Social Neuroscience

ISSN: 1747-0919 (Print) 1747-0927 (Online) Journal homepage: http://www.tandfonline.com/loi/psns20

# TV programs that denounce unfair advantage impact women's sensitivity to defection in the public goods game

Seongmin A. Park, Soyeong Jeong & Jaeseung Jeong

**To cite this article:** Seongmin A. Park, Soyeong Jeong & Jaeseung Jeong (2013) TV programs that denounce unfair advantage impact women's sensitivity to defection in the public goods game, Social Neuroscience, 8:6, 568-582, DOI: 10.1080/17470919.2013.835280

**To link to this article:** http://dx.doi.org/10.1080/17470919.2013.835280

SOCIAL NEUROSCIENCE, 2013
Vol. 8, No. 6, 568–582, http://dx.doi.org/10.1080/17470919.2013.835280





# TV programs that denounce unfair advantage impact women's sensitivity to defection in the public goods game

**Seongmin A. Park[1,2,3], Soyeong Jeong[4], and Jaeseung Jeong[1,2]**

[1]Graduate School of Culture Technology, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Republic of Korea
[2]Department of Bio and Brain Engineering, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Republic of Korea
[3]Cognitive Neuroscience Centre, CNRS, UMR 5229, Bron Cedex, France
[4]Department of Economics, Ewha Womans University, Seoul, Republic of Korea

We explore the neural underpinnings of gender differences in cooperation and their modulation by intensive media watching. We compared cooperative decisions and electroencephalograph data between genders from who participated in repeated rounds of the public goods game (PGG) and investigated within groups changes that occurred after watching a TV program known as "investigative reporting" that denounces unfair advantages taken by free-riders against the public. Women tended to be more cooperative than men during early rounds of PGG, mostly because they react differently to the defection of others; women also had greater $\beta$ and $\gamma$ band activity in regions estimated to be associated with social cognition. These gender differences disappeared after participants watched the TV programs: women were more likely to choose free-riding in response to the defection of others that elicits significant increases in $\gamma$ band activities that were estimated to be right insula. Greater activity in social cognition leads women to make decisions considering the motives of others, while men tend to make a decision by complying with the social norm. Watching the investigative TV reports produced a greater negative emotion to the defection and led women, in a similar manner as men, to opt for a "tit-for-tat" strategy.

***Keywords:*** Social decision; Gender difference; Game theory; EEG; Insula.

A central problem in the provision of public goods is the presence of free-riders. A cooperative contribution by a member increases the group's benefit; however, all of the members in a group receive the same benefits, regardless of the amount of individual contribution. Greed invites free-riding, or the expectation of taking advantage without any contribution to the public good. It is unclear which motivations make humans decide to cooperate and at which point they change their strategy. Previous studies suggest that a human decision to cooperate is conditional; cooperation is maintained as long as the other people cooperate, and when the expectation of mutual contribution is violated by the defection of one member, the other members

Correspondence should be addressed to: Jaeseung Jeong, Department of Bio and Brain Engineering, Korea Advanced Institute of Science and Technology (KAIST), 373–1 Kuseong-dong, Yuseong-gu, Daejeon 305-701, South Korea. E-mail: jsjeong@kaist.ac.kr

The authors gratefully acknowledge Dr. Dongil Chung (Virginia Tech Carilion Research Institute) for sharing his knowledge on the EEG data analyses and for his helpful comments on the manuscript. This work was supported by grants from the Korea Science and Engineering Foundation (KOSEF) and grants funded by the Korea government [grant number M10644000005-06N4400-00510], [grant number R01-2007-000-21094-0], [grant number M10644000013-06N4400-01310]; Korea Creative Content Agency (KOCCA)/Ministry of Culture, Sports and Tourism (MCST) [grant number 210-7602-003-10743-01-007]; and Seoul Metropolitan Office of Education.

The authors declare that there were no competing financial interests.

conclude that their defection is also legitimate. When one must make a decision under a given social situation, the social norm guiding what should be the standard influences individual members' opinions and decisions (Fehr & Fischbacher, 2004; Ostrom, 2000). For a decision to cooperate, this social norm is known as reciprocity and has explained human behavior in a number of situations (Fehr & Fischbacher, 2004; Fehr & Gächter, 2000a, 2000b, 2002; Fehr, Fischbacher, & Gächter, 2003).

The motives underlying human cooperation and free-riding within a group have been investigated using the public goods game (PGG). Specifically, PGGs repeated with the same people allow us to assess strategic decisions in terms of participants' sensitivity to social norm violation, loss of sensitivity, and perspective-taking (Camerer, 2003; Chung, Kim, & Jeong, 2013; Chung, Yun, Kim, Jang, & Jeong, 2011; Rand, Dreber, Ellingsen, Fudenberg, & Nowak, 2009). In the PGG, a decision to cooperate is made based on the expectation of mutual benefit. However, when the cooperators judge that their partners do not have the intention to cooperate anymore, this strategy changes to free-riding to avoid the risk of losing their contribution. These iterated PGG studies have consistently reported that the cooperation rate gradually decays after the first round of the game and reaches a plateau after a certain number of iterations (Andreoni, 1988; Fehr & Gächter, 2000a; Isaac, Walker, & Williams, 1994). Andreoni has demonstrated that there is no significant behavioral learning effect in the PGG. He showed that the cooperation rate rose again in a new PGG among participants who have experienced with this game, despite their cooperation rate had been gradually decayed (Andreoni, 1988).

Men and women differ when making decisions related to cooperation; this difference has been reported in several experimental games, especially in those that use the PGG or the prisoners' dilemma game, which is designed to investigate the decision of two persons to cooperate or defect. However, results have been controversial. Some studies reported that men are more cooperative than women (Mack, Auburn, & Knight, 1971; Rapoport & Chammah, 1965), while other studies showed the opposite result (Frank, Gilovich, & Regan, 1993; Sibley, Senn, & Epanchin, 1968; Tedeschi, Hiester, & Gahagan, 1969). The cooperative motive is modulated during repeated experiments; indeed, previous studies found that the higher rate of cooperation in women in early rounds disappeared over time (Cadsby & Maynes, 1998; Ortmann & Tichy, 1999). Previous studies suggest that different settings in the experimental design that incur different social cues could lead one gender group to be more cooperative during decision-making than the other gender group; similarly, different settings could result in increased other-regarding motives. Specifically, the motive underlying cooperation tends to be more modulated by social cues in women than in men (Croson & Gneezy, 2009; Gilligan & Attanucci, 1988). Under the PGG settings, the threshold rule states that cooperative contributions are wasteful until the amount of mutually contributed funds reaches a certain threshold; this rule led women to be more cooperative during early rounds of PGG than men (Cadsby & Maynes, 1998). On the other hand, the cooperation among men increased when the cooperation rate of their group was competitive with that of others (Van Vugt, De Cremer, & Janssen, 2007), which suggests that men tend to comply more with social norms than women. We hypothesized that the different tendencies to cooperate in the different genders might stem from a different role played by social cognition networks that influence how to assess the intention of a partner to cooperate in the face of free-riding by others. However, whether and how the different cerebral activity drives the gender differences in the decision to cooperate has not been directly investigated.

The public media shapes viewers' priorities in social agendas and influences the options considered when solving a variety of issues (Eveland & Shah, 2003; McCombs & Shaw, 1972; Yanovitzky & Stryker, 2001). Specifically, the television genre known as "investigative reporting" plays the role of a watchman and determines whether fair contributions have been made toward public goods. These programs, which include "60 minutes" on CBS, "Panorama" on BBC, and "20/20" on ABC, denounce free-riders and the unfair advantages that they gain by deceiving the public (De Burgh, 2008; Ettema, 2007). The effects of investigative TV reporting on viewers have been studied over the past several decades. Previous empirical studies have shown that viewers of investigative reporting became more sensitive to violations of social norms, especially when those social norms relate to the agenda that was broadcasted (Leff, Protess, & Brooks, 1986; Protess et al., 1987; Protess, Leff, Brooks, & Gordon, 1985).

The media influences the shaping of viewers' social norms. We expect that an investigative TV program will make viewers expect a high gain in the PGG by high cooperation from all members of a group who watched the same TV programs. However, in PGGs repeated with the same team members, this higher expectation should incur a greater prediction error if participants notice free-riding by other group members. The viewer might become sensitive to the free-riders when they estimate a person's intention to cooperate in the following round. Our first question was

whether gender differences exist in the cooperation rate in the PGG. Our second question was whether investigative TV programs influenced the decision-making of either gender preferentially. If an interaction effect was detected between the two factors (viewing investigative TV × gender), our next questions would be whether the influences were exerted overall or only during specific rounds of the PGG and whether these effects occurred in response to the outcome or to decisions made by other members. We hypothesized that the media impacts women (whose decision is initially based more on empathy to others) more than men (whose decision conforms more to social norms). To examine the gender differences in the neural basis of decisions to cooperate, we compared the behaviors of both genders and their corresponding electroencephalography (EEG) spectra while they made decisions in the PGG; we also examined how the EEG spectra were modulated after watching the TV programs that report on the violations of social norms in the real world.

