu 2001). Western societies (particularly North America), on the other hand, were characterized by general trust, with low social certainty when interacting with strangers in the face of incentives for dishonesty or defection. Examples of North American society requiring high levels of general trust include more liberal attitudes to family responsibilities and regular staff change-over in business firms in order to maintain flexibility and innovation. General trust is arguably also required in ordinary commerce with strangers, especially between individuals who do not expect to meet again.

Empirical literature supporting this trust theory is provided by Krockow, Takezawa, Pulford, Colman and Kita. (2017), demonstrating that Japanese participants, compared to Western participants, (a) cooperated more frequently in decision situations with higher sense of control; (b) showed higher levels of reciprocity and trustworthiness; and (c) exhibited more trust towards a familiar co-player. This lends support to Yamagishi and Yamagishi's (1994) theory postulating assurance-based trust to be more prevalent in Japan than in Western cultures.

Only one experimental study to date has investigated Japanese decision making within the stable, reciprocal partnerships claimed to be characteristic of Japanese society (Krockow et al. 2017). That study and the present re-

Russel Hardin (2002) described as “encapsulated trust”. However, for the purpose of consistency across the manuscript, we will use the terminology originally introduced by Yamagishi and Yamagishi (1994).

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<sup>1</sup>The concept of “assurance-based trust” appears to be related to what

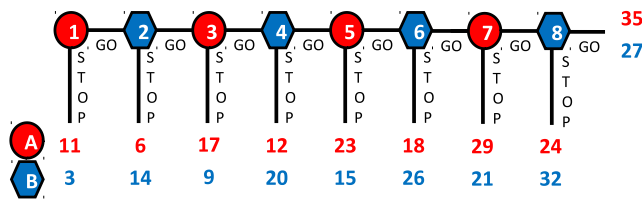


FIGURE 1: Standard Centipede game.

search use Rosenthal’s (1981) Centipede game as a research paradigm (Figure 1). This game involves two players making alternating choices either to continue horizontally through a GO move or to STOP the game and follow the vertical line down to an exit point with an immediate payoff. Player A chooses at odd-numbered decision points or *nodes* and Player B at even-numbered nodes. The payoffs, representing monetary units — including British Pounds Sterling and Japanese Yen — are shown at the bottom of the diagram with Player A’s payoffs above Player B’s. The number of decision nodes is limited to eight but could be extended indefinitely to model longer relationships.

As shown in the payoff function, every GO move increases the players’ combined payoffs by 6 monetary units. GO increases the co-player’s payoff by 11 units while decreasing the GO-chooser’s personal payoff by 5. Hence, a GO move can be interpreted as cooperative action benefitting both the dyadic team and the co-player, while risking a personal disadvantage should the co-player decide to STOP at the following node. A STOP move, on the other hand, always terminates the game with a higher personal payoff than the co-player and can therefore be interpreted as defection. The Centipede game provides a dynamic model of the reciprocal human relationships typical of Japanese society requiring commitment and assurance-based trust to be maintained.

Interestingly, the rational strategy to employ in the Centipede game — according to conventional game theory — is for Player 1 to terminate the game at the very first decision node, the *subgame perfect Nash equilibrium*. This solution, which appears to be paradoxical given the higher payoffs tempting from later exit points in the game, is derived from mathematical backward induction reasoning (Aumann, 1995; 1998; Broome & Rabinowicz, 1999; Colman, Krockow, Frosch & Pulford, 2017). Starting the analysis at the final decision node (Node 8), Player B has to choose between GO, leading to the game’s natural end and a personal payoff of 27, and STOP, terminating the game with a payoff of 32. Since 32 is higher than 27, any rational payoff maximizer should choose STOP at Node 8. Moving backward to Node 7, Player A has to decide between GO, which would immediately and foreseeably be followed by a STOP move of Player B, thus yielding a personal payoff of 24, or STOP, resulting in immediate game termination with a payoff of 29. Again, any rational agent would decide to STOP at this point. This type of reasoning, requiring step-wise

perspective-taking, can be continued to the very beginning of the game where it mandates immediate and unconditional defection by Player A at Node 1.

In contrast with the backward induction argument, the bulk of research on the Centipede game suggests that human decision makers cooperate frequently (e.g., Levitt, List & Sadoff, 2011; Krockow, Pulford & Colman, 2015; Krockow, Colman & Pulford, 2016b; McKelvey & Palfrey, 1992). Across experiments, many games reached the natural end — an outcome dependent on Player B’s altruistic GO move at the last decision node. In an experiment by Bornstein, Kugler and Ziegelmeyer (2004) as many as 16.5% of games reached the final exit point.

However, only one Centipede study using a Japanese sample (Kawagoe & Takizawa, 2012), and one cross-cultural experiment (Krockow et al., 2017) have been published (see Krockow, Colman & Pulford, 2016a, for a review). The current study aimed to build on earlier research by using a modified game version, enabling a more advanced investigation of trust and relationship commitment. Specific objectives included providing a further test of the hypothesized Japanese preference for social certainty and their strong reliance on assurance-based trust compared to Western samples. Our design was based on a research paradigm originally developed by Gerber and Wichardt (2010). Their experiment included Centipede game conditions with optional tools to improve players’ commitment and payoff certainty.

The *bonus tool* involved offering the co-player an incentive, at a personal cost  $b$ , for not ending the game. This incentive was deducted from the payoff of any player who used the tool and added to the co-player’s payoff whenever the player with the tool chose STOP. The *insurance tool* required an initial monetary sacrifice at cost  $c$ , deducted from all payoffs to a player who used this tool but reimbursed if the co-player chose to STOP at any point in the game. Both tools were designed to remove the other player’s fear that the tool-user would rationally quit, and consequently, the other player’s reason for quitting herself. Hence, the tools’ costs reflected the financial price that players had to pay for this disincentive to stop. Rather than paying the cost from a personal endowment, the respective monetary units were deducted from the overall payoffs to be earned in the games. Even though both instruments were effective, the bonus tool required lower levels of iterated reasoning for participants to understand its benefits. In line with Gerber and Wichardt’s (2010) predictions, participants chose the comparatively simpler bonus tool more frequently than the insurance tool, but the use of either tool resulted in later game exits (greater cooperation). The authors interpreted the findings as evidence for limited reasoning skills and as an explanation for cooperation in the Centipede game.

