Medial prefrontal cortex and striatum mediate the influence of social comparison on the decision process

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We compared private and social decision making to investigate the neural underpinnings of the effect of social comparison on risky choices. We measured brain activity using functional MRI while participants chose between two lotteries: in the private condition, they observed the outcome of the unchosen lottery, and in the social condition, the outcome of the lottery chosen by another person. The striatum, a reward-related brain structure, showed higher activity when participants won more than their counterpart (social gains) compared with winning in isolation and lower activity when they won less than their counterpart (social loss) compared with private loss. The medial prefrontal cortex, implicated in social reasoning, was more activated by social gains than all other events. Sensitivity to social gains influenced both brain activity and behavior during subsequent choices. Specifically, striatal activity associated with social gains predicted medial prefrontal cortex activity during social choices, and experienced social gains induced more risky and competitive behavior in later trials. These results show that interplay between reward and social reasoning networks mediates the influence of social comparison on the decision process.

Information on the outcome of actions that we did not choose may be useful in improving our future decisions. Emotions such as regret (1, 2) embody the painful lesson that circumstances would have been better if we had made a different choice (3, 4). Theoretical (5–10) and empirical (11–14) studies have shown that regret and fictive error signals (which consider the difference between the obtained outcome and the outcomes of alternative foregone actions) have an adaptive function—they constitute a way of evaluating past outcomes to adjust choices in the future. By the same logic, information regarding the outcome of actions chosen by others should also be useful. From social comparison theory (15), we derive the insight that individuals use information on outcomes of others to evaluate their own abilities, and therefore, social comparison allows efficient learning.

The neural response to fictive or counterfactual outcomes (that is, the outcomes of unchosen options) has been localized in the human orbitofrontal cortex (12, 16) and the anterior cingulate cortex both in humans (12) and nonhuman primates (17). In addition, the ventral striatum has been found to play an important role in encoding fictive error signals in dynamic decision-making settings (13). Hence, neural structures related to reward processing (18, 19) and learning (20–23) are involved in encoding counterfactual information in the private setting. Little is known about the neural responses to fictive social signals (24, 25), which refer to the comparison between the outcome from the action that we chose and the outcome of an alternative action chosen by someone else. Here, we directly compare the neural underpinnings of fictive signals in private relative to social settings. The first goal of this research was to investigate how individuals evaluate the outcome of their decision in private vs. social contexts to test the hypothesis that, for the same given outcome, social comparison will enhance brain activity related to social reasoning (26–31) in addition to eliciting a stronger response of the reward system (32–34). Second, the study was designed to investigate whether private and social evaluations of outcomes of risky choices differently influence subsequent decisions. Does the process of encoding counterfactual information in private and social settings share the same neural circuitry? How does the interplay between the reward-related brain areas and the social reasoning network mediate the effect of social comparison on the decision process?

To answer these questions, we designed a lottery choice task in which participants could compare the outcome of their choices with the outcome of the unchosen lottery and in one-half of the trials, with the outcome of choices made by another player. We combined functional MRI (fMRI) and skin conductance recordings to measure brain activity and autonomic responses while participants made a sequence of choices between pairs of lotteries that differed in their expected values and levels of risk (Fig. 1*A*). We manipulated the decision context: in the private context, the participant chose in isolation, whereas in the social context, the participant could see, after they had made their choice, a counterpart's independent and simultaneous choice for the same pair of lotteries. The actions of one of the players had no influence on the outcomes of the other. After the participant and counterpart had made their choice, three outcome contexts were possible: private (P), social same choice (SSC), when the participant and the counterpart had made the same choice, and social different choice (SDC), when they chose different lotteries (Fig. 1*B*). Trials were also categorized as relative gain (+) or relative loss (−) trials, depending on the sign of the difference between the outcomes of the chosen and unchosen lotteries. To summarize, we considered different events according to their outcome context and relative valence of the outcome (Fig. 1*B*).

After participants experience others' choices and outcomes as affecting the way they evaluate the outcome of their own choice, they may begin to anticipate this effect on future trials and adapt their decisions accordingly. Our experiment was designed to analyze this effect by randomly allocating participants to two environments that we call bold and prudent (*Methods*) based on the risk attitude of the controlled counterpart. In the bold environment, the counterpart selected lotteries with higher mean returns, whereas the prudent counterpart made safe choices, selecting lotteries with lower variance. In other words, the two groups of participants were facing two different competitors: one

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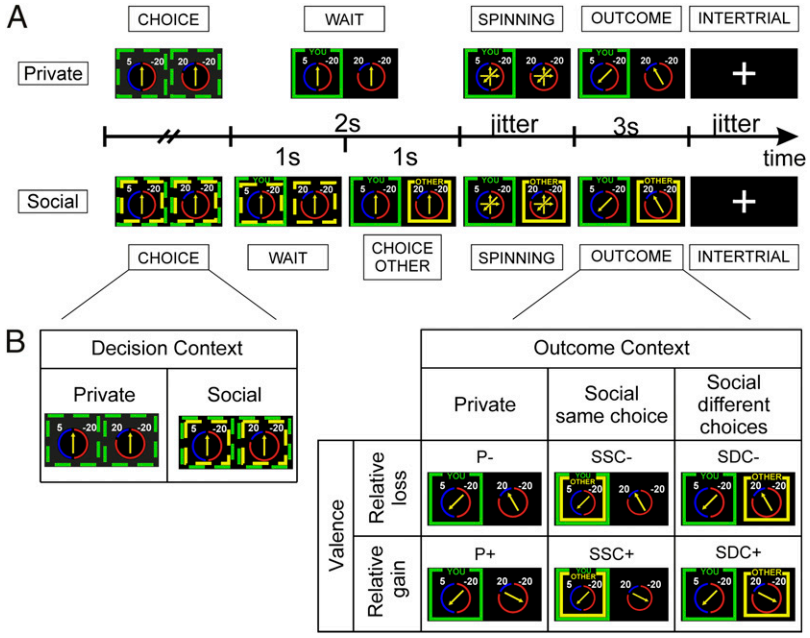

Fig. 1. Experimental paradigm. (*A*) Task and time course. The time courses of the private and social conditions are displayed above and below the time line, respectively. Pairs of lotteries were displayed, with numbers indicating the possible outcomes and probabilities represented by colored sectors of a circle. Lotteries were surrounded by green dotted squares representing the participant's possible choices, plus yellow dotted squares representing the counterpart, in the social condition only. The presence of the yellow dotted square, thus, indicated to the participant that they would see their counterpart's choice. (*B*) Experimental design. At the time of choice, the Blood-oxygen-level dependent (BOLD) signal was analyzed to test the effect of the decision context that could be private or social. During the outcome period, the BOLD signal and skin conductance data were analyzed to test the effect of two factors: valence and outcome context.

group had tough competitors, with high average payoff (bold environment), and the other group had weaker competitors, with relatively lower average earnings (prudent environment).

The theory we adopt (35) (*SI Methods*, *Theoretical Model of Choice*) predicts that sensitivity to relative social gains will motivate participants to outperform the other player, resulting in a more risky behavior, especially when playing with a competitive counterpart. Thus, a difference in participants' risky behavior in the two environments will reveal the effect of social comparison on choice; additionally, more risky behavior than their counterparts will indicate the participants' intent to outperform the others.