# METHODS

## Participants

A total of 60 undergraduate students were recruited using an advertisement on the local community website. Twenty-seven of these students were randomly selected and asked to participate in the EEG experiments. The subjects who did not appear to watch the programs attentively were excluded through a questionnaire (see the section on stimuli). Finally, data from 53 participants were used in the study (mean age = 23.76 ± 2.21 years, M:F = 25:28; the number of validated subjects for the EEG experiment was 26; M:F = 12:14). The number of subjects is described in Table S1 in the supplementary materials.

Each of the subjects participated in the PGG with three other members (four-member groups). One of the four participants participated in the EEG recording while performing the PGG with the other subjects (M:F = 24 (19): 20 (19), 11 groups). In addition, to acquire a sufficient number of EEG data sets, an additional 16 (15) participants (M:F = 6:10 (9)) were recruited to play with three other gender-matched partners under identical experimental conditions. The participants received a monetary compensation for completing the experiment, which could be increased in accordance with the result of an individual's PGG. This condition made subjects fully motivated to make decisions that maximized their own value.

All of the participants were right-handed and had normal or corrected-to-normal vision. Based on the self-reported questionnaire, none of the participants had a history of neurological or psychiatric disorders. Written informed consent was obtained from all of the participants, and the use of human participants and experimental procedures was reviewed and approved by the KAIST Institutional Review Board (KH2008-01) and the code of ethics of the World Medical Association (Declaration of Helsinki) (Rickham, 1964).

## The decision sets of confederates

The decisions of the three other partners were decided in advance. We decided that their decisions should be the same as the decision made by the previous behavioral participants who were on one of the 11 teams of the first group and played the PGG with the 11 other subjects whose EEG signals were recorded.

## The public goods game

As illustrated in Figure 1A, we used a 10-round iterated version of the PGG with a threshold and binary provision in the current study. The iterated PGG design with a threshold has been used successfully with many variations (Bagnoli & McKee, 1991; Cadsby & Maynes, 1999; Dawes, Orbell, Simmons, & Van De Kragt, 1986; Isaac, Schmidtz, & Walker, 1989; Rapoport & Eshed-Levy, 1989). All subjects had been given an instruction on their possible decisions and others', and they were also noticed that four players participated in the PGG as a group, but they were not allowed to see other players. As a group, they were asked to complete 10 rounds with identical partners. The players were also fully aware of the 10 finite repetitions. It allows us to investigate the changes in one's strategic decisions by updating their estimation on others' cooperation intention (Camerer, Ho, & Chong, 2002; Gibbons, 1992; Osborne & Rubinstein, 1994). At the beginning of each round, each member received $1 as an endowment for the game. The endowment was provided via two cards that were endorsed with an actual amount of money ($0 and $1) on one side. PGG play was repeated multiple times among the same set of players. Contrary to one-shot games, our iterated design of the PGG put the participants' decisions in social contexts. The participants' decisions may not be driven purely by self-interest, but may also be driven by perspective-taking behaviors (Camerer, 2003; Chung et al., 2013; Fehr et al.,

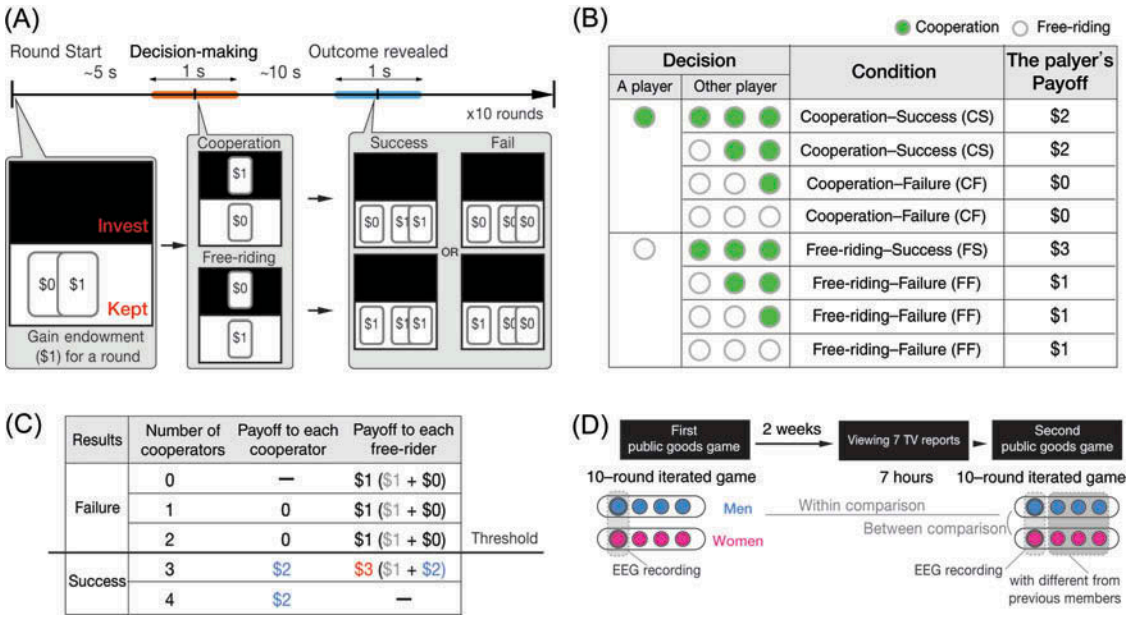


**Figure 1.** (A) A sample round of the PGG and the possible decisions. The orange and blue areas indicate the epochs that were used for the EEG analysis. (B) The payoff matrix shows the possible outcomes and conditions of a player's decision in the PGG. (C) The PGG paradigm used in the current study specifically shows the threshold that was used to decide the earnings from the group fund. Based on the knowledge (B and C) learned before the PGG, the players were able to predict their partners' decisions. (D) The overall procedure of this study indicates that the same gender group of subjects participated twice in the public goods game (PGG) and in the investigative TV reporting presented before the second PGG.

2003; Fehr & Fischbacher, 2004; Fehr & Gächter, 2000b; Rilling et al., 2002; Rilling, Sanfey, Aronson, Nystrom, & Cohen, 2004). "The binary provision" required the players to decide between two options during the game: the participant could invest the full $1 of the endowment (cooperation) or keep the $1 and invest $0 (free-riding). Using these cards, the players participated in the PGG while having real monetary stakes in the outcome, and they notified the dealer (experimenter) of their decisions by holding up one of the two cards. The threshold determined whether the investment was a success. If the total number of contributors exceeded 3 (the stated minimum), each player received an equal amount of the payoff ($2). If the threshold was not reached, the players' contributions were not returned (Figure 1B). In line with the definition of public goods, benefits from these public goods were provided to all members in the group, including free-riders who did not contribute his/her endowment to the group. This version of PGG allowed us to gain enough data from subjects while they experienced violations of social norms. To ensure that players were sufficiently motivated to make real decisions reflecting their own self-interest, they were paid actual earnings after the PGG. Figure 1C illustrates the possible contextual conditions in the PGG and their resulting outcomes.

## The investigative TV reporting

After initially playing the PGG, the participants were instructed to watch an investigative TV news series entitled "In Depth 60 Minutes," a well-known, nationally televised series produced by the Korean Broadcasting System (KBS). We selected seven 1-hour episodes that had been broadcasted 3 years prior to the experiment. We presented reports that specifically denounced the unfair advantages that free-riders obtain from society (see the supplementary materials for detailed contents of the TV reports). Videos of the episodes were presented without editing and were projected (NEC NP2000) onto a TV screen (size, 200 × 150 cm). We confirmed that the participants had never seen any of the seven episodes of the investigative TV reports. To confirm that they watched the TV programs attentively, we asked them to answer three questions about the content of each program.