However, whereas usage of the above tools could indeed inform about backward induction reasoning skills, other-regarding preferences — for example considerations of com-

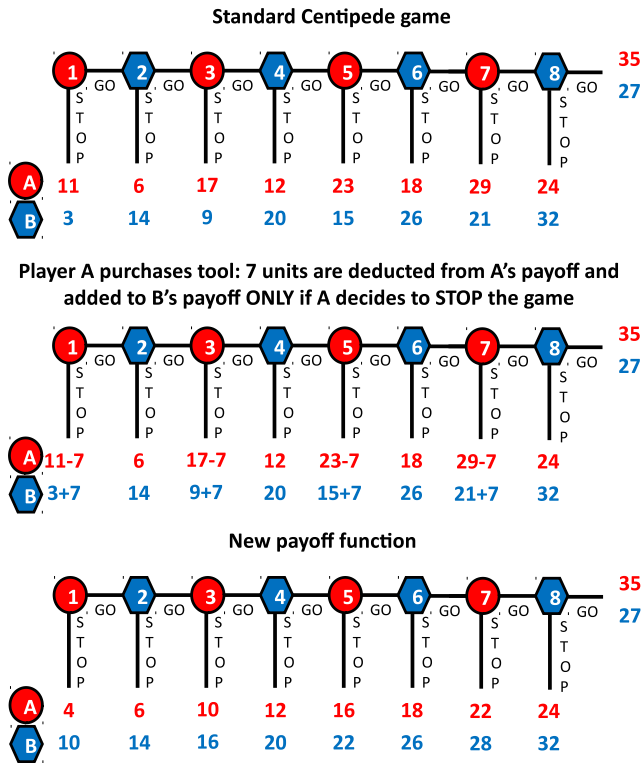


FIGURE 2: Bonus condition: Changes to the standard payoff function if Player A decides to purchase the bonus tool.

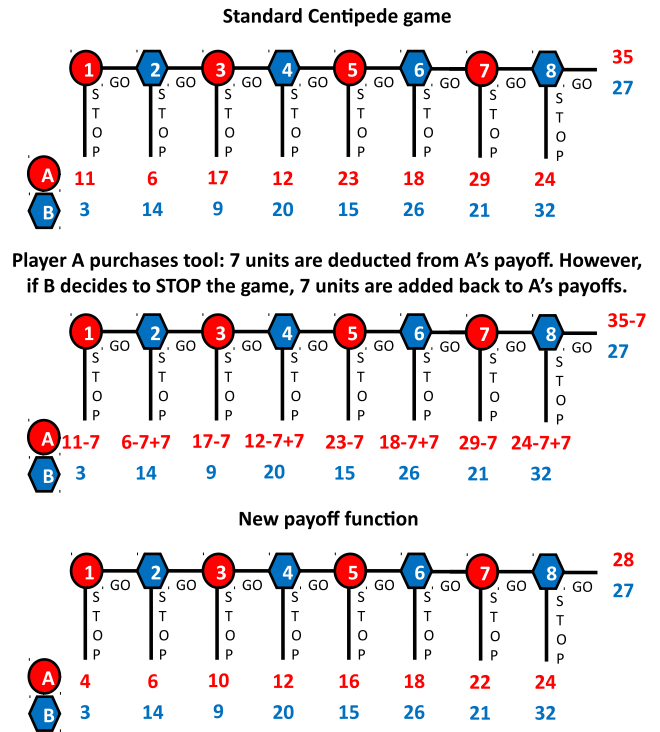


FIGURE 3: Insurance condition: Changes to the standard payoff function if Player A decides to purchase the insurance tool.

mitment and social certainty — may also play a role. This is because the purchase of either tool requires an initial commitment in the form of voluntary reductions of personal payoffs at particular decision nodes, while it increases social certainty in the game through the disincentive to defect. Hence, it is possible to conceptualize tool use as a voluntary institution or a prosocial mechanism supporting cooperation in dyadic relationships. The present study employed Gerber and Wichardt’s (2010) research paradigm to study cross-cultural differences in commitment and cooperation. In addition to the standard Centipede game, we included a bonus condition and an insurance condition, where tools could be purchased by the players at the beginning of each game. Figures 2 and 3 illustrate the effects on payoff functions of typical combinations of tool use (i.e., in the event that only Player A opts for the bonus or the insurance respectively). For each figure, the top part shows the original Centipede game. The game in the center shows the payoffs when only Player A purchases a tool. Finally, the bottom part displays the new payoff function after applying the changes caused by Player A’s tool purchase.

In line with Gerber and Wichardt’s (2010) original design, our bonus tool involves offering the co-player an incentive at a personal cost  $b$  for not stopping the game. In our experiment,  $b = 7$ , meaning that 7 monetary units are taken from the individual who purchases the tool and added to

the co-player’s payoff only in the event of that individual’s STOP move (at odd-numbered exit nodes). The consequent changes to the payoff function show that both players’ payoffs are affected by Player A’s purchase of the bonus and, as a result, both players’ payoffs strictly increase from one decision node to the next until reaching Node 8. This change to the payoff function also alters the game’s equilibrium solution: Applying backward induction reasoning, neither player has a rational reason to terminate the game before the 8th decision node.

In the insurance condition, tool purchase involves an initial monetary sacrifice deducted from all personal payoffs in the game of the player who chose the tool. To match the cost of the bonus tool, we set  $c = 7$ . Consequently, 7 monetary units are deducted from all of Player A’s payoffs; see Figure 3. The tool further includes reimbursement of the insurance cost in case of a STOP move by the co-player. This is reflected in the repayment of 7 units to Player A at all even-numbered nodes (nodes where Player B could terminate the game). Only Player A’s payoffs are affected by tool purchase in this condition, resulting in a strict increase from one node to another. As in the bonus condition, these changes alter the game’s equilibrium solution. Player A no longer has an incentive to defect, thus mandating cooperation until Node 8. As a result, Player B no longer needs to fear that Player A will defect rationally. With this fear lifted, Player B’s reason for

defection — the pre-emption of Player A's possible STOP move — is removed, too. Consequently, both players are rationally expected to cooperate in the altered game version.

Both tools require an initial commitment, because their purchase involves voluntarily reducing personal payoffs at certain decision nodes in the game. Moreover, they have similar consequences: they change the payoff function and create higher social certainty. The new game-theoretic solutions prescribe cooperation until the near-end in both cases and thus foster reciprocal GO moves. Given the obvious benefits of choosing GO in the altered Centipede games, the co-players' intentions are also easier to predict. Nevertheless, whereas the bonus tool affects both players' payoffs, yielding easily observable consequences that do not require any perspective-taking, this is not the case for the insurance tool. Buying insurance affects only the payoffs of the insured player and leaves the co-player's payoffs unchanged. To recognize the benefits of the insurance tool, the co-player has to perform iterated reasoning, taking into account the insured player's incentives and likely intentions.