Results

Social Comparison Affects Choice Behavior. Participants took significantly longer to make their choice in the social context (3.97 ± 1.39 s) compared with the private context [3.82 ± 1.24 s; Wilcoxon signed rank test (WSRT), $z = 2.714$, $P < 0.01$]. The social or private nature of the comparison affects choice behavior as well. This finding is reflected in participants' attitude to risk. Regression analysis (*Methods*, Table S1, and *SI Methods*, *Logit Model*) on choice behavior over all participants ($n = 24$) and trials shows that participants chose by maximizing expected value ($dEV = 0.171$, $P < 0.001$) and were risk-neutral ($dSD = 0.003$, $P > 0.5$). We then tested whether participants' risk attitude differed between the two environments and found that there was an interaction between environment (bold and prudent) and risk attitude of participants (Environment × $dSD = 0.036$, $P < 0.05$). When the regression was run separately for the two environments, we found that participants in the prudent environment ($n = 12$) were risk-neutral ($dSD = 0.003$, $P > 0.5$), whereas participants in the bold environment ($n = 12$) were risk-seeking ($dSD = 0.039$, $P < 0.001$) (Table S1). The interaction between the variable risk and environment was not significant for the first 20 trials (Environment × $dSD = -0.041$, $P > 0.5$); thus, the two groups did not differ in risk attitude in early trials (Table S1). To control for the number of trials, we also ran the same regression on the last 20 trials. The results are very similar to those results of the regression including all trials, with a significant interaction between environment and risk (Environment × $dSD = 0.114$, $P < 0.005$). Participants adapted their choice behavior across the experiment to take into account that of their counterpart. In summary, as predicted (*SI Methods*, *Theoretical Model of Choice*), individuals in a more challenging environment became more risk-seeking.

Participants' behavioral adjustment to the behavior of their counterpart across the experiment was related to the social gains that they experienced in early trials. The difference between the participant's and their counterpart's payoffs, in early social gain events, was strongly correlated with the distance between the two players' risk behavior in late trials of the experiment ($r = 0.85$, $P < 0.001$) (Fig. 2). This distance was measured as the difference between the subject's and counterpart's *dSD* coefficients given by the logistic regression. In other words, participants who experienced greater amounts of social gain in early trials behaved in a more risk-seeking manner in subsequent trials, making choices that were likely to yield a relatively higher payoff compared with their counterpart. This relation did not hold for experienced social losses (Fig. 2) ($r = 0.34$, $P > 0.1$).

fMRI Results. ***Brain activity during outcome evaluation.*** Our hypotheses imply that both the counterfactual outcome (i.e. the outcome of the nonchosen lottery) and the outcome context (private or social) influence the way participants react to their obtained outcomes. We searched for brain regions where activity is modulated by (*i*) the comparison between the outcomes of the two lotteries, (*ii*) the outcome context, and (*iii*) the integration of these two signals. We conducted a two-way ANOVA with two factors: outcome context (three levels: P, SSC, and SDC) and valence at the time of outcome (two levels: relative loss and relative gain) (*Methods*, *Functional MRI Model*).

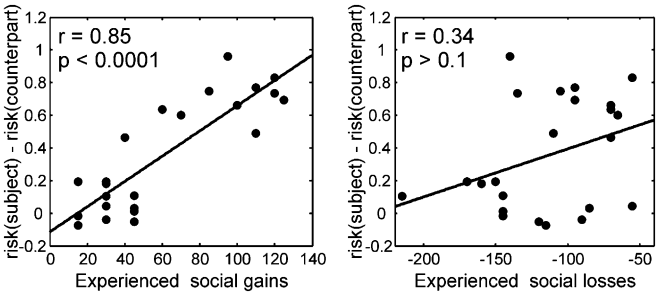

Fig. 2. Behavioral effect of experienced outcomes. (*Left*) The scatter plot represents the across-subjects correlation between the distance of subject's risk behavior to its counterpart (in sessions 2 and 3) and the cumulated experienced social gains in early trials (session 1). (*Right*) The plot shows the same correlation for the experienced social losses. The distance between the subject's and counterpart's risk attitude was computed as the difference between the subject's and counterpart's *dSD* individual coefficients given by the logit regression. In a single trial, experienced social loss and social gain were measured as the difference between the obtained outcome and the outcome of the lottery chosen by the other player. We then summed these differences to compute the total value of each experienced outcome. One data point was excluded from the two correlations analyses, because participant's risk difference score was >3 SD from the grand mean. When including the outlier, $r = 0.49$ and $P < 0.02$ for early social gains, and $r = 0.05$ and $P > 0.5$ for early social losses.

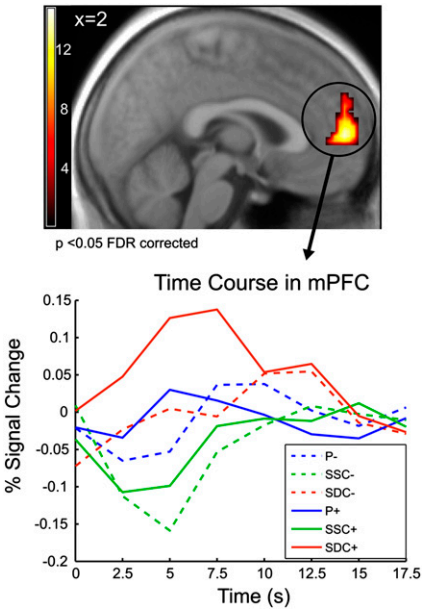

Fig. 3. mPFC activity related to social gains. (*Upper*) mPFC activity discriminates between the three outcome conditions (P, SSC, and SDC), when the outcomes of the two lotteries are revealed. *F* maps projected on the subjects' averaged brain. (*Lower*) Time course in the mPFC (0, 54, 9) for the six possible outcomes. The mPFC is more activated for social gain than for all other events.

Activity related to the valence of the relative outcomes was found (Fig. S1) in the bilateral ventral striatum [caudate and putamen; peak voxels Montreal Neurological Institute coordinates (x, y, z): left (−12, 9, −9) and right (21, 15, −3)] and the orbitofrontal cortex (0, 48, −12; Table S2 has a complete list of regions, coordinates, and statistics). In all reported clusters, activity was larger for relative gains than relative losses.

Looking at the effect of outcome context allows us to differentiate brain regions implicated in social comparison from regions involved in mere comparison of lottery outcomes. The main effect of outcome context revealed brain activity in the right ventral striatum (15, 21, −9), the medial prefrontal cortex (mPFC; 0, 54, 9), the dorsolateral prefrontal cortex (45, 21, 30), and the temporoparietal junction [TPJ; left (−45, −60, 27) and right (54, −54, 21)] (Fig. S1 and Table S2). Fig. 3 shows that activity in the mPFC (0, 54, 9) related to social gain events was greater than activity related to all other events. To test whether this difference was significant, we contrasted the social gain (SDC+) event with all five other events using an inclusive mask of the main effect of outcome context. This analysis revealed that activity related to SDC+ was indeed significantly higher than all other events in the brain regions reported above ($P < 0.001$, false discovery rate-corrected for all peak voxels). Because these regions are not activated in the SSC condition (Fig. 3), the current pattern of results suggests that they do not simply encode social vs. private context but rather, a competitive/strategic component of the interaction, with the favorable social comparison having the strongest activation.

To test whether some structures processed relative gains and losses differently in the three outcome contexts (P, SSC, and SDC), we looked at the interaction between the valence and outcome context. Several areas, including the bilateral striatum, showed an interaction between the factors valence and social context (Table S2). We extracted the percent of signal change from the striatum (*Methods*) to look at specific contrasts. The activity related to social loss (SDC−) in the ventral striatum was more intensively deactivated compared with private loss (P−) (Fig. 4*A*) [posthoc test: $F(1, 23) = 13.48$, $P < 0.001$ in left caudate and nucleus accumbens (−9, 9, −3); $F(1, 23) = 13.86$, $P < 0.001$ in right caudate and nucleus accumbens (9, 12, −3)]. Activity related to social gain (SDC+) was relatively higher compared with private gain [P+; $F(1, 23) = 4.29$, $P < 0.05$ in left caudate, not significant in right caudate]. Notably, the striatum was the only brain area that exhibited this particular pattern.

This pattern of activity closely resembles the pattern of skin conductance responses recorded during the fMRI experiment (Fig. 4*B*) and subjective ratings participants gave for each event in previous behavioral study using the same task (Fig. 4*C*). Skin conductance response (SCR) magnitudes (*Methods* and *SI Methods, Skin Conductance Recording*) in outcome evaluation depended on the outcome context (Fig. 4*B*) (Friedman test: $\chi^2 = 11.375$, $P < 0.005$); responses to relative gains and relative losses for the SDC events were more arousing than the SSC (WSRT: $z = 2.637$, $P < 0.05$) and the private events (WSRT: $z = 2.017$, $P < 0.05$). This finding suggests that the relatively larger activation (deactivation) related to social gain (loss) events compared with private gain (loss) events is associated with higher skin conductance responses.