## Experimental procedure

The overall procedure is illustrated in Figure 1D. The decisions of individuals to cooperate or free-ride were recorded twice during a 10-round iterated PGG. Between the two administrations of the PGG, the

participants were asked to attentively watch the investigative TV programs. The participants did not know until the second PGG that they would be required to complete the second test. For both of the PGGs, four individuals of identical genders who were not acquainted with each other were assigned to each group. Prior to the PGG, the participants learned the rules of the PGG, and their understanding of the game rules was fully tested by asking them about the appropriate payoffs under different conditions. During the PGG, the gaze of each participant was restricted to one direction to reduce the potential influences of facial expressions. Two weeks after the first PGG, the participants were asked to watch the investigative TV reports in a dark room with other participants through a screen (the number of viewers ranged from 4 to 12). Seven TV reports were presented over 2 days in a random order for a total of 7 hours. Four TV reports were presented on the first day, and three TV reports were presented on the following day.

To examine the influence of investigative TV reports on the decision to cooperate or free-ride, we scheduled another PGG. Four of the participants who had watched all of the TV reports were immediately invited to participate in the PGG. We confirmed and notified the participants that the new group consisted only of individuals who had not played with any of the other participants in the previous PGG. In addition, we assigned groups so that all of the participants had an equal waiting time before their second PGG. The participants played the PGG under identical conditions as those used in the previous PGG. The participants knew that their partners had also watched the same investigative TV reports. No information about their partners' decisions or their partners' gains from the previous PGG was given to the participants at any time. To avoid any potential confounding, no communication between participants was allowed during the experiment.

## Behavioral analysis

We first compared the cooperation rates of the participants in each round by gender in the PGG using the Wilcoxon rank-sum test. Next, the effect of gender on the overall time point (each round of an iterated PGG) of the PGG was compared using a two-way analysis of variance (ANOVA). A player in an iterated game will have to consider the impact of their current decision on the future decisions of other players, a process known as reputation. The player's decision also depends on the histories of other players that help to predict other people's intention to cooperate (Camerer et al., 2002; Osborne & Rubinstein, 1994). Therefore, to investigate changes in decision-making and the motivations underlying the group's intention to comply with or violate social norms, the cooperation rates in each round were collapsed according to the previous earnings. A two-factor ANOVA was used to reveal the potential influences of investigative TV reporting on changes in decision-making. We used "the earnings in the previous rounds" as an index to distinguish the participants' previous choices and their results, as follows (Figure 1C): \$0 means that a person chose cooperation but failed to obtain the group reward (CF); \$1 means that a person decided to free-ride and the group failed to obtain the group reward (FF); \$2 means that a person's cooperation was reciprocated by others to successfully obtain the group reward (CS); and \$3 means that, despite free-riding, the group successfully obtained the group reward (FS). The effect of media may be revealed more in interaction with the context of the PGG. This analysis allows us to investigate whether the gender and media effects on an agent's motives to cooperation when his/her decision is based on a strategy such as the "tit-for-tat" that indicates ones' cooperation decision depends on the previous cooperative actions of other partners, and changes to free-riding in response to the decreases in the cooperation rates of others). All of the statistical comparisons were performed with SPSS 15.0 software (IBM cooperation, Armonk, NY, USA).

## EEG data acquisition

To determine which neural substrates are correlated with cooperation or free-riding behavior under the influence of investigative TV reporting, we recorded a continuous EEG from one participant of each group during both PGG sessions. The same subjects participated in the two EEG recordings. Participants who took part in the EEG recording were asked to press separate buttons using their right index fingers only. For decision-making, a keypad with three buttons was used (contribution for the first button; free-riding for the second button), and the participants were asked to notify that they were ready to confirm each outcome (the third button). The results of each round of payoff were revealed immediately after the third button was pressed. This scenario was performed to record the exact timing of the start of a reaction epoch for the EEG recording and analysis.

A Neuroscan EEG recording system was used (Compumedics, Charlotte, NC, USA) with a cap of 32 electrodes (Ag/AgCl Quick cap, Compumedics). Standard electrode sites were used in the study,

following the international 10–20 system nomenclature (Jasper, 1958). An extra electrode, Fz, was used between FP1 and FP2 as a ground. Eye movement and blinking were recorded by monitoring vertical and horizontal electrooculogram (EOG) activity. The impedances of all of the electrodes were kept below 5 KΩ. EEG data were digitized at a sampling frequency of 1000 Hz and amplified with a 32-channel SynAmps2 amplifier (Compumedics). Eye movement artifacts and 55–60 Hz electricity noise were removed using an independent component analysis, and artifacts were removed by visual inspection. EEG data were filtered using a band pass of 0.5–100 Hz and a notch of 55–60 Hz. We used STIM2 hardware (Compumedics) to record the exact timing of decision-making (i.e., pressing a button), the revelation of the outcome, and the reaction to the payoff result. The STIM2 hardware produced time cues whenever buttons were pressed at the corresponding point in the EEG data. The EEGs recorded during the PGG were classified into four different oscillation bands according to frequency, as follows: 4–7 Hz as the $\theta$ band, 8–12 Hz as the $\alpha$ band, 13–30 Hz as the $\beta$ band, and 30–50 Hz as the $\gamma$ band. These measurements were related to decision or reaction times in the EEG and recorded when the participants pressed the button response box.

## EEG time/frequency and power spectrum analysis

Event-related spectral perturbation (ERSP) has been utilized in EEG time–frequency analyses to assess event-related spectral amplitudes, phase, and coherence perturbations in EEG data sets (Pfurtscheller & Aranibar, 1979). The digitized signals were analyzed using a fast wavelet transformation (Schiff, Aldroubi, Unser, & Sato, 1994). To examine changes in brain dynamics engendered by the execution of cooperation or free-riding, 6 s windows of the EEG epoch were trimmed as follows: the *reaction epoch* included 1 s of the recorded EEG that precedes the outcome revelation, followed by 5 s at each trial of the PGG; the *decision epoch* included 3 s preceding the decision-making and 3 s following each trial of the PGG. We estimated and visualized ERSPs to determine the significant changes in the EEG oscillations of the participants in both the reaction epochs and the decision epochs, given knowledge of the previous outcomes. Significant ERSPs for the 30 channels were determined by Bootstrap distributions. A significance level of $\alpha = 0.001$ was applied for the Bootstrap distributions provided by EEGLAB v.6.03 (www.sccn.ucsd.edu/eeglab) (Delorme & Makeig, 2004). In addition, the EEG power spectra in 30 single electrodes were compared to examine changes in the power of spectral patterns of the participants' EEGs that occurred at each frequency band during performance. Significant changes were analyzed with a two-way ANOVA, with factors such as the PGG time point and the gender of the participant ($p < .005$, uncorrected).

## EEG source localization

We estimated the source of EEG activity changes during a 2-s segment: the reaction epoch lasted until 2 s after the participant confirmed the outcome and the decision epoch lasted until 2 s after the subjects had made a decision. The standardized low resolution electromagnetic tomography (sLORETA; Pascual-Marqui et al., 1994) was utilized to estimate the intracranial current density ($\mu A/mm^2$) distribution in a three-dimensional brain model (see the supplementary methods). We created cross-spectra EEGs for 26 participants and compared the spectra within a gender group (PGG before and after viewing the TV reports) and between gender groups (PGG at an identical time point between males and females) to identify the corresponding cortical sources of neuronal oscillations for each frequency band. Each frequency band of the cortical source was then compared across the extracted decision and reaction epochs of the PGGs using the statistical nonparametric mapping (SnPM) program provided in the sLORETA software package. We used the $F$-test analysis method to reveal significant behavioral changes that occurred after watching investigative TV reporting. Electrode/voxel-wise normalization and 5000 permutation randomizations with no smoothing for SnPM were also used. The statistical significance was set to $p < .05$.

# RESULTS

## Behavior

The 10-round iterated PGG typically lasted 5 min. The participants earned statistically similar amounts for both rounds (an average of \$7.10 ± 0.99 from the first PGG and \$7.70 ± 0.87 from the second PGG). The mean cooperation rates of 45.40% (before, standard error of the mean (SEM) = 0.021)) and 41.91% (after, SEM = 0.021)) for the two PGGs were not significantly different (one-way ANOVA; $F = 2.402$; $p = .122$). We attempted to understand the influence of the media by examining the effect of the gender × trial

of the PGG (round) interaction. The cooperation rates for the periods before and after the viewing of the TV reports were categorized by three criteria and compared.

First, the influence of the media on each round of the PGG was compared for the different genders. We found that, during the initial PGG, women cooperated more in the early rounds (round 1, 2, 3, and 4) of the game than men ($p < .05$, Wilcoxon rank-sum test; Figure 2A). This difference was no longer significant in later rounds of the game. However, after viewing the investigative TV reports, the decisions to cooperate in women significantly decreased, and the significant gender differences observed in the first PGG disappeared for all rounds of the second PGG ($p > .05$).