To sum up, the use of either tool indicates commitment and preference for social certainty. Furthermore, in addition to the tools' direct influences on the payoff functions, the mere choice of purchasing a tool might signal cooperativeness to the other player, thereby leading to higher levels of overall assurance-based trust and cooperation. These aspects could be of particular importance to Japanese participants, who are historically used to close, committed relationships with low uncertainty. However, only the insurance tool requires higher cognitive reasoning skills. This also entails the tool-user's assumption that the co-player possesses similar skills to recognize tool purchase as insurance in the game. Comparing the bonus and the insurance conditions can therefore expose variations in cognitive abilities. We hypothesized that in both Japan and Europe, the simpler bonus tool would be chosen more frequently than the insurance tool. For both samples, both tools were expected to increase cooperation relative to games without tool purchases. Due to the higher need for social certainty attributed to the Japanese participants, we further hypothesized that the Japanese would purchase significantly more commitment-enhancing tools than the Europeans.

Finally, to assess the effects of individual difference variables other than assurance-based trust itself, this study included the same personality questionnaires assessing social value orientation (SVO), general trust and risk-taking as used in Krockow et al.'s (2017) earlier experiment. On the basis of our previous research in the area, we did not anticipate significant differences between Japan and Europe in SVO. However, we hypothesized that Japanese participants would score lower than European participants on measures of risk-taking and — possibly — general trust, and that individual differences in SVO, risk-taking and trust could correlate significantly with cooperativeness in the Centipede game,

because of earlier findings (Pulford, Colman, Lawrence & Krockow, 2016; Pulford, Krockow, Colman & Lawrence, 2016).

## 2 Method

**Subjects.** The sample comprised 60 Japanese nationals from Hokkaido University in Japan and 54 European subjects from the University of Leicester in the UK. All subjects were undergraduate students. The study was advertised on established online recruitment systems for participation in psychology experiments at the respective universities, and subjects could sign up electronically. In Japan, the sample comprised 34 males, 25 females and one of unknown gender, with a mean age of 18.81 years ( $SD = 0.71$ ). The sample in the UK included 9 males, 44 females and one of unknown gender, with a mean age of 18.65 years ( $SD = 0.94$ ). In both countries, a between-subjects random lottery incentive system was used to incentivize choices in the games (see Bolle, 1990, and Cubitt, Starmer & Sugden, 1998, for a discussion of this incentive scheme). In particular, from each of the 6 testing sessions (three sessions in Japan and three in the UK), one subject was randomly chosen to win a payoff from a randomly selected played game. The games' payoffs were converted into Japanese Yen and British Pounds Sterling at rates of 242.32 and 1.36 respectively, to result in comparable stakes and consequent payments. In Japan, the three lottery winners received an average of ¥5173.3 (US\$43.78), and in the UK, they won an average of £28.3 (US\$40.32).

**Design.** The experiment was based on a 2 (Sample)  $\times$  3 (Condition) design. The subjects of both samples (Japanese and European) were randomly assigned to one out of three game conditions: (a) Standard Centipede game (Condition 1); (b) Centipede game with bonus tool (Condition 2); (c) Centipede game with insurance tool (Condition 3). The main dependent variable to compare cooperativeness in the games across testing sessions was the mean exit point of the 20 game rounds an individual completed during the course of the experiment, with higher scores showing later exiting (i.e., higher cooperation levels), and lower scores earlier exiting (i.e., lower cooperation levels). Additionally, to measure the level of commitment and preference for social certainty of an individual, the total number of tool purchases was calculated. A maximum score of 20 indicated very high commitment and strong preference for social certainty whereas lower scores suggested accordingly lower levels of commitment.

**Materials.** The testing sessions were conducted in large laboratories equipped with computer desks separated with dividing walls. Subjects saw the other subjects when entering the laboratories. It is possible that some subjects knew each other. However, once they sat down, they were shielded by the dividing walls, and could no longer observe other subjects. At no time were they aware of what the co-player in

any particular game looked like. Hence, even if they got partnered with a known person by chance, they were unaware of this fact. All subjects received colorfully illustrated instruction booklets — in Japanese or in English — with detailed explanations of example situations in the games. They interacted in the games through z-Tree software (Fischbacher, 2007) on their computers, which provided real-time feedback about the co-players’ choices and the outcome of the current as well as previous games. The Japanese subjects were presented with a fully translated version of the software. To assess individual differences, paper copies of the following questionnaires were distributed: (a) six-item SVO slider measure (Murphy, Ackermann & Handgraaf, 2011); (b) 30-item Domain-specific risk-taking (DOSPERT) scale and respective risk-perception scale (Blais & Weber, 2006); and (c) the first five items of Yamagishi and Yamagishi’s (1994) scale on general trust.

**Procedure.** Six testing sessions were conducted, comprising 20 subjects each in Japan and 18 subjects each in the UK. Each testing session lasted between 60 and 75 minutes. After filling in the consent form, the subjects read through the instruction booklets in their own time. Then, the subjects were given a short comprehension test that the experimenters checked for any misunderstandings. Once everybody had fully understood the instructions, the computerized experiment was started. The program randomly assigned each subject a player role (Player A or B) retained for the whole experiment. The subjects completed 20 rounds of the Centipede game with random and anonymous re-pairings after every round. This random matching scheme, where subjects were paired randomly but could encounter the same co-player more than once, was used as the closest possible alternative to a fully rotating matching scheme (perfect stranger matching scheme), where no co-player is encountered more than once. In the game conditions with either bonus or insurance tool, the players were given the option to purchase a tool before the start of each round. The choices of both players were subsequently revealed on the screen and the game payoffs incorporating any changes due to tool purchases were displayed. All subjects were compensated for their time with a show-up fee or course credits, and the randomly chosen lottery winner in that session additionally received the payoff from a randomly selected game they completed in the experiment.

### 3 Results

**Analysis of exit points.** Overviews of game terminations per exit node for the three game conditions are depicted in Figure 4. Striking differences between Japan and Europe are evident, with Japanese subjects generally cooperating much more frequently than Europeans. Some differences across conditions are also noticeable in the graphs, but any