Brain activity during choice period is influenced by outcome-related striatal activity. Our analysis of behavior has shown that past experience of outcomes in the social condition affects later behavior. We investigate the neural basis for this behavioral effect by first comparing the activity at the moment of choice in the two contexts and then examining the path from outcome-related striatal activity to choice making.

We found larger activity in mPFC in the social than private contexts during the choice period (−3, 42, 39 and 9, 54, 3). Superior temporal sulcus [left: (−63, −6, −21) and right: (54, −15, −12)], bilateral TPJ [left: (−60, −51, 21) and right: (57, −39, 18)], and precuneus (9, −48, 42) were also activated by the social condition relative to the private condition (Fig. S2 and Table S3) (no significant activity was found for the contrast private > social).

To determine whether outcome-related striatal activations influenced decision-related activity, we ran a connectivity analysis using beta seed correlations methods (*SI Methods* has a detailed description of the procedure). This analysis allowed us to find all brain voxels that had activity during the choice period correlated with the striatal activity during the previous outcome evaluation. We found that activity of the left (−9, 9, −3) and right (9, 12, −3)

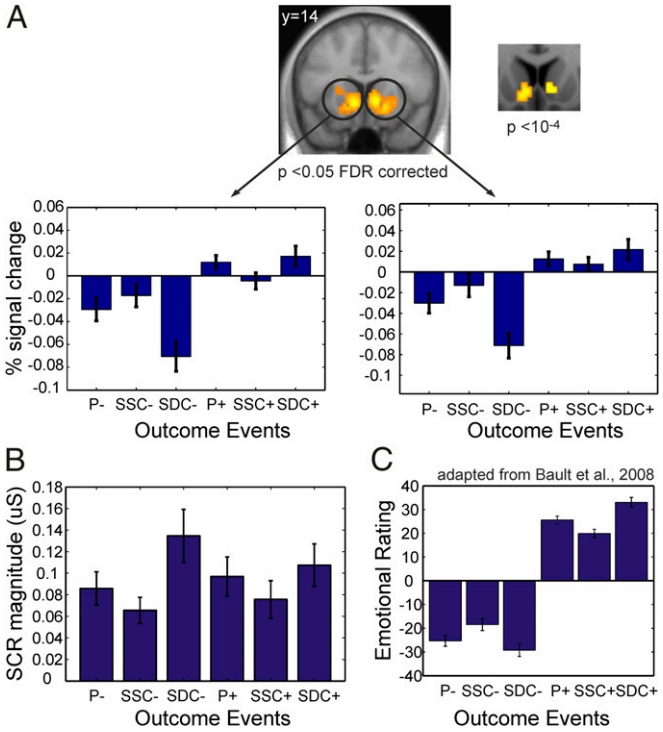

Fig. 4. (*A*) Striatal activity encoding outcomes' relative valence and outcome context during the outcome evaluation period. The coronal slice shows the interaction effect between the valence and outcome context factors. The bar graphs indicate the percent of signal change (± SEM) for the left (−9, 9, −3) and right (9, 12, −3) caudate (areas of interest defined from the interaction analysis). (*B*) Mean skin conductance responses (± SEM) for the six outcome events. Responses are reported in microsiemens. (*C*) Emotional evaluations [on a scale from −50 (extremely negative) through 0 (neither positive nor negative) to +50 (extremely positive)] given by 42 participants for the six outcome events in a previous behavioral study. Adapted from Bault et al. (41).

ventral striatum during the outcome phase correlated with activity in the mPFC during the decision phase (Fig. 5).

We also found a cross-subjects correlation ($r = 0.52$, $P = 0.01$) between activity of the mPFC (−1, 46, 30) at the time of choice and putamen activity (30, −12, −3) during outcome evaluation in social gain (SDC+) events. More specifically, participants with higher putamen activity during SDC+ events at outcome exhibited higher mPFC activity during social choices. The correlation between private gain events and private choices within the same two regions was not significant ($P > 0.05$).

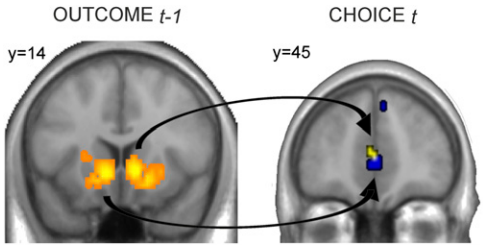

Fig. 5. Effect of experienced outcomes on choice-related brain activity. Functional connectivity analysis. The map shows the voxels where activity during the choice period *t* is correlated with activity of the striatum during the outcome evaluation of the previous trial *t* − 1. The seed regions are the left and right ventral striatum regions that showed an interaction between the factors valence and outcome context (Fig. 4*A*).

Discussion

We combined a choice task with functional brain imaging and physiological recordings to directly compare the brain activity underlying decision making in social and private contexts. More specifically, our goal was to understand how counterfactual and social comparisons influence choice. Our experimental design has two main advantages compared with previous studies. It enabled us to directly contrast private and social decision processes within a single task, and it also allowed us to study the effect of social comparisons made by subjects on their subsequent choices (hence, to study the effect of social loss and social gains on choice behavior and brain activity).

The striatum, a brain structure implicated in reward processing (18, 19), encoded both relative gains and losses and outcome context, showing amplified responses when social comparison was involved compared with the private context and same choice events. These findings support results from previous studies reporting that the ventral striatum encodes social rewards (34, 36), positive social comparison (33), social ranking (32), and emotional reaction to the misfortune of previously envied people (i.e., the feeling of Schadenfreude) (37).

In addition to the ventral striatum, we found evidence for the involvement of areas of the mentalizing network (a brain network associated with the attribution of mental states to others) (26–31), such as the mPFC and the TPJ, in relative social reward processing. Activity in these regions was driven by a favorable social comparison (social gain), signaling situations in which the participant had done better than her counterpart.

mPFC, superior temporal sulcus, TPJ, and precuneus were selectively activated during choices in the social context. Notably, in our experiment, participants interacted with their counterpart in a minimal way; it was made clear in the instructions that player's payoffs were completely independent. Despite the minimal level of interaction during decision making, the mentalizing network was strongly recruited. This finding is in accordance with the behavioral results: participants adjusted their choices to the choices of their counterpart, making choices that were likely to yield a relatively higher payoff compared with the other. Recent neuroimaging studies have suggested that the mPFC and other regions of the mentalizing network compute prediction errors of the expected behavior of others (24, 25), the uncertainty about other's strategy (38), and the level of strategic reasoning in competitive games (39). Thus, we suggest that mPFC activity at choice in our experiment is related to the strategic and competitive component of the social context and not simply to the presence of the other player.

The design of our study, in contrast to previous studies investigating social comparison (33, 37, 40), enabled us to investigate the neural underpinnings of the effect of social comparison on subsequent choices. We found that the mPFC was more activated in the social context than the private context, both at choice and outcome phases. First, mPFC activity during choice was correlated with activity in the ventral striatum during the outcome period of the previous trial. Second, mPFC activity during choice in the social context depends on how rewarding the social gain events are to the subjects, which was suggested by the across-subjects correlation between the activity of the striatum during social gains and the activity of the mPFC during choice. During outcome evaluation, mPFC activity was more specifically related to social gains. Finally, participants who experienced more social gains behaved in subsequent trials in a more competitive way, seeking more rewarding and risky options. We suggest that this coherent pattern of brain and behavior characterized the dynamical relationship between the experience and the anticipation of social rewards. Furthermore, there are some aspects of the current study that could be addressed in future work. We did not detect a significant dif-

ference between the brain activity involved in the two environments (bold and prudent). We believe that this indicates that the mental processes underlying the behavioral effect of social comparison in both environments are highly similar, but alternative hypotheses should be explored. Future work could also consider including a (nonsocial) computer condition. This condition would create nonsocial same and nonsocial different choices. These could be more directly compared with the SSC and SDC condition, because neither of these additional conditions should induce social comparison.