Second, to investigate the effect of the media on the overall cooperation rate, we compared the accumulated cooperation rates in the periods before and after the viewing of the TV reports for within-gender groups (cooperative decisions across all rounds in each PGG). We found that the females opted to cooperate less frequently after watching the reports than before (two-way ANOVA; $F = 1.390$; $p = .008$). However, the effect of the gender × media interaction on the overall cooperation rate was not significant (between-gender comparisons; $F = 2.146$; $p = .203$).

Third, we categorized the decisions according to the strategies (decisions made in response to earnings made in a previous round) to investigate whether the TV reporting specifically influences a decision made in response to specific conditions. This method was inspired from previous empirical studies where subjects made decisions for iterated rounds conducted with the same partners; these studies indicated that the economic decisions influenced by the defection (or free-riding) of another subject made in the current round can be attributed to the outcome of the previous round (Camerer et al., 2002; Osborne & Rubinstein, 1994). In this type of PGG, the earnings in the previous round also reflect previous decisions made by the participant and the consequences of those decisions. To investigate whether and how much the gender, media, and the interaction between the two influence the decision to cooperate under each of the four types of conditions, another series of two-way ANOVA analyses was performed. We found that the interaction of gender × media only had a significant effect on the decision under the "cooperation–failure (CF)" condition; the probability of cooperating in round $N$ was significantly reduced for the women who contributed their goods at round $N - 1$, but noticed that their contributions became wasteful due to the actions of free-riders (the effect of the gender × media interaction; $F = 0.839$; $p = 4.847\text{E-}06$). As illustrated in

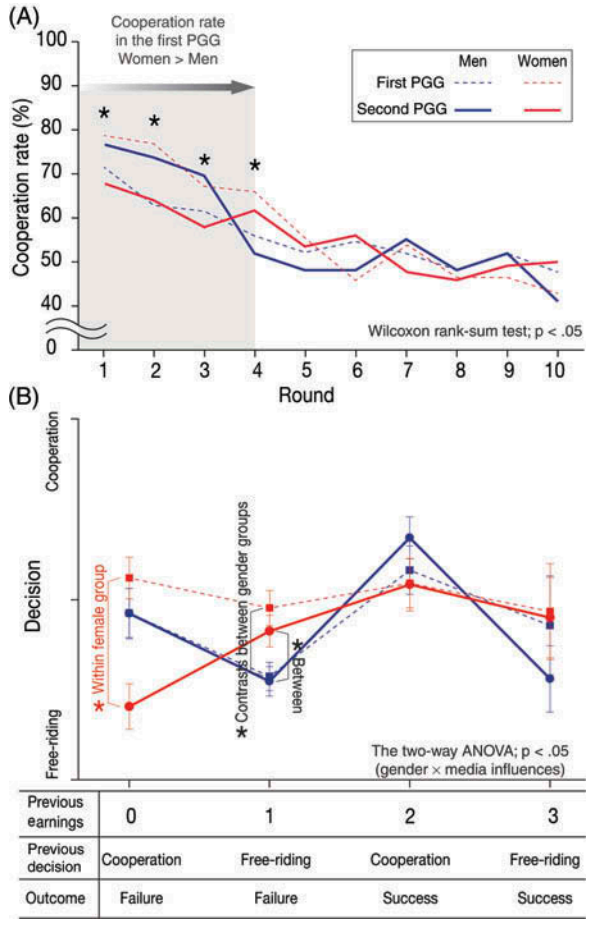


**Figure 2.** The rate of cooperation in men (blue) and women (red) during the first (dashed line) and second PGG (bold line), which was performed after the viewing of the investigative TV reports. (A) shows the changes in cooperation rates of each group within the round, highlighting the consistent decays in the cooperation rate of the four groups and the significantly higher rate of cooperation in early rounds in women than in men during the first PGG (Wilcoxon rank-sum test, $p < .05$). (B) The cooperation decision data were collapsed according to members' and previous decision and consequence outcomes. The results show the influence of investigative TV reporting on the female viewers' strategy (less cooperative in the case of the violation of their expectation in group earning, the Cooperation–Failure (CF) condition).

Figure 2B, we found a significant decrease in the mean cooperation rate of the women viewers (from 56.00% (SEM = 0.058) to 20.32% (SEM = 0.063)) after viewing the TV reports ($F = 0.677$; $p = 1.288\text{E-}09$), while the cooperation rates of the men were not significantly changed (from 46.30% (SEM = 0.068) to 46.15% (SEM = 0.070)) ($F = 0.675$; $p = .566$). We also found that when a decision was made after a subject noticed their cooperation rate fail to reach the threshold level in the previous round which was also due to his/her previous free-riding decision (the free-riding – failure condition), men and women tend to make different

decisions: in both PGGs, women changed from free-riding to cooperation significantly more often than men when they noticed the failure to obtain mutual benefits. Men tended to maintain their free-riding strategy regardless of the results. The cooperation rate during the PGG conducted before the TV reporting viewing was 27.30% for men (SEM = 0.032) and 49.25% (SEM = 0.052) for women ($p$ = 2.372E-04); these rates changed to 29.75% (SEM = 0.037) for men and to 45.73% (SEM = 0.084) for women ($p$ = 6.289E-04) after the viewing of the investigative TV programs. No significant effects of interactions, gender, or media were found under any conditions. This result indicates that female cooperators changed to free-riding after realizing that their previous contributions had been exploited; these tendencies were significantly enhanced by viewings of the TV reports. The numbers for the data classified according to each outcome case are shown in Table S2.

## EEG analysis results: response epoch

*EEG time/frequency and power spectrum changes*

We estimated and visualized ERSPs to test for significant changes in the EEG oscillations of the participants during both of the reaction epochs. Significant ERSPs for the 30 channels were determined by Bootstrap distributions ($\alpha = 0.001$). The average powers of all 30 channels with significant ERSPs in the time–frequency domain are shown in Figure 3. The responses of the participants who noticed the CF outcome are illustrated in Figure 3; their contributions became wasteful due to the small number of contributors of their group and the failure to obtain a reward. We compared the significant ERSPs from before and after the viewing of the investigative TV reports. The color of each image pixel indicates the power (dB) at a given frequency and the latency relative to the time-locked event of the grand means of all 30 channels. The ERSPs that were not significant are marked with a zero in the time frequency charts.

We found that stronger $\gamma$ band activities following the females' reaction to failed cooperation (at 0 ms) peaked within 500 ms of the outcome revelation after viewing the TV reports. The male participants, on the other hand, had increased $\gamma$ band activities within 500 ms during the first PGG, but these activities dwindled after viewing the TV reports. We computed regional differences between the two gender groups in each of 30 electrodes. A comparison using an independent $t$-test showed significant differences in ERSPs measured within 6 s of the revelation of the CF outcomes before and after viewing the TV reports (Figure 3). The significant ERSPs measured when subjects were making their subsequent decision after noting the CF outcome are shown in Figure 4.

## Single electrode comparisons

To investigate the effects of the interaction between time point and gender on the absolute EEG power ($\mu V^2$), the mean power in the $\beta$ and $\gamma$ bands at each electrode was compared for the reaction epochs (6 s). We found that watching the TV reports significantly decreased the power in both of the frequency bands in the female participants. Specifically, the power in the $\beta$ band decreased in the bilateral temporal areas of the females after the viewing of the TV reports. Differences in the $\gamma$ band power between the two genders were also greater in the early reaction period prior to the viewing of the reports ($p < .05$, uncorrected).

## EEG source distributions

To examine how alterations in EEG oscillations related to behavioral changes in our female participants under the CF condition, we trimmed the brain activity for 2 s from when the outcome was revealed and compared this segment for the periods before and after the viewing of the TV reports using sLORETA. To compare gender differences, we also estimated the differences in the current densities in the male participants. Identical durations were compared for the before and after conditions with $F$-statistic analyses for independent groups performed with 5000 randomizations. All of the other segments that had absolute increases or decreases in activity were not statistically significant ($p < .05$).

A between-group comparison (female–male) of EEG data showed significantly lower activations in the brain regions that are implicated in the theory of mind (TOM), including the right temporal parietal junction (TPJ), the right inferior parietal lobule (iPL), and the right precuneus (Gallagher & Frith, 2003; Lieberman, 2007) (see Table S4). On the other hand, there was no significant difference in the EEG activations recorded after watching the TV reports between the genders (see Table S3).