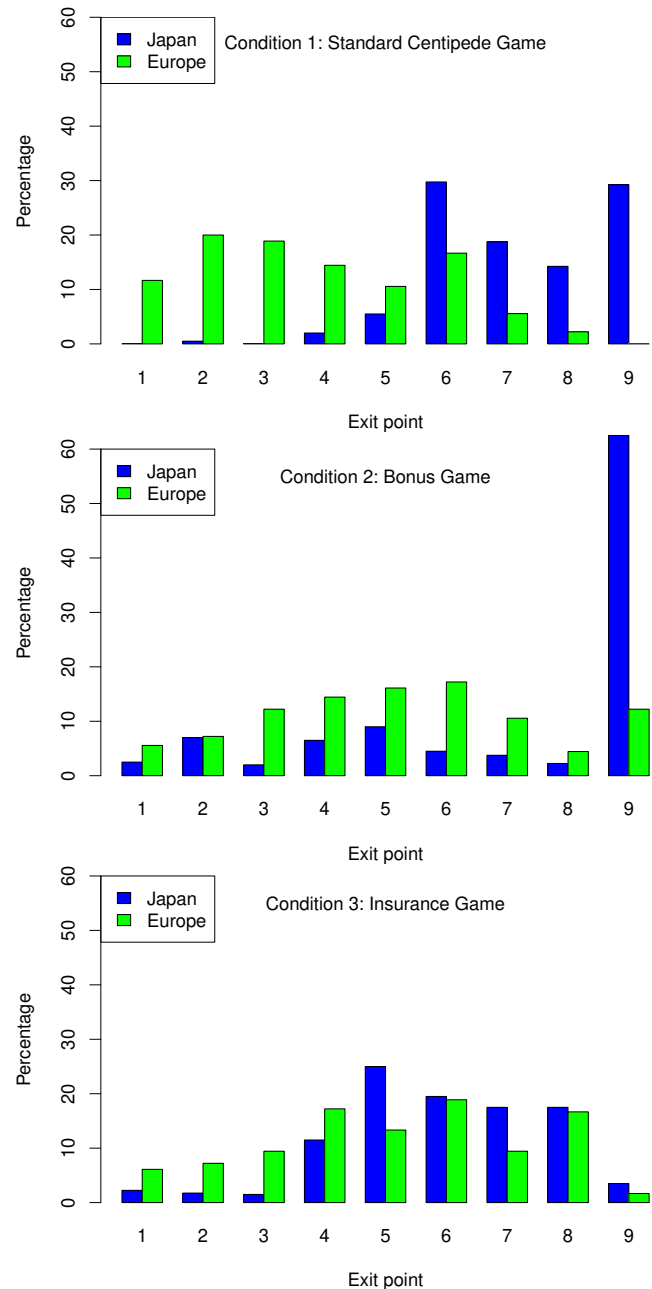


FIGURE 4: Percentages of game terminations per exit point across game conditions and samples.

interpretation has to be treated with caution due to comparatively small sample sizes for each condition per country. In Condition 1 (standard game), the exit points of the Japanese subjects are skewed toward the right, indicating late game exits, with the two most frequent exits points being Node 6 and, notably, the game’s natural end (Node 9) — almost 30% of games each terminated at those exit points. Not a single game exited at Node 1. In contrast, the European sample produced much earlier game exits with the data skewed toward the left. The two most frequent exit points, with ap-

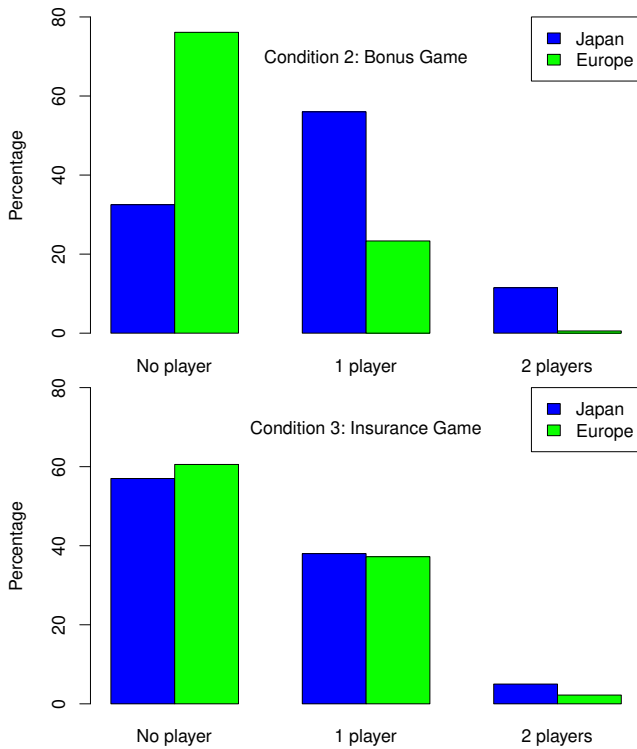


FIGURE 5: Percentage of games where no, one or two players purchased tools across the bonus and the insurance game conditions and the two samples.

proximately 20% of game terminations each, were Nodes 2 and 3, and not a single game reached the natural end.

In Condition 2 (bonus game), completely different exit patterns were found. In both samples, game terminations show a wide spread across exit nodes. The Japanese data feature a large spike at Node 9, with a remarkable 62.5% of games reaching this natural end. For the UK, Nodes 5 and 6 show the highest percentages of game exits with 16.1% and 17.2% respectively but this condition also yielded a substantial percentage of games reaching the natural end (12.2%).

Condition 3 (insurance game) again yielded wide data spreads for both samples. Over 90% of Japanese games ended at Nodes 4–8, and only 3.5% reached the natural end. The European sample produced very mixed results, with the most frequent exit points being Nodes 4, 6, and 8 (all between 16.5% and 19%) and very few games terminating at Node 9 (1.7%).

A two-way ANOVA tested for effects of sample and game conditions on mean exit points. Descriptive statistics are displayed in Table 1. There was a significant main effect of sample: the mean exit point of the Japanese sample ( $M = 6.81$ ;  $SD = 1.15$ ) was significantly higher than that of the European sample ( $M = 4.69$ ;  $SD = 1.1$ ),  $F(1, 108) = 145.153$ ,  $p < .001$ ,  $\eta_p^2 = .57$ . Another main effect was found for the game condition,  $F(2, 108) = 7.359$ ,  $p < .005$ ,  $\eta_p^2 = .12$ . For both

samples taken together, the insurance condition produced the lowest exit points ( $M = 5.54$ ;  $SD = 0.86$ ), followed by the standard game condition ( $M = 5.59$ ;  $SD = 1.96$ ), and then the bonus condition ( $M = 6.28$ ;  $SD = 1.54$ ). Post-hoc comparisons using Tukey HSD tests indicated significant differences between the bonus condition and both other game conditions ( $p < .005$ ). However, these results have to be interpreted with caution, as the two factors also interacted significantly,  $F(2, 108) = 19.217$ ,  $p < .001$ ,  $\eta_p^2 = .26$ , indicating that the effect of the game condition depended on the sample. In Japan, the first two conditions produced similar mean exit points, but the mean for the insurance condition was significantly lower ( $p < .001$ ). In Europe, the standard game produced significantly lower exit points than both the bonus and the insurance game, ( $p < .001$ ).

To check for any confounding gender effects in the context of different gender proportions across the two samples, a three-way ANOVA was carried out, investigating the effects of gender in addition to those of the sample and game condition on mean exit points. No significant main effect of gender was found,  $F(1, 100) = 2.152$ ,  $p = .145$ , nor any two-way or three-way interactions including gender. To test for learning effects, temporal exit patterns across the 20 game rounds were examined, but non-significant results from time series analysis indicated no significant behavioral adaptation based on experience.