Crucial findings in our study are the role of the mPFC in signaling the events in which participants won more than their counterpart (social gain events) and the observation that mPFC activity was correlated with earlier activity in reward-related brain structures. These findings suggest that the brain is equipped with the ability to detect and encode social signals, make social signals salient, and then, use these signals to optimize future behavior. Specifically, the interaction between the reward and the mentalizing networks mediates the competitive component of evaluation of social outcomes and social decision making. Finally, it is important to note that such brain activity and behavior in a social context is driven more by the prospect of winning than by the prospect of losing.

Methods

Participants. Twenty-four subjects (12 females, 2 left-handed subjects, mean age = 23 ± 3.7 y) participated in the study. These volunteers gave fully informed consent for the project, which was approved by the French National Ethical Committee. Individuals with a history of psychiatric or neurological problems were not included in the study.

Experimental Procedure. Participants underwent 120 trials in three successive sessions (Table S4 has a complete list of trials). A lottery task adapted from the work of Bault et al. (41) was used with an event-related design, varying the magnitude and probabilities of potential gains and losses. Subjects repeatedly chose between two lotteries. Each lottery had two outcomes, each outcome from the set of values {−20; −5; +5; +20}. The probability of the first outcome was taken from the set {0.2; 0.5; 0.8}. The same pseudorandomized sequence of pairs of lotteries and outcomes was used for all participants. A trial could be private (60 trials) or social (60 trials). In social trials, participants were instructed that they would see the other player's choice and outcome. The order of the two types of trials was randomized inside each of the three fMRI runs. They were very similar regarding visual features and time course (Fig. 1*A*). At the beginning of the trial, two lotteries were displayed. A green dotted square surrounded the lotteries in private trials, and a yellow dotted square surrounded the lotteries in social trials, as depicted in Fig. 1*A*. The subject could choose one of the two lotteries at any time by pressing one of two buttons of an MR-compatible response box placed in the subject's right hand. After the choice, a continuous green line surrounded the lottery chosen by the individual during 2 s. In addition, in social trials, a continuous yellow line indicated the choice made by the other during 1 s. After a spinning period (4–6 s), the outcomes of both lotteries were displayed at the same time for 3 s. The participants could then compare their outcome to the outcome of the lottery not chosen (private counterfactual comparison) or to the outcome of the second player (social comparison). The outcome of a lottery chosen by both players was the same for both. The second player was a confederate of same sex as the subject. The confederate was introduced to the subject as another participant recruited in the same conditions as he had been. They went through the training part in the same room, and therefore, the participant was lead to believe that he would see the other's choice while inside the scanner. We ensured that the confederate played his role until the subject was installed in the scanner. During the experimental sessions, counterpart's choices were made by a computer algorithm. This procedure allowed us to first analyze the participant's behavior independently from the other player. It also allowed us to manipulate the environment created by the other player's choice behavior and the outcomes that the subject was facing. In one group of 12 participants (six females), the algorithm chose the lottery with the highest expected value in 90% of the trials (bold environment). This algorithm was very competitive, cumulating 206 Euros over the experiment for the given pseudosequence of outcomes, thus creating an environment in which the opponent was realizing large sums on average. In the second group of the remaining 12 participants (six females), the computer was selecting the lottery with the lowest SD in 90% of the trials (prudent environment). This second algorithm corresponded to a more prudent behavior, winning less (only 15 Euros over the 60 social trials) but with smaller variability. During debriefing at the end of the experiment, no participant reported any doubt about with whom they were playing (*SI Methods, Debriefing Questionnaires*). To avoid having participants mentally sum their earning and be able to treat trials independently, participants were told that the outcome from 20 randomly drawn trials would be sum at the end of the experiment and that they would receive this amount added to a 5 Euros show-up fee. For ethical reasons, all participants received 50 Euros, irrespective of their gains in the game.

Choice Behavior Analysis. Choice behavior was analyzed based on panel data analysis (*SI Methods, Logit Model* has more details) using the statistical software package Stata (Stata). We ran panel logit regressions, which take each participant as the unit and the trial as time, and we estimated both random and conditional fixed effects. We report the results for the random effects analysis. We estimate, with the logit regression, the probability of the participant choosing the first lottery ($c = 1$) as a function of the difference in expected value (*dEV*) and SD (*dSD*; i.e., risk) between the first and the second lottery (Eq. **1**):

$$\Pr(c = 1|dEV, dSD) = \frac{\exp[\alpha + \beta(dEV) + \gamma(dSD)]}{1 + \exp[\alpha + \beta(dEV) + \gamma(dSD)]}. \quad [1]$$

A positive and significant *dEV* coefficient indicates that subjects chose, everything else being equal, the lottery with highest expected value; a significant and positive (negative) *dSD* indicates choices of higher (lower) level of risk, and nonsignificant *dSD* indicates risk neutrality. The distance between the two players' risk behavior (Fig. 2) was measured by the difference between the subject's and the counterpart's *dSD* coefficients estimated in the logit regression.

Skin Conductance Responses. Skin conductance was continuously recorded and sampled at 50 Hz using a BIOPAC MP150 data acquisition unit (BIOPAC Systems) (*SI Methods, Skin Conductance Recording* has more details). The SCR amplitude was thresholded at 0.02 μS. SCR magnitude was calculated as the mean response amplitude computed across all trials, including trials without a measurable response. Nonparametric tests were applied on the datasets, because it violated several parametric assumptions.

fMRI: Data Acquisition, Preprocessing, and Statistical Analysis. fMRI data acquisition and preprocessing were carried out using standard procedures described in *SI Methods, fMRI Analysis*. Voxel-wide differences in BOLD contrast within the smoothed normalized images resulting from the different task conditions and trial types were examined using SPM5. Standard neuroimaging methods using the general linear model were used with the first level (individual subject analyses), providing contrasts for group effects analyzed at the second level (group analyses). No voxel showed significant activation when comparing the two environments (bold and prudent), neither during the choice period nor outcome period in the social context, even when applying a liberal threshold of $P < 0.001$, uncorrected. We, thus, merged the data from the two groups for the analyses. Two time periods were of interest for the fMRI analysis: choice and outcome. They were both preceded by a 4- to 6-s jittered period. The jitter periods and trial order were set to optimize estimation efficiency and detection power (42, 43). We introduced all four events of the trial (decision, button press, anticipatory, and outcome) in the same general linear model to attribute signal variance to all known sources of variance. The decision period was modeled as a variable epoch, time-locked to the onset of the trial, and ended with the button press indicating choice (self-paced). The button press was modeled as a δ-function. The anticipatory period was modeled with an epoch of duration of the spinning, and the outcome period started when the spinning stopped with 3-s duration. All regressors were convolved with the canonical hemodynamic response function.

fMRI Model. For choice, regressors came in two conditions: private and social (decision context) (Fig. 1*B*). For the anticipatory period, we modeled separately the P, SSC, and SDC trials. For the outcome period, trials were categorized into six events according to the condition and the relative gains (+, obtained outcome greater than outcome of the unchosen lottery) or relative loss (−, obtained outcome less than outcome of the unchosen lottery): private loss (P−), shared loss (SSC−), social loss (SDC−), private gain (P+), shared gain (SSC+), and social gain (SDC+). Eight trials could not be categorized as relative gain or loss, because the outcomes of the two lotteries were identical. These trials were not included in the analysis. Linear contrasts were

used to obtain subject-specific estimates for each regressor. These estimates were entered into a second-level analysis treating subjects as a random effect using a full factorial analysis. For the choice period, there was one factor, the decision context with two levels of private and social. For the outcome period, we tested a 3×2 factorial design (Fig. 1*B*), with the first factor representing the outcome context (P, SSC, and SDC) and the second factor representing the valence of the outcome (relative gain or loss). We report results from three contrasts, namely the main effect of the outcome context, the main effect of valence, and the interaction between the outcome context and the valence.