Within-group comparisons suggested that significantly more oscillations in both the $\beta$ and $\gamma$ bands came from the right insula and the right middle temporal gyrus (mTG); in addition, these oscillations were significantly more activated in women after the viewing of the TV reports. However, no significant

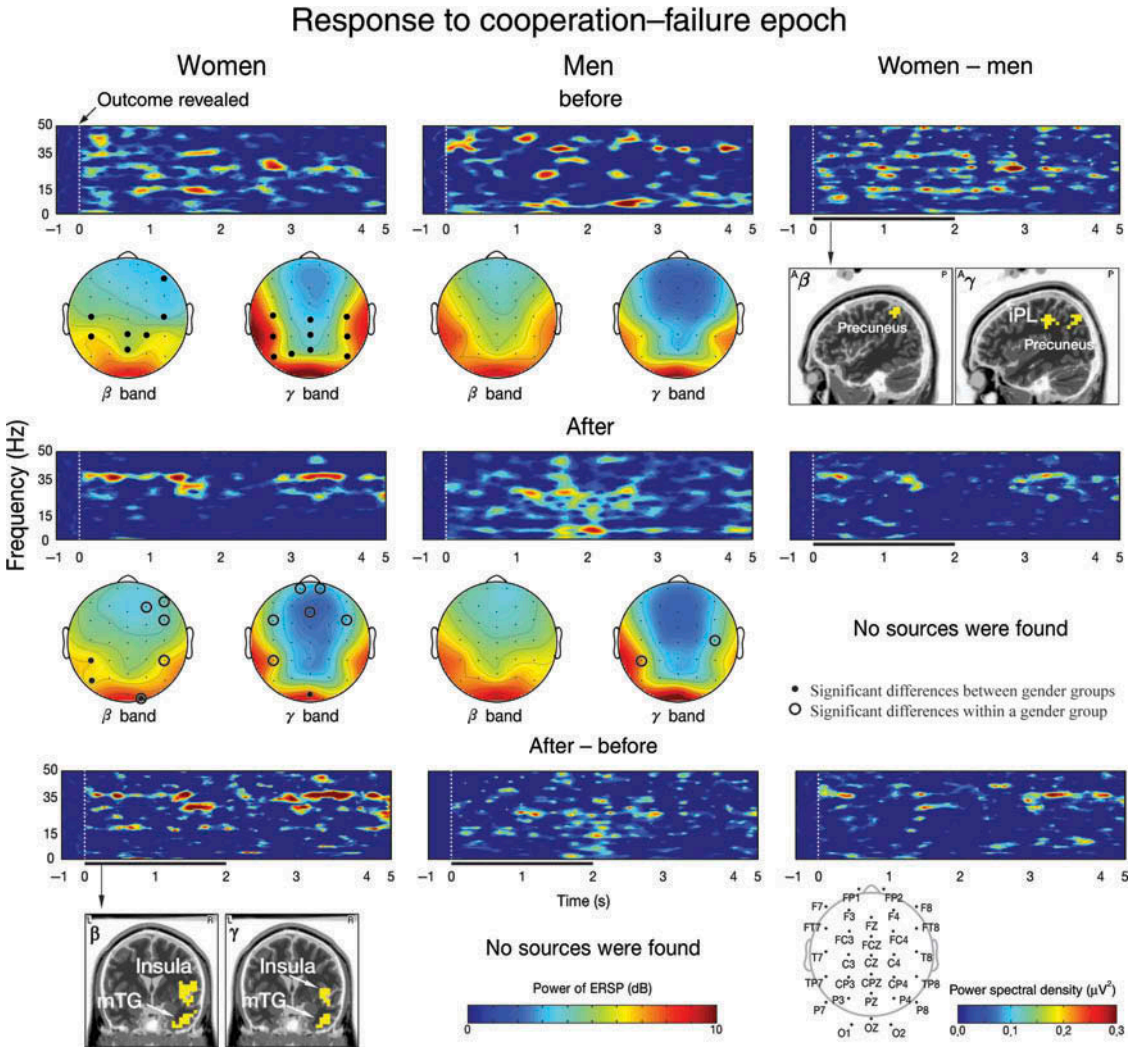


**Figure 3.** The results of the time–frequency analysis of brain activity modulated during the response epochs (6 s). The grand means of the significant ERSPs from 30 electrodes were visualized across the frequency range (significance levels of $p < .005$ were computed by Bootstrap distributions, and statistically *nonsignificant* ERSPs were masked with a zero). The between-gender group comparisons of the cortical activity of the male and female participants based on the time–frequency analysis before (top panel) and after (middle panel) viewing the investigative TV reports (right panel), and the within-gender group comparisons (bottom panel) were calculated by the grand mean subtractions. The power ($\mu V^2$) distribution patterns were calculated based on the EEG signals over the participants' scalps. The electrodes showing significant EEG power differences for the between- (closed circle) and the within-group (open circle) comparisons were marked on the scalps (two-way ANOVA; $p < .05$). The sLORETA-based SnPM shows the cortical source where significant differences in current density values ($\mu A/mm^2$) were estimated through between- and within- group comparisons. Brain areas estimated as eliciting significantly more activity are colored in yellow, and those eliciting significantly less activity are colored in blue and in the corresponding band frequency ($p < .05$; iPL, inferior parietal lobule; mTG, middle temporal gyrus).

change in the activity was observed in the reaction epochs of the male participants (see Table S4).

## EEG analysis: decision epoch

*EEG time/frequency and power spectrum changes*

The same analyses used for the reaction epochs were performed for the ERSPs acquired for the decision epochs (6 s including 3 s before and after the decision). The significant ERSPs for the 30 channels were determined and averaged ($\alpha = 0.001$; Figure 4). To assess the ERSP patterns elicited during decision-making, we computed ERSPs separately for the cooperative and free-rider conditions. The amplitudes of the $\gamma$ bands were higher in females who maintained their contribution after the CF outcome and had seen the TV reports than in females who had not seen the TV reports; the EEG amplitudes of the males