**Analysis of tool purchase.** Figure 5 reveals large differences in the bonus condition: in Japan less than a third of all games (32.5%) were played without a bonus purchase of either player. For most games, only one player purchased this tool, but in many games (11.5%) both players purchased the bonus. In the UK, the percentage of games with no bonus purchases was more than twice as high as in Japan (76.1%), and in only 23.3% of games did one player choose the bonus tool. In only one game out of 180, did both players purchase the tool.

For the insurance condition, cross-cultural differences were absent. In both samples, most games were completed without an insurance tool purchase, and 40% of games where played following tool purchase by one player. The proportion of games in which both players purchased a tool was very low in both samples ( $\leq 5\%$ ).

A two-way ANOVA investigated the effects of sample and game condition on the number of tools purchased per subject. Means, standard deviations and 95% confidence intervals are displayed in Table 2. The mean number of tools purchased in Japan ( $M = 6.35$ ;  $SD = 7.52$ ) was significantly higher than in Europe ( $M = 3.31$ ;  $SD = 3.91$ ),  $F(1, 72) = 4.83$ ,  $p < .05$ ,  $\eta_p^2 = .063$ . No main effect was found for the game condition,  $F(1, 72) = 0.247$ ,  $p = .62$ , and the interaction was also non-significant,  $F(1, 72) = 3.029$ ,  $p = .086$ . Even though the two-way ANOVA found non-significant differences between treatments, a separate t-test for the Bonus condition alone showed particularly large differences between the numbers

TABLE 1: Mean exit points, standard deviations, and 95% confidence intervals per sample and game condition.

	C1: Standard condition	C2: Bonus condition	C3: Insurance condition	Total
Japan	7.23 (0.84) [6.82, 7.65]	7.27 (1.34) [6.86, 7.70]	5.92 (0.64) [5.51, 6.34]	6.81 (1.15) [6.57, 7.05]
Europe	3.76 (0.92) [3.32, 4.20]	5.18 (0.86) [4.74, 5.62]	5.12 (0.88) [4.68, 5.56]	4.69 (1.10) [4.43, 4.94]
Total	5.59 (1.96) [5.19, 5.80]	6.28 (1.54) [5.92, 6.53]	5.54 (0.86) [5.22, 5.83]	5.80 (1.55) [5.57, 5.92]

TABLE 2: Mean numbers of tools purchased, standard deviations, and 95% confidence intervals per sample and game condition.

	C2: Bonus condition	C3: Insurance condition	Total
Japan	7.90 (8.57) [5.21, 10.59]	4.80 (6.13) [2.11, 7.49]	6.35 (7.52) [4.45, 8.25]
Europe	2.44 (3.81) [-0.39, 5.28]	4.17 (3.93) [1.33, 7.00]	3.31 (3.91) [1.30, 5.31]
Total	5.32 (7.21) [3.22, 7.13]	4.50 (5.15) [2.53, 6.44]	4.91 (6.24) [3.45, 6.21]

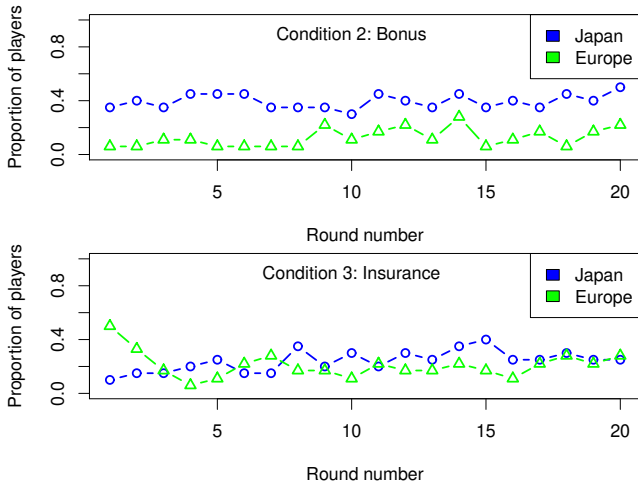


FIGURE 6: Proportion of players who purchased a tool in each game round in the bonus and insurance conditions across samples.

of bonus tools purchased in Europe ( $M = 2.44$ ;  $SD = 3.81$ ) and Japan ( $M = 7.90$ ;  $SD = 8.57$ ),  $t(36) = 2.486$ ,  $p < .05$ ,  $d = 0.808$ .

Temporal patterns in tool purchase are shown in Figure 6. Time series analysis revealed a learning curve of the Japanese subjects in the Insurance condition, with the number of tool purchases increasing across rounds. An exponential smoothing Holt model provided the best fit, indicating a significant linear increase in tool purchase. An estimate of the model's goodness of fit yielded a value of  $R^2 = .32$ , hence the model explains more than 30% of the data variance. The Ljung-Box statistic  $Q$  was calculated to test whether the model was correctly specified, and  $Q(16) = 7.17$ , ( $p = .97$ ) showed that no significant patterns in the data set were unaccounted for by the Holt linear model. Analysis revealed no significant learning patterns pertaining to tool purchase in any other

game condition.

Additional analyses were conducted to compare the exit points of games in which no player, one player or both players purchased tools. Figures 7 and 8 show the percentages of games terminating at each exit point across game conditions and samples, and it appears that games in which no player purchased a tool (zero-tool games), yielded different results from the standard game (without the option to purchase a tool) and the two conditions with tools purchased.<sup>2</sup>

Additionally, we examined effects of tool purchase on the game outcomes. In Figure 8, it is obvious that tool purchase drastically changed exit points. Across both samples and game conditions, tool purchase increased cooperation. This is most visible in the Japanese bonus condition, with over 90% of all games reaching the final end. However, the extreme results of the European samples for games with tool purchases by both players (in the bonus condition, 100% reached Node 9, and in the insurance condition, 75% reached Node 8) need to be interpreted with caution, as these data

<sup>2</sup>The Japanese data, skewed to the right in the standard game condition, are skewed more to the left in the zero-tool instances of the bonus and insurance game conditions. In the UK, the opposite can be observed, with overall higher exit points in the tool conditions compared to the standard Centipede game. A two-way (Sample  $\times$  Game condition) ANOVA examining the effects on exit points of zero-tool games confirmed these observations, but results need to be interpreted with caution due to small sample sizes. Overall, the Japanese sample produced significantly higher exit points ( $M = 5.76$ ;  $SD = 1.36$ ) than the European sample ( $M = 4.3$ ;  $SD = 1.03$ ),  $F(1, 104) = 68.209$ ,  $p < .001$ ,  $\eta_p^2 = .40$ . On the whole, the standard game produced significantly higher mean exit points ( $M = 5.59$ ;  $SD = 1.96$ ) than the zero-tool games of the bonus condition ( $M = 4.66$ ;  $SD = 0.96$ ) and the insurance condition ( $M = 4.84$ ;  $SD = 0.84$ ),  $F(2, 104) = 9.108$ ,  $p < .001$ ,  $\eta_p^2 = .15$ . Finally, there was a significant interaction,  $F(2, 104) = 38.785$ ,  $p < .001$ ,  $\eta_p^2 = .43$ , suggesting that the effect of the game condition on mean exit points of zero-tool games differed between samples. In Japan, the standard game produced significantly higher mean exit points than the bonus and insurance games,  $p < .001$ . The European sample yielded significantly lower mean exit points in the standard game than the bonus and insurance games,  $p < .05$ .