Activations Localization and Reported Statistics. Reported coordinates conform to the Montreal Neurological Institute space. Activations are reported as significant for clusters > 10 voxels with $P = 0.05$, corrected for multiple comparisons using voxel-wise control of the false discovery rate. Plots representing percent of signal change as well as cross-subject correlations of brain activity between brain regions were realized by extracting BOLD data for areas of interest. Areas of interest were functionally defined, based on main effect of decision and the interaction effect between outcome context and valence, for the choice and outcome period, respectively. Parameter estimates from the fitted model were extracted and averaged across all voxels in the cluster for each subject, and then, the percent of signal change was estimated. In the striatum, a small volume correction was applied using an anatomical mask to determine more precisely which parts of this region encoded the outcome context, the valence, and their interaction. For the cross-subject correlation, the mPFC area of interest was defined from the main effect of decision context, and the putamen area of interest was defined from the interaction analysis between outcome context and valence. These analyses were performed with the MarsBaR 0.41 SPM toolbox (http://marsbar.sourceforge.net/).

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Supporting Information

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SI Methods

Theoretical Model of Choice. We consider the value V when the subject chooses the act f and the alternative is g of the simple form (Eq. **S1**):

$$V(f,g) = \int_S u(f(s))dP(s) + \int_S \gamma[u(f(s)) - u(g(s))]dP(s), \quad \textbf{[S1]}$$

where S is the state set (i.e., all of the possible outcomes), P is the subjective probability on it, and u is the utility function. The theory incorporates in its second component, described by the function γ, responses to the difference between the selected and unselected acts (i.e., a counterfactual comparison). If $\gamma = 0$ (i.e., no counterfactual comparison), the subject just maximizes expected utility. The crucial property of the function γ is the relative weight of gains $[u(f(s)) > u(g(s))]$ and losses $[u(g(s)) > u(f(s))]$. In the one-player trials, the act g is the act that the subject has not chosen. In the two-player trials, g is the act chosen by the other subject, and therefore, $\gamma \neq 0$ implies social comparison. If social losses loom larger than gains, for any possible value (x) of the difference between the expected outcomes of the selected and unselected acts, $-\gamma(-x) > \gamma(x)$, and equilibria are symmetric. Theory of interdependent utilities (1, 2) predicts the same behavior for the two participants; instead, if gains loom larger than losses, $\gamma(x) > -\gamma(-x)$, the equilibria are asymmetric, and the behavior of participants should be different from the behavior of their counterpart, seeking for differences in final incomes (i.e., social gains).

Logit Model. We estimate with the logit regression the probability of the participant choosing the first lottery as a function of the difference in expected value (dEV) and SD (dSD) between the first and second lottery (Eq. **S2**) is

$$\Pr(c = 1|dEV, dSD) = \frac{\exp[\alpha + \beta(\mathrm{dEV}) + \gamma(\mathrm{dSD})]}{1 + \exp[\alpha + \beta(\mathrm{dEV}) + \gamma(\mathrm{dSD})]}. \quad \textbf{[S2]}$$

The variables dEV and dSD are defined as (Eqs. **S3** and **S4**)

$$dEV = EV_1 - EV_2 = [px_1 + (1-p)y_1] - [qx_2 + (1-q)y_2] \text{ and} \quad \textbf{[S3]}$$

$$dSD = SD_1 - SD_2 = \sqrt{p(x1 - EV_1)^2 + (1-p)(y_1 - EV_1)^2} - \sqrt{q(x_2 - EV_2)^2 + (1-q)(y_2 - EV_2)^2}, \quad \textbf{[S4]}$$

where x_1, y_1 and x_2, y_2 are the two possible outcomes of the first and the second lotteries, respectively, with $x_1 > y_1$ and $x_2 > y_2$. The probability of x_1 is p, and the probability of y_1 is $(1 - p)$. The probability of x_2 is q, and the probability of y_2 is $(1 - q)$.

Skin Conductance Recording. Two MRI-compatible Ag/AgCl electrodes were placed on the subject's left hand after cleaning with neutral soap. A constant voltage of 0.5 V was applied between the electrodes. MR artifact was removed offline by median filtering. Data from eight subjects was removed because of acquisition problems or lack of measurable responses (less than 10% of the trials with detectable responses). For the 16 remaining subjects, we considered the event-specific skin conductance responses (SCRs) as occurring between 1 s after stimulus onset and 0.5 s before the end of the event (3, 4). The SCR amplitude was thresholded at 0.02 μS. SCR magnitude was calculated as the mean response amplitude computed across all trials, including those trials without a measurable response.

Debriefing Questionnaires. Debriefing questionnaires revealed that participants believed the outcomes of lotteries were random: they answered 5.08 ± 0.27 on a scale from one (outcomes manipulated) to seven (outcomes random). They had the feeling that they were observing the choices of an actual human counterpart: they answered 5.71 ± 0.26 on a scale from one (I did not feel that I was interacting with a real human being) to seven (I strongly felt that I was interacting with a real human being). Those participants who answered four (four subjects) or less (one subject) reported that the experimental setting (being in a different room and interacting through computers) made the interaction less salient. No participant reported any doubt about with whom they were playing.

Participants were not aware of their choice behavior being influenced by their counterpart: they answered 2.79 ± 0.38 on a scale from one (not influenced at all) to seven (much influenced).

Functional MRI Analysis. ***Images acquisition.*** Functional MRI data were collected using a 1.5-Tesla MRI scanner (Magnetom Vision Plus; Siemens). Functional images were acquired using a gradient echo-planar imaging sequence (repetition time = 2.5 s; echo time = 50 ms) over three runs. Signal dropout in basal frontal and medial temporal structures because of susceptibility artifact was reduced by using a tilted plane of acquisition (30° to the anterior commissure posterior commissure line, rostral > caudal) and performing z shimming in the slice selection direction. Partial brain coverage (some of the parietal cortex was not scanned) was obtained with 29 axial slices (thickness = 3.7 mm; gap = 0.47 mm; in-plane resolution = 3.44 × 3.44 mm; 64 × 64 matrix). Echo-planar images were coregistered to a high-resolution structural T1-weighted image obtained during the same session (176 sagittal slices; thickness = 1 mm; 256 × 256 matrix). Head motions were minimized by the use of foam padding. Headphones were used to dampen the scanner noise.

Images preprocessing. Image preprocessing and subsequent analyses were performed using SPM5 (Wellcome Trust Centre for Neuroimaging) running on a Matlab platform. The first five functional volumes of each run were removed to allow for magnet stabilization. The remaining images were corrected for differences in slice acquisition time. Images were then realigned and unwarped to correct for motion artifacts. Unwarping was performed based on phase maps calculated using the Fieldmap SPM toolbox. For each participant, structural image was coregistered to the mean functional image. Structural data were normalized by matching them to the standardized Montreal Neurological Institute template, and the transformation parameters estimated in this step were applied to all functional images. Functional images were spatially smoothed with an 8-mm full width at one-half maximum Gaussian kernel before statistical analysis. High-resolution T1-weighted structural volumes from the 24 subjects were averaged together to permit anatomical localization of the functional activations at the group level.

Beta Seed correlations. Beta seed correlations analyses were performed using the methodology described by Rissman et al. (5). Separate covariates were used to model activity evoked during each stage (decision, button press, anticipatory, and outcome) of each individual trial. This first step was implemented in SPM5 in the context of a general linear model. The resulting parameter

estimates (beta values) were sorted according to the stage from which they derived from to form a set of decision-specific and a set of outcome-specific beta series. The two vectors of betas were shifted so that beta values deriving from the choice period (t) were correlated with beta values deriving from the previous trial outcome evaluation ($t - 1$). Correlation of the seed's beta series (averaged across the seed voxels) with the beta series of all other voxels in the brain was computed using Matlab 7.4 (http://www.mathworks.com), and seed correlation maps were generated. The correlation coefficients were then converted to z scores. Group-level random effects t tests were then conducted to identify voxels for which the mean of the individual subjects' transformed correlation coefficients was reliably greater than zero. False discovery rate correction for multiple comparisons was applied using routines from SPM5. All statistical maps are displayed using MRIcron.