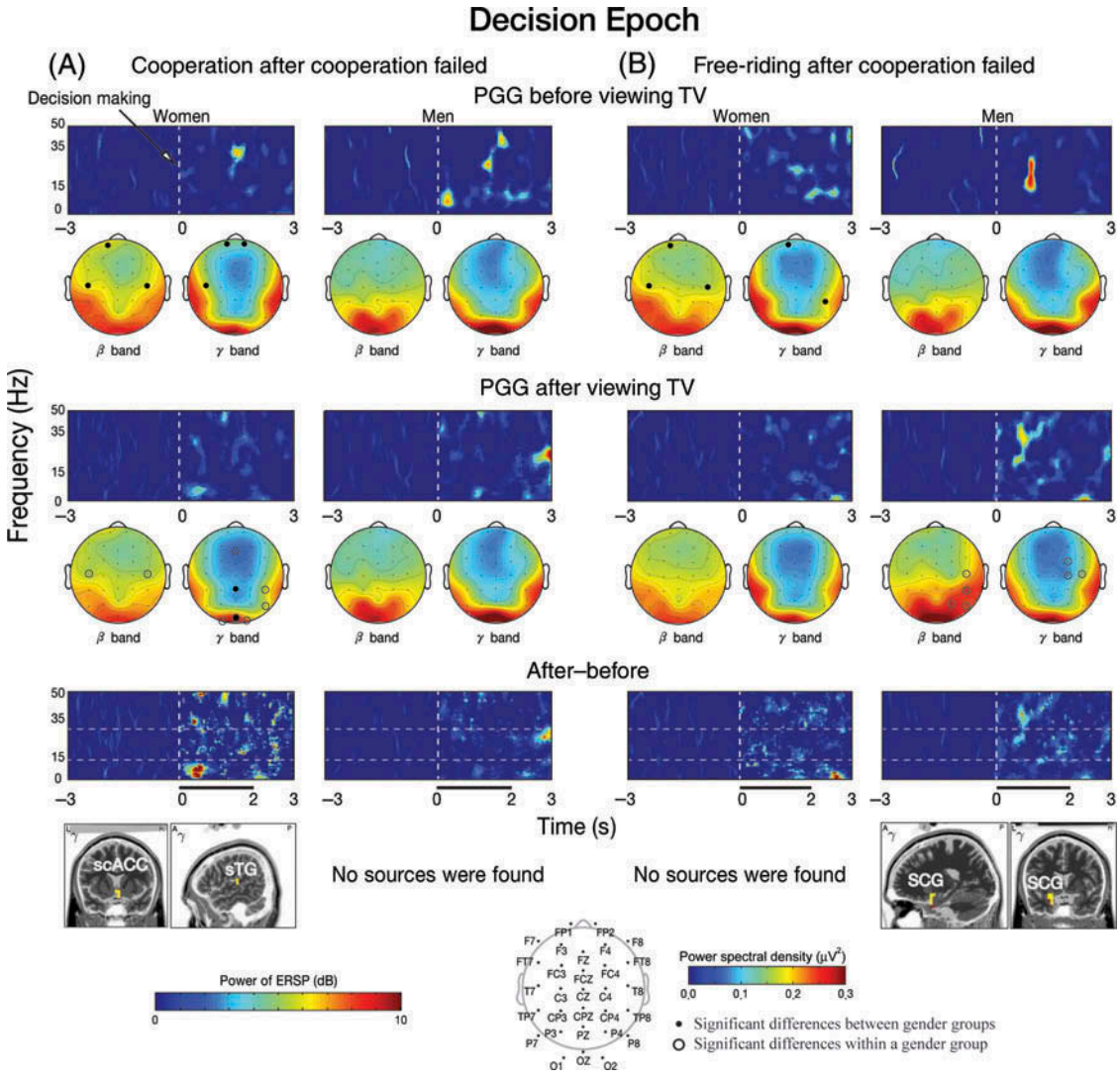


**Figure 4.** The analysis used in Figure 3 was performed here with different decision epochs (6 s) of the PGGs for the different genders and decisions in a given round: (A) for cooperation and (B) for free-riding. The results show the grand means of the significant ERSPs ($p < .005$); the power ($\mu V^2$) distribution patterns were calculated based on the EEG signals measured over the participants' scalp ($p < .05$), and the sLORETA-based SnPM shows the cortical sources where significant differences in current density values ($\mu A/mm^2$) were estimated for within- and between-group comparisons during specific periods at the marked frequency band ($p < .05$; mFG, middle frontal gyrus; scACC, subcallosal anterior cingulate cortex; sTG, superior temporal gyrus; iPL, inferior parietal lobule; SCG, subcallosal gyrus).

did not differ significantly (Figure 4A). The changes in the ERSP after decisions to free-ride were reduced after subjects had watched the TV reports. The peak increases in the male free-riders in the second PGG were elicited 300 ms later than the peak in the first PGG (Figure 4B).

## Single electrode comparisons

Separate analyses were conducted for decision epochs (6 s) depending on whether the participants decided to cooperate or free-ride. Within-participant contrasts by time point revealed that the TV reports influenced EEG power only for the female viewers. Significant increases were observed in the power of both types of frequency bands in the prefrontal cortex when women chose to cooperate in the second PGG. Gender differences were also observed during the initial PGG after a decision was made to free-ride, as the power of the bands was lower in the second PGG ($p < .05$, uncorrected).

## EEG source distributions

EEGs from the period 2 s after a decision was made in each trial after the participants were notified of

the CF outcome were analyzed by decision. After deciding to cooperate, the $\gamma$ band activity estimated to come from inside the subcallosal anterior cingulate cortex (scACC) and the superior temporal gyrus (sTG) increased in women. The source of activity could not be identified in the within-group comparison of the men. When women decided to free-ride, no significant changes in the source of the activity could be found. However, in the male free-riders, we observed significantly increased $\gamma$ oscillation activations thought to come from the subcallosal gyrus (SCG) (see Table S5).

## DISCUSSION

We found that more women decided to cooperate than men. In each round of the PGG, we found that women tended to cooperate more in the early rounds of the PGG; however, this cooperation decayed in a manner similar to that observed in men, which is consistent with previously observed behavioral patterns (Cadsby & Maynes, 1998). Evolutionary studies have explained that gender differences in social preferences in decision-making result in a higher level of cooperation in women; women tend to prioritize their inter-personal relationships more than men, who are more likely to conform with social norms and are more sensitive to norm violations (Gilligan, 1977). Recent findings suggest that women care about the impacts of their decisions on others more than men, which is observed as greater activation of the regions of the brain implicated in social cognition (Schulte-Ruther, Markowitsch, Shah, Fink, & Piefke, 2008; Toussaint & Webb, 2005). Women felt more empathetic pain, even the pain is given to their previous uncooperative partner, while men were more likely to gain rewards instead (Singer et al., 2006). Another study found a relationship between testosterone and decisions made with less regard for others; males with elevated testosterone levels who were offered less generous terms in the ultimatum game were more likely to pay the cost of punishing their partners who proposed less generous offers to them (Burnham, 2007; Zak et al., 2009).

Our results indicate that the gender predilections to cooperate in the PGG could be due to different susceptibilities to the violation of social norms by free-riders. When the PGG was played before the viewing of the TV programs, significantly greater EEG power in the $\beta$ and $\gamma$ bands was elicited in women when they noticed the CF outcome. This gender difference was also confirmed by the electrodes that were localized in the central and temporal areas for the $\beta$ band and in the temporal areas for the $\gamma$ band. The $\beta$ band activation in the temporal areas has been reported to be associated with emotional processing, and the activation of the parietal areas with high frequency bands has been shown to be associated with the processing of emotional or cognitive information (Ray & Cole, 1985). The oscillations in the $\gamma$ band in the parietal and occipital areas have been found to be associated with attention to affective stimuli (Keil, Gruber, & Müler, 2001; Müler, Gruber, & Keil, 2000). We estimate that the sources of the gender-related differences in the EEG are the TPJ, the iPL, and the precuneus. These regions of the brain are known as "the mirror area of social cognition" and are activated when the perspectives of others are considered (Frith & Frith, 2007; Gobbini, Koralek, Bryan, Montgomery, & Haxby, 2007; Van Overwalle, 2009). In previous economic game studies, activity in the iPL has been associated with the cognitive demands of perspective-taking for subsequent decision-making (Rilling et al., 2002). Our results show that women recruit the social cognition networks more than men in response to the defection of another person. Taken together with behavioral differences, at first, we speculate the activation leads women to make a decision with more regard for the motives of others and it makes them requires more trials to ascertain another person's intention. The second possible speculation is that women tend to be reluctant to make free-riding decisions because of the potential impact of their decision on other potential cooperators. On the other hand, our results suggest that the decisions made by men are more associated with the reciprocal rules that their decision is determined by previous decisions of their partners.

Under our PGG design, the CF outcome provokes a negative emotion for two reasons: first, it is the only outcome that causes a loss in the current PGG paradigm (a negative monetary prediction error); second, the participants' expectation of a reciprocal contribution is violated by the other person (negative social prediction error). Previous studies showed that the direct violation of reciprocity and the destabilization in trust between group members not only causes a strong negative emotion but also significantly influences one's subsequent decisions (Dupré, 1987; Fehr & Gächter, 2002; Pillutla & Murnighan, 1996; Tzieropoulos, De Peralta, Bossaerts, & Andino, 2010; Xiao & Houser, 2005). For example, a negative emotion leads to the decision to punish free-riders, even if this action incurs a cost (Van't Wout, Kahn, Sanfey, & Aleman, 2006).

The PGG that we used in this study was "the complete information game," which indicates that all participants had relevant information associated with a decision and knew that the other people also had knowledge of the game (Camerer, 2003; Gibbons, 1992; Osborne & Rubinstein, 1994). All of

the participants knew that the other people had also watched the same investigative TV reports. The investigative TV reporting watched in this study emphasized the equity of sharing the resources of a group (De Burgh, 2008; Ettema, 2007). We had speculated that the content of the TV program might cause the women to expect that the other participants would make decisions in compliance with social norms (e.g., to cooperate in the PGG). The expectation of cooperation could have caused women to become more vulnerable to exploitation by free-riders. The influence of the investigative TV program could incur larger disappointment and faster decisions to free-ride (to avoid being exploited) in women who had higher expectations of reciprocal contributions after watching the TV program (Fehr et al., 2003; Fehr & Fischbacher, 2004; Fehr & Gächter, 2000b). This approach represents a strategic decision known as the "tit-for-tat strategy." Under this strategy, decisions to cooperate are influenced by the cooperation of other participants in the previous round of PGG. The decision to free-ride can serve as a signal to other free-riders to consider reciprocity and represents a way for women to express their negative emotions.

Our EEG results support that the underlying motives behind the tit-for-tat type of free-riding decisions that could stem from the greater negative emotion incurred by the defection of other participants. When we conducted the within-gender group comparison of EEG powers to examine the influences of investigative TV reporting, we observed increases in the power of the $\gamma$ band only for women viewers; these increases were significant in the electrodes located in the posterior and right temporal areas. We estimated that increases in the $\gamma$ oscillation in the brains of women who were notified of the CF outcome were produced by activation in the right insula. This region is known to be associated with negative emotional states (Calder, Lawrence, & Young, 2001) and with autonomic arousal (Critchley, Elliott, Mathias, & Dolan, 2000). In a social cognition domain, the insula also plays a role in detecting violations of social norms (King-Casas et al., 2008) and is associated with the processing of emotion for social interactions (Couto et al., 2012; Lamm & Singer, 2010). Corresponding EEG results suggest that the decrease in cooperative behaviors observed in females might stem from greater negative emotive reactions to the CF outcome.