TABLE 3: Mean exit points, standard deviations, and 95% confidence intervals per sample, differentiating between zero-tool games and games with one or two tool purchases.

		C2: Bonus condition	C3: Insurance condition	Total
Zero-tool Games	Japan	4.74 (0.94) [4.29, 5.18]	5.09 (0.58) [4.68, 5.50]	4.93 (0.78) [4.61, 5.22]
	Europe	4.59 (1.00) [4.16, 5.01]	4.55 (1.00) [4.13, 4.97]	4.57 (0.98) [4.27, 4.86]
	Total	4.66 (0.96) [4.36, 4.97]	4.83 (0.84) [4.53, 5.11]	4.74 (0.90) [4.53, 4.95]
Games with Tool Purchase	Japan	8.45 (0.85) [7.86, 9.05]	6.94 (0.74) [6.40, 7.49]	7.63 (1.09) [7.30, 8.10]
	Europe	6.79 (1.69) [6.23, 7.35]	5.82 (1.22) [5.26, 6.38]	6.31 (1.54) [5.91, 6.70]
	Total	7.57 (1.59) [7.21, 8.03]	6.40 (1.14) [5.99, 6.77]	6.96 (1.48) [6.72, 7.29]

were based on only a single case in the bonus condition and 4 cases in the insurance condition.

To provide a statistical test of the visual differences outlined above, we combined data from games in which either one or two players had purchased tools. Then we conducted a mixed (within/between-subject) ANOVA comparing the subjects' mean exit points for zero-tool games and games in which one or two players had chosen tools, while testing for differences between the two samples and game conditions (bonus and insurance) — see Table 3. The analysis showed a significant difference between mean exit points of games with and without tools,  $F(1, 67) = 191.855$ ,  $p < .001$ ,  $\eta_p^2 = .74$ ; zero-tool games yielded a mean exit point of 4.74 ( $SD = 0.90$ ), and games with tool purchase a mean of 6.96 ( $SD = 1.48$ ). There was also a significant interaction between the within-subjects factor (games with or without tool purchase) and the sample,  $F(1, 67) = 10.216$ ,  $p < .01$ ,  $\eta_p^2 = .13$ , indicating that in Japan, the differences between the mean exit points of zero-tool games ( $M = 4.93$ ;  $SD = 0.76$ ) and games with tool purchases ( $M = 7.63$ ;  $SD = 1.09$ ) were significantly larger than the differences observed in Europe (zero-tool games:  $M = 4.56$ ;  $SD = 0.98$ ; games with tool purchases:  $M = 6.31$ ;  $SD = 1.54$ ). Additionally, the results demonstrated a significant interaction: for the bonus game condition, the differences between the mean exit points of zero-tool games and those of games with tool purchases were significantly larger than the differences observed in the insurance game condition,  $F(1, 67) = 18.244$ ,  $p < .001$ ,  $\eta_p^2 = .21$ . No significant three-way interaction was found for the variables of interest. Finally, we conducted a detailed analysis of the individual difference variables SVO, risk taking and general trust, which is reported in the supplement.

## 4 Discussion

This study focused on cross-cultural differences in trust and cooperation between Japanese and European nationals using the Centipede game as a behavioral decision task. In particular, we tested previous concepts of trust proposed by

Yamagishi and Yamagishi (1994) that differentiated between two types of trust: general trust in situations of low social certainty with higher prevalence in US/Western subjects and assurance-based trust in prolonged relationships of higher social certainty with higher prevalence in Japanese subjects. Our research followed up on an initial study by Krockow et al. (2017), in which Japanese subjects cooperated more frequently than European subjects in the sequential the Centipede game, a decision task with repeated opportunities for repeated mutual reciprocity and assurance-based trust. This finding was replicated by the present study: whereas both samples recurrently deviated from the Nash equilibrium solution in the standard Centipede game (STOP at Node 1), the Japanese subjects exited significantly later than the Europeans. The percentage of Japanese games reaching the natural end was unusually high (almost 30%). Hence, cultural background certainly appears to be important, given that the perfect cooperation amongst the Japanese sample was almost twice as frequent as in Bornstein et al.'s (2004) study of Centipede games played by Western subjects. The high cooperation levels of Japanese subjects may be linked to higher levels of assurance-based trust.

**Use and effects of commitment-enhancing tools.** This study further included two game conditions offering tools designed to enhance social certainty and commitment. Gerber and Wichardt (2010), who introduced these tools, argued that both enhanced the players' welfare by inducing higher cooperation and delaying defection. The simpler bonus tool involves offering the co-player a bonus for not exiting the game, whereas the insurance tool requires initial payment in order to receive an insurance compensation if the co-player terminates the game. Both can be interpreted as types of contracts of cooperation between players of repeated games. In real-life examples where people are involved in repeated exchanges of favors with the same other individual (e.g., manual labor followed by financial rewards, or alternating emotional support in romantic relationships), commitment-enhancing tools include employment contracts that specify working hours and guarantee payments and certificates of marriage/civil partnerships that bind two individuals to-