Activations localization and reported statistics. Anatomic labeling of activated regions was done both computationally with the SPM Anatomy toolbox (version 1.5; http://www.fz-juelich.de/inm/inm-1/DE/Forschung/_docs/SPMAnantomyToolbox/SPMAnantomyToolbox_node.html) and visually by superposing the functional activations on a maximum probability atlas based on 30 subjects and containing 83 regions, based on ref. 6, in MRIcron (version 1.39, Build 4; http://www.sph.sc.edu/comd/rorden/).

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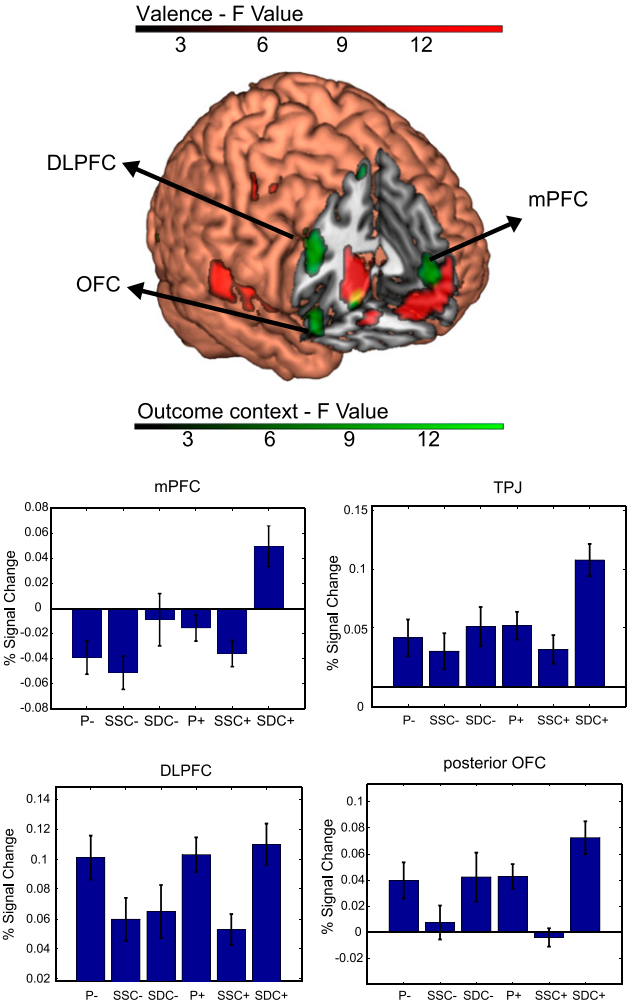

Fig. S1. Main effect of valence (red) and outcome context (green) during outcome evaluation. *F* maps projected on a canonical template brain. Red, activity related to valence (relative losses vs. relative gains) is found in the bilateral striatum (caudate and putamen) and the medial orbitofrontal cortex; green, activity within the medial prefrontal cortex, striatum, and lateral posterior orbitofrontal cortex discriminates between the three outcome conditions (private, social with same choices, and social with different choices) when the outcomes of the two lotteries are revealed. Group data (displayed at $P = 0.0005$, uncorrected) is overlaid on a 3D-rendered canonical template brain.

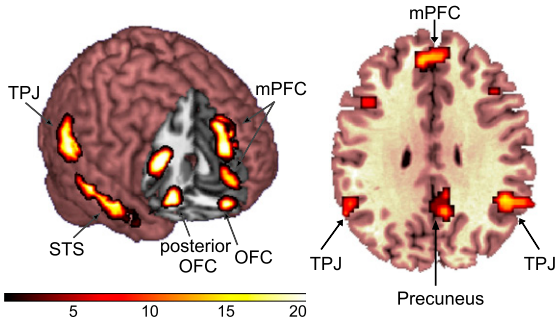

Fig. S2. Main effect of decision context during choice. *F* map projected on a canonical template brain (displayed at $P = 0.05$, corrected) for the main effect of decision context during the choice period. All regions (medial prefrontal cortex, orbitofrontal cortex, dorsolateral prefrontal cortex, superior temporal sulcus, precuneus/posterior cingulate cortex, and temporo-parietal junction) activated in this analysis were more activated in the social than the private condition).

Table S1. Panel logit regression for choice, the two groups, and the first 20 trials

					95% CI	
Variable name	Coefficient	SE	*z*	*P*	Lower value	Upper value
All subjects* (*n* = 24)						
dEV	0.171	0.015	11.74	<0.001	0.143	0.200
dSD	0.003	0.010	0.29	0.771	−0.016	0.022
Environment × *dEV*	0.035	0.021	1.65	0.099	−0.007	0.076
Environment × *dSD*	0.036	0.014	2.57	0.010	0.008	0.063
Constant	−0.059	0.042	−1.40	0.161	−0.141	0.023
Subjects in the prudent environment† (*n* = 12)						
dEV	0.171	0.015	11.74	<0.001	0.143	0.200
dSD	0.003	0.010	0.29	0.771	−0.016	0.022
Constant	−0.078	0.056	−1.39	0.164	−0.187	0.032
Subjects in the bold environment‡ (*n* = 12)						
dEV	0.207	0.015	13.430	<0.001	0.177	0.237
dSD	0.039	0.010	3.890	<0.001	0.019	0.058
Constant	−0.039	0.068	−0.570	0.567	−0.173	0.095
All subjects§ (*n* = 24) first 20 trials						
dEV	0.136	0.034	3.98	<0.001	0.069	0.203
dSD	0.009	0.023	0.38	0.701	−0.037	0.055
Environment × *dEV*	0.009	0.049	0.18	0.853	−0.086	0.105
Environment × *dSD*	−0.041	0.033	−1.22	0.221	−0.107	0.025
Constant	−0.109	0.095	−1.14	0.253	−0.296	0.078

CI, confidence interval. Log likelihood = −311.67, Wald χ^2 (3) = 7.41, and probability > χ^2 = 0.000.
*Number of observations = 2,880. Log likelihood = −1,808.06, Wald χ^2 (3) = 322.03, and probability > χ^2 = 0.000.
†Number of observations = 1,440. Log likelihood = −917.55, Wald χ^2 (3) = 141.31, and probability > χ^2 = 0.000.
‡Number of observations = 1,440. Log likelihood = −890.02, Wald χ^2 (3) = 181.19, and probability > χ^2 = 0.000.
§Number of observations = 480. Data from early trials ($t < 20$).