In the real world, we often make cooperative decisions as a member of a group of strangers to increase the overall benefits of the group. The group members contribute, expecting mutual benefit and reciprocal contributions. A series of behavioral studies was conducted to investigate the dynamics of cooperation and free-riding in the PGG (Andreoni, 1988; Bagnoli & McKee, 1991; Cadsby & Maynes, 1999; Chung et al., 2011; Fehr & Gächter, 2000a; Isaac et al., 1994; Marwell & Ames, 1979; Rapoport & Eshed-Levy, 1989), and persistent gender differences in cooperation have been reported (Brown-Kruse & Hummels, 1993; Cadsby & Maynes, 1998; Nowell & Tinkler, 1994; Ortmann & Tichy, 1999; Van Vugt et al., 2007). However, the motives underlying these gender differences are still debated, and little is known about the neural underpinnings that drive the gender differences in decisions to cooperate. Providing both behavioral and EEG results, we found that the propensity to cooperate in women may stem from different processes in the region of the brain associated with social cognition and with predicting the intentions to cooperate of other members based on their previous decisions. We speculate that women tend to use more social cognition brain networks to understand others or the influence of their decision on others, while the decisions of men are conditionally determined by the decisions of others. We found that the differences in both behavioral and brain activity levels in response to the free-riders among men and women disappeared after the viewing of the investigative TV reports. In addition, we demonstrated the influence of the media on the decision to cooperate. The increases in both the free-riding and the $\gamma$ band oscillation considered to come from the insula in response to the defections of partners indicate that women became more sensitive to their loss and to the violation of social norms.

Here, we suggest that the gender differences in deciding to cooperate stems from different social preferences and that the decision to cooperate is more malleable by context in women, which is consistent with previous findings (Croson & Gneezy, 2009; Gilligan & Attanucci, 1988). We extended these behavioral findings to neuroimaging by comparing the EEGs of subjects who chose to cooperate and those who chose to free-ride; we also compared the EEG data of men and women. We found that the gender difference is caused by the differential activation of social brain regions in response to the defection of another person. Specifically, the response of a subject to another subject's decision significantly determines their future decision when they interact repeatedly with the same partners. Our results had limitations: we could not conclude whether fewer cognitive processes observed during the decision epochs stemmed from less cognitive and affective processing or from the failure to time lock due to individual differences. In future studies, a punishment option could be considered to clarify whether the increases in free-riding came from the negative emotion (Brandt, Hauert, & Sigmund, 2003; Fehr et al., 2003; Fehr & Fischbacher, 2004; Fehr & Gächter, 2000a, 2000b, 2002). Because we performed

the two PGGs with different partners and because a previous study showed that there was no learning effect from the previous PGG (Andreoni, 1988), we assumed that there was no learning effect from the first PGG. Despite this limitations, our results strongly support the hypothesis that a subject's judgment of the intention to cooperate of other participants and their resulting decisions are determined by previous outcomes; as a result, a computational model-based approach to understanding how the brain updates the prior outcomes and the judgments of the decisions of others and how it leads to behavioral differences in decision-making within a group should be used (O'Doherty, Hampton, & Kim, 2007).

Relatively few studies have used the EEG in association with decision-making, even though it provides high temporal resolution data that are acquired under environments of real human interaction (Fallani et al., 2010; Yun, 2013). Although we could not acquire EEG data on all of the participants that would show the interaction between brains, to the best of our knowledge, this study is the first investigation to determine the neural underpinnings of decision-making in the PGG using the EEG and the influences of public media on viewers' decisions to cooperate. More specifically, the EEG source localizations suggest that different areas associated with social cognition and emotional processing are involved in decision-making and that the decisions to cooperate when a subject updates their assessment of the intention to cooperate of a fellow group member differs by gender. The social preference in women makes women more likely to be cooperative in the early rounds of a group decision. In addition, the investigative TV reports that denounce an unfair advantage against public welfare makes female viewers report stronger negative emotions and adopt a tit-for-tat strategy toward free-riders.

## Supplementary material

Supplementary (Tables S1 to S5) is available via the 'Supplementary' tab on the article's online page (http://dx.doi.org/10.1080/17470919.2013.835280).

Original manuscript received 19 December 2012
Revised manuscript accepted 12 August 2013
First published online 12 September 2013

## REFERENCES

Andreoni, J. (1988). Why free ride? Strategies and learning in public goods experiments. *Journal of Public Economics*, *37*(3), 291–304.

Bagnoli, M., & McKee, M. (1991). Voluntary contribution games: Efficient private provision of public goods. *Economic Inquiry*, *29*(2), 351–366.

Brandt, H., Hauert, C., & Sigmund, K. (2003). Punishment and reputation in spatial public goods games. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, *270*(1519), 1099–1104.

Brown-Kruse, J., & Hummels, D. (1993). Gender effects in laboratory public goods contribution: Do individuals put their money where their mouth is? *Journal of Economic Behavior and Organization*, *22*(3), 255–267.

Burnham, T. C. (2007). High-testosterone men reject low ultimatum game offers. *Proceedings of the Royal Society B: Biological Sciences*, *274*(1623), 2327–2330.

Cadsby, C. B., & Maynes, E. (1998). Gender and free riding in a threshold public goods game: Experimental evidence. *Journal of Economic Behavior and Organization*, *34*(4), 603–620.

Cadsby, C. B., & Maynes, E. (1999). Voluntary provision of threshold public goods with continuous contributions: Experimental evidence. *Journal of Public Economics*, *71*(1), 53–73.

Calder, A. J., Lawrence, A. D., & Young, A. W. (2001). Neuropsychology of fear and loathing. *Nature reviews. Neuroscience*, *2*(5), 352–363.

Camerer, C. (2003). *Behavioral game theory: Experiments in strategic interaction*. Princeton, NJ: Princeton University Press.

Camerer, C. F., Ho, T.-H., & Chong, J.-K. (2002). Sophisticated experience-weighted attraction learning and strategic teaching in repeated games. *Journal of Economic Theory*, *104*(1), 137–188.

Chung, D., Kim, Y. T., & Jeong, J. (2013). Cognitive motivations of free riding and cooperation and impaired strategic decision making in schizophrenia during a public goods game. *Schizophrenia Bulletin*, *39*(1), 112–119.

Chung, D., Yun, K., Kim, J. H., Jang, B., & Jeong, J. (2011). Different gain/loss sensitivity and social adaptation ability in gifted adolescents during a public goods game. *PLoS One*, *6*(2), e17044.

Couto, B., Sedeño, L., Sposato, L. A., Sigman, M., Riccio, P. M., Salles, A., . . . Ibanez, A. (2012). Insular networks for emotional processing and social cognition: Comparison of two case reports with either cortical or subcortical involvement. *Cortex*, *49*(5), 1420–1434.

Critchley, H. D., Elliott, R., Mathias, C. J., & Dolan, R. J. (2000). Neural activity relating to generation and representation of galvanic skin conductance responses: A functional magnetic resonance imaging study. *The Journal of Neuroscience*, *20*(8), 3033.

Croson, R., & Gneezy, U. (2009). Gender differences in preferences. *Journal of Economic Literature*, *47*(2), 448–474.

Dawes, R., Orbell, J., Simmons, R., & Van De Kragt, A. (1986). Organizing groups for collective action. *The American Political Science Review*, *80*(4), 1171–1185.

De Burgh, H. (2008). *Investigative journalism*. New York, NY: Routledge.

Delorme, A., & Makeig, S. (2004). EEGLAB: An open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of Neuroscience Methods*, *134*(1), 9–21.

Dupré, J. (1987). *The latest on the best: Essays on evolution and optimality*. Cambridge, MA: MIT press.

Ettema, J. (2007). Journalism as reason-giving: Deliberative democracy, institutional accountability, and the news

media's mission. *Political Communication*, *24*(2), 143–160.

Eveland, Jr W. P., & Shah, D. V. (2003). The impact of individual and interpersonal factors on perceived news media bias. *Political Psychology*, *24*(1), 101–117.

Fallani, F. D. V., Nicosia, V., Sinatra, R., Astolfi, L., Cincotti, F., Mattia, D., & He, B. (2010). Defecting or not defecting: How to "read" human behavior during cooperative games by EEG measurements. *PloS One*, *5*(12), e14187.