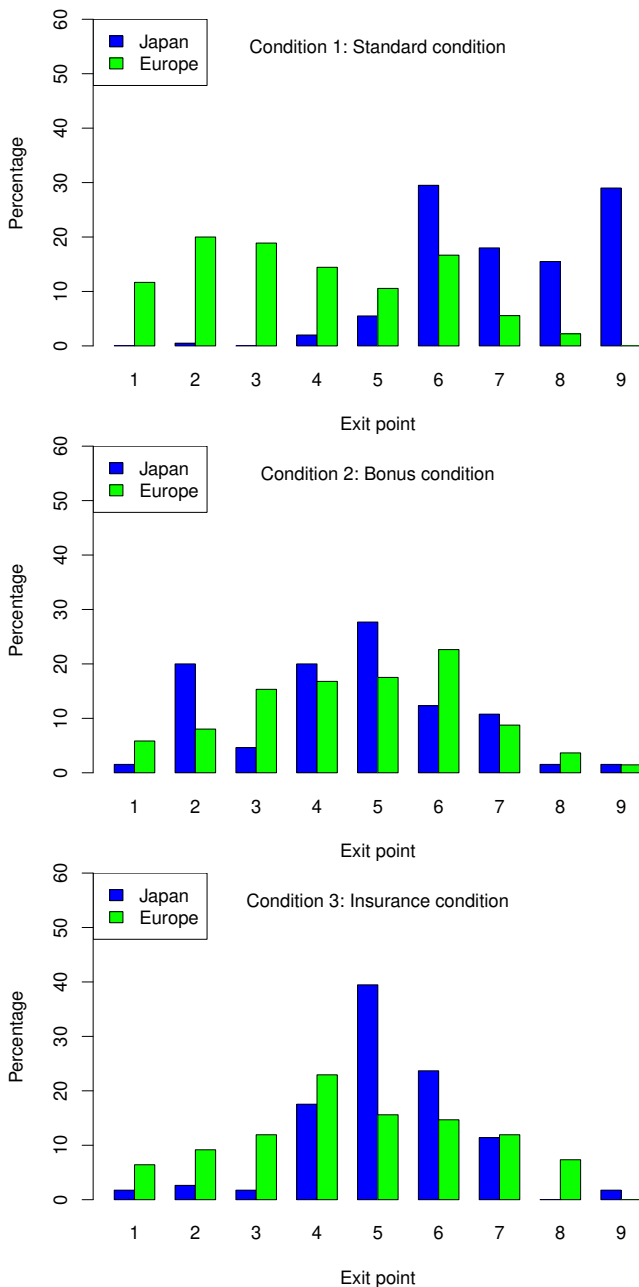


FIGURE 7: Percentages of game terminations per exit node when no tools were purchased.

gether in life-long reciprocal relationships. The introduction of tools to this study adds a more specific test for the preference for social security in the game, complementing an earlier cross-cultural comparison of the Centipede game (Krockow et al., 2017).

We predicted that tool purchase would occur more frequently in the bonus condition than in the insurance condition. However, whereas in Japan bonus purchase was more frequent than insurance purchase — 67.5% of games in the bonus condition were completed with at least one player hav-

ing purchased the tool compared to 43% in the insurance condition — this difference was not statistically significant. In Europe, no significant differences were found, and the insurance tool was used more often than the bonus tool. However, tool purchase rates in general were lower: 76.1% of games in the bonus condition and 60.1% in the insurance condition were played without any tool purchases. These findings contrast with previous results of Gerber and Wichardt (2010), who found striking differences. Our non-significant results could be explained by our detailed and illustrated instruction materials, which presented the subjects with all possible payoff scenarios resulting from their tool purchase. Also, our software included an automatic update of the game’s payoff function to reflect any tool purchases by the respective players. This payoff update was not available in Gerber and Wichardt’s original software, and its presence in our study could have reduced the subjects’ cognitive load — particularly in the more difficult insurance condition — yielding a less pronounced difference in tool usage.

Little learning was evident in tool use. The only exception was a linear increase in the use of the insurance tool in Japan, suggesting that Japanese subjects gradually learned its benefits. For the European sample, no temporal patterns were found.

In line with expectations, opting for either the bonus or the insurance tool significantly increased cooperation relative to games where no tool was chosen. This was observed in both Japan and Europe, suggesting that both tools’ benefits were recognized by the subjects, leading to an improvement of commitment and social certainty. However, the purchase of commitment-enhancing tools led to larger increases of cooperation in Japan than Europe. Furthermore, the bonus tool was more effective in increasing cooperation than the insurance tool, suggesting that its benefits were easier to comprehend. This corroborates Gerber and Wichardt’s (2010) theoretical analysis, pointing out that only the insurance tool requires subjects to use backward induction reasoning in order to understand its benefits.

Our hypothesis of lower cooperation in the standard game condition than the bonus and insurance conditions was partly confirmed. In Europe, the control condition yielded significantly lower cooperation levels than the two tool conditions, but the bonus and the insurance conditions did not differ significantly from one another. In Japan, cooperation in the standard game produced similar mean exit points to the bonus condition, and both the standard and the bonus conditions yielded significantly higher cooperation than the insurance condition.<sup>3</sup>

<sup>3</sup>Additional statistical analyses were conducted, but need to be interpreted with caution due to small sample sizes: Comparing the standard Centipede game with the zero-tool games (in which tools were available but not used) showed significant differences in cooperativeness in the Japanese subjects between all three conditions, with the standard condition being the most cooperative, followed by the insurance condition, and lastly, the bonus condition. Given that the payoff structures of these games were identical,