Table S2. Activated brain regions during the outcome period

Location	Side	Voxels	*F*	*P* (FDR corrected)	MNI coordinates		
					x	*y*	*z*
Main effect of valence							
Caudate and putamen	Left	711	88	<0.0001	−12	9	−9
Caudate and putamen	Right	1,278	58.70	<0.0001	21	15	−3
Precentral gyrus	Right	283	41.68	<0.0001	42	−12	51
Orbitofrontal cortex	—	278	26.70	0.0001	0	48	−12
Superior posterior temporal gyrus	Right	34	26.65	0.0001	36	−30	−3
Supplementary motor area	—	130	26.64	0.0001	3	−9	54
Posterior temporal lobe	Right	54	25.78	0.0001	33	−57	−15
Cerebellum	Left	265	23.97	0.0002	−9	−54	−18
Cerebellum	Right	77	21.92	0.0004	24	−84	−18
Angular gyrus	Left	53	21.65	0.0004	−39	−66	36
Cerebellum	Right	72	21.56	0.0004	33	−72	−33
Superior parietal gyrus and postcingulate	Left	376	21.51	0.0004	−15	−42	36
Precentral gyrus	Left	32	20.23	0.0007	−24	−24	57
Thalamus incl.	Left	19	20.09	0.0007	−3	−18	18
Precentral gyrus	Left	63	19.59	0.0008	−39	−15	39
Precentral gyrus	Left	91	19.56	0.0008	−57	0	12
Middle frontal gyrus	Left	72	19.44	0.0009	−27	12	42
Middle occipital gyrus	Left	14	18.80	0.0010	−15	−102	6
Superior frontal gyrus	Right	13	18.77	0.0011	21	45	45
Middle temporal gyrus	Left	25	18.56	0.0011	−57	−45	−3
Anterior orbital gyrus	Left	13	17.81	0.0014	−24	36	−9
Main effect of outcome context							
Caudate	Right	40	14.88	0.0140	15	21	−9
Superior medial frontal gyrus	—	133	14.56	0.0140	0	54	9
Inferior frontal gyrus, posterior orbital gyrus, and insula	Right	124	14.45	0.0140	48	30	−3
Inferior/middle frontal gyrus	Right	98	14.05	0.0140	45	21	30
Superior parietal gyrus	Right	14	11.81	0.0167	24	−45	24
Middle central gyrus/precental gyrus	Left	74	11.62	0.0171	−33	−3	45
Superior parietal gyrus	Left	11	10.60	0.0205	−27	−45	42
Middle occipital gyrus	Left	12	10.32	0.0226	−30	−78	27
Angular gyrus/temporal sup	Right	25	10.07	0.0247	54	−54	21
Supramarginal gyrus	Right	14	9.91	0.0265	54	−39	39
Cerebellum	Left	14	9.84	0.0270	−15	−54	−45
Middle occipital gyrus	Left	13	9.31	0.0298	−33	−78	9
Middle occipital gyrus	Right	16	9.19	0.0313	42	−75	9
Angular gyrus	Left	14	9.13	0.0317	−45	−60	27
Interaction between valence and outcome context							
Ventral striatum	Left	48	19.41	0.0009	−9	9	−3
Supramarginal gyrus	Right	35	15.18	0.0037	57	−45	33
Ventral striatum	Right	32	14.46	0.0048	9	12	−3
Angular gyrus	Right	14	13.87	0.0066	45	−48	24
Cerebellum	Left	14	12.95	0.0089	−36	−72	−51
Superior frontal gyrus	Right	14	12.53	0.0106	18	42	36

MNI, Montreal Neurological Institute.

Table S3. Main effect of decision context during the decision period

Location	Side	Voxels	*F*	*P* (FDR corrected)	MNI coordinates		
					x	*y*	*z*
Lingual gyrus, calcarine, and inferior occipital	Right	871	66.65	0.0000	12	−87	−3
TPJ (sup temporal gyrus, mid temp, angular, supramarginal)	Right	256	39.22	0.0001	57	−39	18
Posterior orbital gyrus, insula	Right	42	38.50	0.0001	27	21	−15
Superior temporal sulcus (STS)	Right	209	37.81	0.0001	54	−15	−12
Inferior frontal tri	Right	96	31.76	0.0003	42	24	24
TPJ (sup temporal gyrus, mid temp, angular, supramarginal)	Left	170	29.10	0.0005	−60	−51	21
Medial superior frontal	—	151	28.74	0.0005	−3	42	39
Medial orbital gyrus	Right	11	27.66	0.0007	9	54	−15
Mid temporal gyrus	Right	39	27.03	0.0007	48	−54	−3
Precuneus	Right	96	27.03	0.0007	9	−48	42
Mid and posterior cingulate	Left	33	25.47	0.0010	−36	18	−18
Superior medial frontal gyrus, ACC	Right	50	23.45	0.0014	9	54	3
Brainstem	—	18	20.14	0.0028	−9	−27	−6
Superior temporal sulcus	Left	11	18.24	0.0041	−63	−6	−21
Superior medial frontal gyrus	Right	11	18.09	0.0043	12	36	57
Superior temporal sulcus	Left	13	18.07	0.0043	−57	−27	−6
Inf frontal	Left	17	17.36	0.0050	−42	15	30

FDR, false discovery rate.

Table S4. Pairs of lotteries used in the experiment

Trial	Players	*p*(*x1*)	*x1*	*y1*	Outcome of lottery 1	*p*(*x2*)	*x2*	*y2*	Outcome of lottery 2	dEV	dSD	Bold counterpart's choices	Prudent counterpart's choices
1	1	0.2	20	5	20	0.5	20	−5	−5	0.5	−6.5	—	—
2	1	0.5	20	5	5	0.8	20	−20	−20	0.5	−8.5	—	—
3	1	0.2	20	5	5	0.8	20	−5	20	−7	−4	—	—
4	1	0.2	5	−20	5	0.5	−5	−20	−20	−2.5	2.5	—	—
5	2	0.5	5	−20	5	0.2	20	−20	−20	4.5	−3.5	1	1
6	2	0.8	20	−20	20	0.5	20	−5	−5	4.5	3.5	1	2
7	2	0.5	5	−20	−20	0.2	5	−5	−5	−4.5	8.5	2	2
8	2	0.8	20	−5	20	0.5	20	5	5	2.5	2.5	1	2
9	2	0.8	20	−5	20	0.2	20	5	5	7	4	1	2
10	1	0.2	20	−20	−20	0.5	5	−20	5	−4.5	3.5	—	—
11	2	0.5	−5	−20	−5	0.2	5	−20	−20	2.5	−2.5	1	2
12	2	0.5	20	−5	20	0.2	20	5	5	−0.5	6.5	2	2
13	1	0.2	5	−20	−20	0.8	−5	−20	−5	−7	4	—	—
14	1	0.5	20	−5	20	0.8	20	−20	20	−4.5	−3.5	—	—
15	1	0.2	20	−20	20	0.5	−5	−20	−20	0.5	8.5	—	—
16	1	0.2	5	−5	−5	0.5	5	−20	5	4.5	−8.5	—	—
17	1	0.5	20	5	5	0.8	20	−5	20	−2.5	−2.5	—	—
18	1	0.5	−5	−20	−20	0.2	20	−20	−20	−0.5	−8.5	—	—
19	1	0.8	−5	−20	−5	0.2	5	−20	−20	7	−4	—	—
20	2	0.8	20	−20	−20	0.5	20	5	20	−0.5	8.5	2	2
21	2	0.5	−5	−20	−5	0.2	20	−20	−20	−0.5	−8.5	2	1
22	2	0.8	−5	−20	−5	0.2	5	−20	−20	7	−4	1	1
23	2	0.5	20	5	5	0.8	20	−20	−20	0.5	−8.5	1	1
24	1	0.8	20	−20	20	0.5	20	−5	−5	4.5	3.5	—	—
25	2	0.2	20	5	5	0.8	20	−5	20	−7	−4	2	1
26	2	0.2	20	−20	20	0.5	−5	−20	−20	0.5	8.5	1	2
27	2	0.2	20	−20	−20	0.5	5	−20	5	−4.5	3.5	2	2
28	1	0.5	5	−20	−20	0.2	5	−5	−5	−4.5	8.5	—	—
29	2	0.2	5	−20	−20	0.8	−5	−20	−5	−7	4	1	2
30	1	0.8	20	−5	20	0.2	20	5	5	7	4	—	—
31	2	0.2	20	5	5	0.5	20	−5	20	0.5	−6.5	1	2
32	1	0.5	−5	−20	−5	0.2	5	−20	−20	2.5	−2.5	—	—
33	1	0.8	20	−5	−5	0.5	20	5	20	2.5	2.5	—	—
34	2	0.5	20	−5	−5	0.8	20	−20	20	−4.5	−3.5	2	1
35	2	0.5	20	5	20	0.8	20	−5	20	−2.5	−2.5	2	1
36	2	0.2	5	−5	−5	0.5	5	−20	−20	4.5	−8.5	1	1
37	1	0.5	5	−20	−20	0.2	20	−20	20	4.5	−3.5	—	—
38	1	0.5	20	−5	−5	0.2	20	5	20	−0.5	6.5	—	—
39	1	0.8	20	−20	−20	0.5	20	5	5	−0.5	8.5	—	—
40	2	0.2	5	−20	−20	0.5	−5	−20	−5	−2.5	2.5	2	2
41	1	0.2	5	−5	−5	0.5	5	−20	5	4.5	−8.5	—	—
42	2	0.8	−5	−20	−5	0.2	5	−20	−20	7	−4	1	1
43	2	0.8	20	−5	20	0.5	20	5	5	2.5	2.5	1	2
44	2	0.8	20	−5	20	0.2	20	5	5	7	4	2	1
45	2	0.5	20	−5	20	0.2	20	5	5	−0.5	6.5	2	2
46	1	0.5	20	5	20	0.8	20	−20	−20	0.5	−8.5	—	—
47	2	0.8	20	−20	20	0.5	20	−5	−5	4.5	3.5	1	2
48	1	0.2	20	5	5	0.5	20	−5	20	0.5	−6.5	—	—
49	1	0.5	20	−5	−5	0.8	20	−20	20	−4.5	−3.5	—	—
50	2	0.8	20	−20	20	0.5	20	5	5	−0.5	8.5	2	2
51	2	0.5	5	−20	5	0.2	20	−20	−20	4.5	−3.5	1	1
52	2	0.5	−5	−20	−20	0.2	20	−20	20	−0.5	−8.5	2	1
53	1	0.5	20	5	20	0.8	20	−5	−5	−2.5	−2.5	—	—
54	2	0.5	5	−20	5	0.2	5	−5	−5	−4.5	8.5	2	2
55	1	0.2	5	−20	−20	0.8	−5	−20	−5	−7	4	—	—
56	2	0.5	−5	−20	−20	0.2	5	−20	5	2.5	−2.5	1	1
57	2	0.2	20	−20	−20	0.5	−5	−20	−20	0.5	8.5	1	2
58	1	0.2	20	5	5	0.8	20	−5	20	−7	−4	—	—
59	2	0.2	5	−20	−20	0.5	−5	−20	−5	−2.5	2.5	2	1
60	1	0.2	20	−20	−20	0.5	5	−20	5	−4.5	3.5	—	—
61	1	0.2	5	−20	−20	0.5	−5	−20	−20	−2.5	2.5	—	—
62	1	0.2	20	−20	−20	0.5	−5	−20	−5	0.5	8.5	—	—