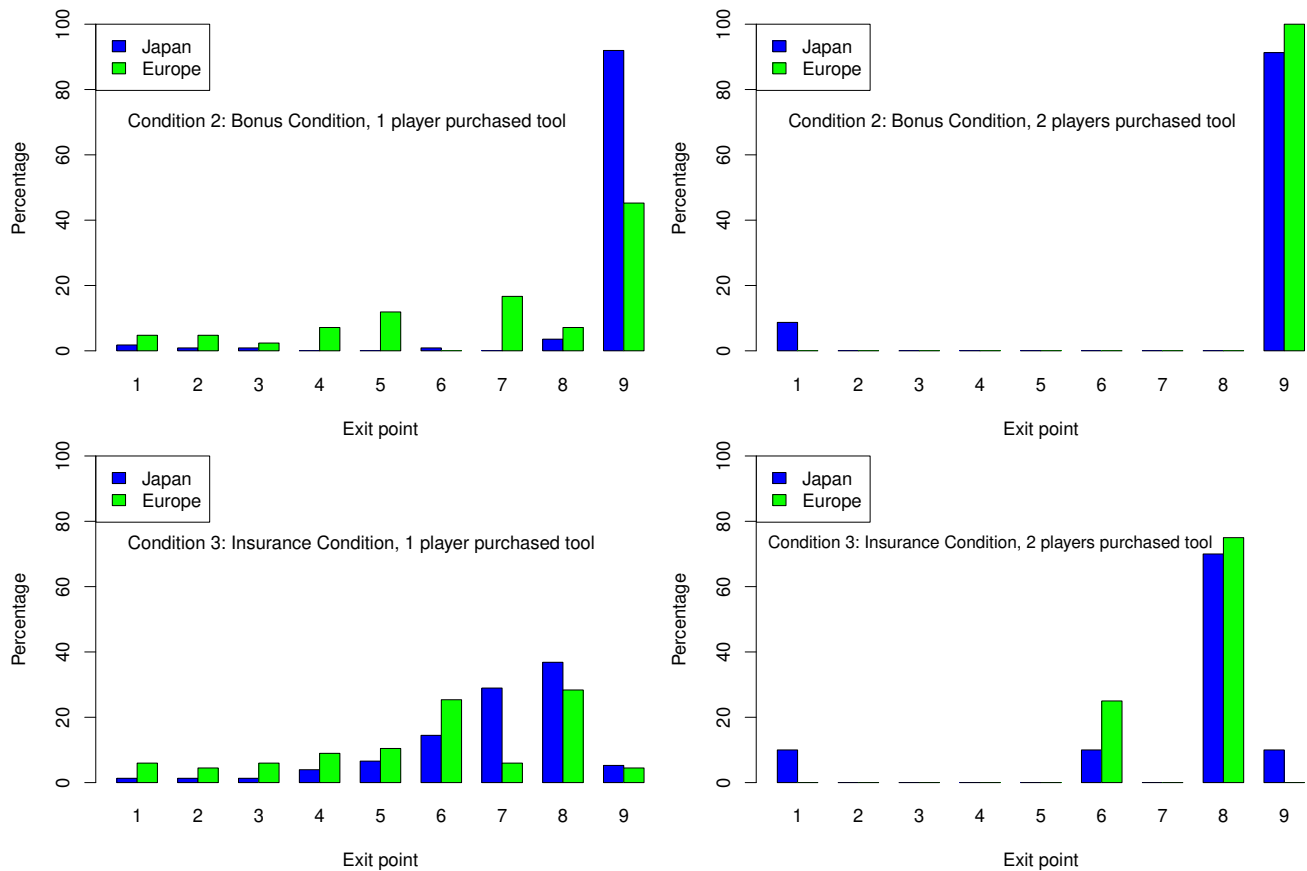


FIGURE 8: Percentages of game terminations per exit node when tools were purchased.

In the insurance condition, tool choices were less frequent, and the insurance tool — despite improving cooperation compared to zero-tool games — was significantly less effective than the bonus. Hence, the games with insurance choices failed to balance out the low cooperativeness of the games with the insurance tool available but not chosen, therefore producing significantly lower mean exit points overall compared to the standard and the bonus conditions.

One interpretation could be that offering commitment-enhancing tools in Japan to increase security in the game can increase cooperation, but only if at least one player actually opts to purchase the tool.<sup>4</sup> Failure to do so could

these results are surprising. A possible explanation could be that the refusal to purchase a tool was interpreted as a refusal to commit and a sign of likely defection early in the game. As a result, assurance-based trust may have been lowered for these zero-tool games, particularly in the simpler bonus condition. However, despite the low levels of cooperativeness in zero-tool games of the bonus condition, the condition produced similar mean exit points compared to the standard game condition. This can be explained by the high number of bonus choices that led to significantly later exit points. Overall, the very high cooperation levels of the games with bonus choices balanced out the very low cooperation levels of the games with the bonus tool available but not chosen, consequently producing mean exit points seemingly similar to the standard game condition.

<sup>4</sup>It is also possible that those who did not purchase the tool differed from those who did in their tendency to cooperate spontaneously. Due to the

be interpreted as a signal of non-cooperation, ultimately resulting in earlier game exits. These findings are in contrast with the study by Gerber and Wichardt (2010) in which no differences between the exit points of the control condition and the zero-tool games were reported for both bonus and insurance conditions.

The same comparison of zero-tool games was conducted for the European sample and produced almost opposite results: the zero-tool games in the bonus and insurance conditions yielded significantly higher cooperation levels than the standard game condition. Again, interpretation is somewhat speculative due to the complex between-subjects design with relatively small numbers per condition. One interpretation could be that in Europe, the mere offer of a commitment-enhancing tool — regardless of whether players actually chose it — led to more committed and more cooperative strategies in the game. This finding could be explained by priming effects: instructions about commitment-enhancing tools and the recurrent offers of tool purchase may have primed the subjects to exhibit more commitment in the decision tasks that followed.

between-subjects design, we can only speculate how non-users of available tools would have behaved in the no-tool (control) condition.

As predicted, tool purchase was significantly more frequent in Japan than in Europe. This main finding corroborates previous trust theories (Kiyonari, Yamagishi, Cook & Cheshire, 2006; Yamagishi & Yamagishi, 1994; Yuki, Maddux, Brewer & Takemura, 2005) and suggests a greater need of social certainty and commitment among the Japanese subjects.

**Conclusions.** The results reported in this article are among the first to enable a cross-cultural comparison of trust and cooperation in Japanese and European samples. They corroborate and extend the findings of previous investigations into trust among Japanese and North American samples (e.g., Krockow, et al. 2017; Yamagishi & Yamagishi, 1994) while employing and improving an interesting new research paradigm using bonus and insurance tools introduced by Gerber and Wichardt (2010). Our study confirmed that Japanese subjects cooperated more frequently than European subjects. This supports previous trust theories that stated the Japanese tend to exhibit more assurance-based trust and thus cooperativeness than Western subjects in close, sequential relationships (Yamagishi & Yamagishi).

The introduction of commitment-enhancing tools yielded very different results in Japan and Europe. Japanese subjects opted more frequently for commitment-enhancing tools than Europeans, thus confirming their higher need for social certainty. Also, across both samples, the use of commitment-enhancing tools was found to increase cooperation relative to games where no tools were available. However, the most interesting evidence was provided by those games where tools were available but were not chosen. In Japan, these games showed significantly less cooperation than the control condition without tools. This was explained by signaling effects, with the refusal to opt for a tool suggesting a lack of commitment and likely defection in the game. In Europe, the opposite effect was observed: even in games where neither subject chose a commitment-enhancing tool, cooperation was significantly higher than in the control condition. These findings point to priming effects of the available tools, making commitment more salient to the European subjects. Hence, whereas the mere offer of commitment-enhancing tools improved mutual cooperation in Europe, more complex effects were found in Japan, where tools increased cooperation only if they were chosen by the subjects, and otherwise decreased cooperation.

Finally, this experiment assessed a number of individual difference variables (e.g., SVO and risk-taking attitudes) identical to those reported by Krockow et al., (2017). These variables did not offer any new insights beyond the contribution reported in the earlier article. We have therefore excluded these variables from the Discussion in this article, but all findings are discussed in the supplement.

If applied to real life decision making, the results suggest large differences in trust and cooperation between individuals from Japanese and Europe. In relationships charac-

terized by a repeated exchange of favors with another individual, Japanese people appear to show greater loyalty and reciprocity as based on higher levels of assurance-based trust than Europeans, reflected (for example) in close, long-term business partnerships. When faced with optional instruments to enhance commitment in repeated relationships, while the mere availability of such options increases cooperation in Europeans, the Japanese might be more sensitive to rejection (refusals to choose these options), ultimately lowering their trust and increasing their defection.

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