Table S4. Cont.

Trial	Players	$p(x1)$	$x1$	$y1$	Outcome of lottery 1	$p(x2)$	$x2$	$y2$	Outcome of lottery 2	dEV	dSD	Bold counterpart's choices	Prudent counterpart's choices
63	2	0.5	20	5	20	0.8	20	−20	−20	0.5	−8.5	1	1
64	1	0.8	20	−5	20	0.2	20	5	5	7	4	—	—
65	1	0.5	−5	−20	−20	0.2	20	−20	20	−0.5	−8.5	—	—
66	1	0.8	20	−20	20	0.5	20	−5	−5	4.5	3.5	—	—
67	2	0.2	20	5	20	0.5	20	−5	−5	0.5	−6.5	1	1
68	1	0.8	−5	−20	−5	0.2	5	−20	−20	7	−4	—	—
69	2	0.2	20	5	5	0.8	20	−5	20	−7	−4	2	1
70	2	0.2	20	−20	20	0.5	5	−20	−20	−4.5	3.5	1	2
71	1	0.5	5	−20	5	0.2	20	−20	−20	4.5	−3.5	—	—
72	1	0.5	−5	−20	−5	0.2	5	−20	−20	2.5	−2.5	—	—
73	1	0.5	5	−20	−20	0.2	5	−5	−5	−4.5	8.5	—	—
74	1	0.8	20	−20	−20	0.5	20	5	20	−0.5	8.5	—	—
75	2	0.5	20	5	5	0.8	20	−5	20	−2.5	−2.5	2	1
76	1	0.5	20	−5	20	0.2	20	5	5	−0.5	6.5	—	—
77	2	0.2	5	−5	5	0.5	5	−20	−20	4.5	−8.5	2	1
78	1	0.8	20	−5	20	0.5	20	5	20	2.5	2.5	—	—
79	2	0.2	5	−20	−20	0.8	−5	−20	−5	−7	4	2	2
80	2	0.5	20	−5	−5	0.8	20	−20	20	−4.5	−3.5	2	1
81	2	0.5	5	−20	5	0.2	20	−20	−20	4.5	−3.5	1	1
82	2	0.5	−5	−20	−20	0.2	5	−20	−20	2.5	−2.5	1	1
83	2	0.5	−5	−20	−20	0.2	20	−20	20	−0.5	−8.5	2	1
84	1	0.5	20	5	5	0.8	20	−20	20	0.5	−8.5	—	—
85	1	0.2	5	−20	−20	0.8	−5	−20	−5	−7	4	—	—
86	1	0.2	5	−5	−5	0.5	5	−20	−20	4.5	−8.5	—	—
87	2	0.5	5	−20	5	0.2	5	−5	−5	−4.5	8.5	2	2
88	1	0.2	20	−20	−20	0.5	5	−20	5	−4.5	3.5	—	—
89	2	0.8	−5	−20	−5	0.2	5	−20	−20	7	−4	1	1
90	1	0.2	20	5	5	0.8	20	−5	20	−7	−4	—	—
91	2	0.8	20	−5	20	0.2	20	5	5	7	4	1	2
92	1	0.2	20	5	5	0.5	20	−5	20	0.5	−6.5	—	—
93	1	0.5	20	−5	−5	0.8	20	−20	20	−4.5	−3.5	—	—
94	2	0.8	20	−20	−20	0.5	20	5	5	−0.5	8.5	2	2
95	2	0.8	20	−20	20	0.5	20	−5	20	4.5	3.5	1	1
96	2	0.5	20	−5	−5	0.2	20	5	20	−0.5	6.5	1	1
97	1	0.2	5	−20	−20	0.5	−5	−20	−5	−2.5	2.5	—	—
98	1	0.2	20	−20	20	0.5	−5	−20	−20	0.5	8.5	—	—
99	1	0.5	20	5	5	0.8	20	−5	20	−2.5	−2.5	—	—
100	2	0.8	20	−5	−5	0.5	20	5	20	2.5	2.5	1	2
101	2	0.5	20	−5	−5	0.8	20	−20	20	−4.5	−3.5	2	1
102	1	0.8	20	−5	20	0.5	20	5	5	2.5	2.5	—	—
103	2	0.2	20	−20	−20	0.5	−5	−20	−5	0.5	8.5	1	2
104	2	0.2	5	−5	−5	0.5	5	−20	−20	4.5	−8.5	1	1
105	1	0.8	−5	−20	−5	0.2	5	−20	−20	7	−4	—	—
106	1	0.8	20	−20	20	0.5	20	−5	−5	4.5	3.5	—	—
107	2	0.2	20	5	5	0.8	20	−5	20	−7	−4	2	1
108	2	0.5	20	5	20	0.8	20	−5	−5	−2.5	−2.5	2	1
109	1	0.5	5	−20	−20	0.2	5	−5	5	−4.5	8.5	—	—
110	2	0.2	20	−20	−20	0.5	5	−20	5	−4.5	3.5	2	2
111	2	0.2	20	5	5	0.5	20	−5	20	0.5	−6.5	1	1
112	2	0.2	5	−20	−20	0.8	−5	−20	−5	−7	4	2	2
113	2	0.5	20	5	20	0.8	20	−20	−20	0.5	−8.5	2	1
114	1	0.5	5	−20	5	0.2	20	−20	−20	4.5	−3.5	—	—
115	1	0.5	−5	−20	−5	0.2	5	−20	−20	2.5	−2.5	—	—
116	1	0.8	20	−20	−20	0.5	20	5	20	−0.5	8.5	—	—
117	2	0.2	5	−20	−20	0.5	−5	−20	−5	−2.5	2.5	2	2
118	1	0.8	20	−5	20	0.2	20	5	5	7	4	—	—
119	1	0.5	−5	−20	−5	0.2	20	−20	−20	−0.5	−8.5	—	—
120	1	0.5	20	−5	20	0.2	20	5	5	−0.5	6.5	—	—

The column Players is equal to one for a private trial and two for a social trial. $x1$ and $y1$ are the two possible outcomes of lottery 1. $p(x1)$ is the probability of $x1$ [$p(y1) = 1 - p(x1)$]. $x2$ and $y2$ are the two possible outcomes of lottery 2. $p(x2)$ is the probability of $x2$. dEV is the difference between the expected values of lotteries 1 and 2. dSD is the difference in SD (risk) between the two lotteries.