Fehr, E., & Fischbacher, U. (2004). Social norms and human cooperation. *Trends in Cognitive Sciences*, *8*(4), 185–190.

Fehr, E., Fischbacher, U., & Gächter, S. (2003). Strong reciprocity, human cooperation, and the enforcement of social norms. *Human Nature*, *13*(1), 1–25.

Fehr, E., & Gächter, S. (2000a). Cooperation and punishment in public goods experiments. *The American Economic Review*, *90*(4), 980–994.

Fehr, E., & Gächter, S. (2000b). Fairness and retaliation: The economics of reciprocity. *The Journal of Economic Perspectives*, *14*(3), 159–181.

Fehr, E., & Gächter, S. (2002). Altruistic punishment in humans. *Nature*, *415*, 137–140.

Frank, R. H., Gilovich, T., & Regan, D. T. (1993). Does studying economics inhibit cooperation? *The Journal of Economic Perspectives*, *7*(2), 159–171.

Frith, C. D., & Frith, U. (2007). Social cognition in humans. *Current Biology*, *17*(16), R724–R732.

Gallagher, H. L., & Frith, C. D. (2003). Functional imaging of theory of mind. *Trends in Cognitive Sciences*, *7*(2), 77–83.

Gibbons, R. (1992). A primer in game theory. Essex: Pearson Education.

Gilligan, C. (1977). In a different voice: Women's conceptions of self and of morality. *Harvard Educational Review*, *47*(4), 481–517.

Gilligan, C., & Attanucci, J. (1988). Two moral orientations: Gender differences and similarities. *Merrill-Palmer Quarterly, (1982–)*, *34*(3), 223–237.

Gobbini, M. I., Koralek, A. C., Bryan, R. E., Montgomery, K. J., & Haxby, J. V. (2007). Two takes on the social brain: A comparison of theory of mind tasks. *Journal of Cognitive Neuroscience*, *19*(11), 1803–1814.

Isaac, R., Schmidtz, D., & Walker, J. (1989). The assurance problem in a laboratory market. *Public Choice*, *62*(3), 217–236.

Isaac, R., Walker, J., & Williams, A. (1994). Group size and the voluntary provision of public goods: Experimental evidence utilizing large groups. *Journal of Public Economics*, *54*(1), 1–36.

Jasper, H. H. (1958). The ten-twenty electrode system of the International Federation. *Electroencephalography and Clinical Neurophysiology*, *10*(2), 371–375.

Keil, A., Gruber, T., & Müler, M. (2001). Functional correlates of macroscopic high-frequency brain activity in the human visual system. *Neuroscience and Biobehavioral Reviews*, *25*(6), 527–534.

King-Casas, B., Sharp, C., Lomax-Bream, L., Lohrenz, T., Fonagy, P., & Montague, P. R. (2008). The rupture and repair of cooperation in borderline personality disorder. *Science*, *321*(5890), 806.

Lamm, C., & Singer, T. (2010). The role of anterior insular cortex in social emotions. *Brain Structure and Function*, *214*(5), 579–591.

Leff, D., Protess, D., & Brooks, S. (1986). Crusading journalism: Changing public attitudes and policy-making agendas. *Public Opinion Quarterly*, *50*(3), 300–315.

Lieberman, M. D. (2007). Social cognitive neuroscience: A review of core processes. *Annual Review of Psychology*, *58*, 259–289.

Mack, D., Auburn, P. N., & Knight, G. P. (1971). Sex role identification and behavior in a reiterated Prisoner's Dilemma game. *Psychonomic Science*, *24*(6), 280–282.

Marwell, G., & Ames, R. (1979). Experiments on the provision of public goods. I. Resources, interest, group size, and the free-rider problem. *American Journal of Sociology*, *84*(6), 1335–1360.

McCombs, M. E., & Shaw, D. L. (1972). The agenda-setting function of mass media. *Public Opinion Quarterly*, *36*(2), 176–187.

Müler, M., Gruber, T., & Keil, A. (2000). Modulation of induced gamma band activity in the human EEG by attention and visual information processing. *International Journal of Psychophysiology*, *38*(3), 283–299.

Nowell, C., & Tinkler, S. (1994). The influence of gender on the provision of a public good. *Journal of Economic Behavior and Organization*, *25*(1), 25–36.

O'Doherty, J. P., Hampton, A., & Kim, H. (2007). Model Based fMRI and Its Application to Reward Learning and Decision Making. *Annals of the New York Academy of Sciences*, *1104*(1), 35–53.

Ortmann, A., & Tichy, L. K. (1999). Gender differences in the laboratory: Evidence from prisoner's dilemma games. *Journal of Economic Behavior & Organization*, *39*(3), 327–339.

Osborne, M. J., & Rubinstein, A. (1994). *Course in game theory*. Cambridge, MA: MIT press.

Ostrom, E. (2000). Collective action and the evolution of social norms. *The Journal of Economic Perspectives*, *14*(2000), 137–158.

Pascual-Marqui, R. D., Michel, C. M., & Lehmann, D. (1994). Low resolution electromagnetic tomography: A new method for localizing electrical activity in the brain. *International Journal of Psychophysiology*, *18*(1), 49–65.

Pfurtscheller, G., & Aranibar, A. (1979). Evaluation of event-related desynchronization (ERD) preceding and following voluntary self-paced movement. *Electroencephalography and Clinical Neurophysiology*, *46*(2), 138.

Pillutla, M., & Murnighan, J. (1996). Unfairness, anger, and spite: Emotional rejections of ultimatum offers. *Organizational Behavior and Human Decision Processes*, *68*(3), 208–224.

Protess, D., Cook, F., Curtin, T., Gordon, M., Leff, D., McCombs, M., & Miller, P. (1987). The impact of investigative reporting on public opinion and policymaking targeting toxic waste. *Public Opinion Quarterly*, *51*(2), 166–185.

Protess, D., Leff, D., Brooks, S., & Gordon, M. (1985). Uncovering rape: The watchdog press and the limits of agenda setting. *Public Opinion Quarterly*, *49*(1), 19–37.

Rand, D. G., Dreber, A., Ellingsen, T., Fudenberg, D., & Nowak, M. A. (2009). Positive interactions promote public cooperation. *Science*, *325*(5945), 1272–1275.

Rapoport, A., & Chammah, A. M. (1965). *Prisioner's Dilema: A study in conflict and cooperation*, Vol. 165. Ann Arbor: University of Michigan Press.

Rapoport, A., & Eshed-Levy, D. (1989). Provision of step-level public goods: Effects of greed and fear of being gypped. *Organizational Behavior and Human Decision Processes*, *44*(3), 325–344.

Ray, W. J., & Cole, H. W. (1985). EEG alpha activity reflects attentional demands, and beta activity reflects emotional and cognitive processes. *Science*, *228*(4700), 750.

Rickham, P. (1964). Human experimentation. Code of ethics of the world medical association. Declaration of Helsinki. *British Medical Journal*, *2*(5402), 177.

Rilling, J., Gutman, D., Zeh, T., Pagnoni, G., Berns, G., & Kilts, C. (2002). A neural basis for social cooperation. *Neuron*, *35*(2), 395–405.

Rilling, J., Sanfey, A., Aronson, J., Nystrom, L., & Cohen, J. (2004). The neural correlates of theory of mind within interpersonal interactions. *NeuroImage*, *22*(4), 1694–1703.

Schiff, S., Aldroubi, A., Unser, M., & Sato, S. (1994). Fast wavelet transformation of EEG. *Electroencephalography and Clinical Neurophysiology*, *91*(6), 442–455.

Schulte-Ruther, M., Markowitsch, H. J., Shah, N. J., Fink, G. R., & Piefke, M. (2008). Gender differences in brain networks supporting empathy. *NeuroImage*, *42*(1), 393–403.

Sibley, S. A., Senn, S. K., & Epanchin, A. (1968). Race and sex of adolescents and cooperation in a mixed-motive game. *Psychonomic Science*, *13*(2), 123–124.

Singer, T., Seymour, B., O'Doherty, J. P., Stephan, K. E., Dolan, R. J., & Frith, C. D. (2006). Empathic neural responses are modulated by the perceived fairness of others. *Nature*, *439*(7075),466–469.

Tedeschi, J. T., Hiester, D. S., & Gahagan, J. P. (1969). Trust and the prisoner's dilemma game. *The Journal of Social Psychology*, *79*(1), 43–50.

Toussaint, L., & Webb, J. R. (2005). Gender differences in the relationship between empathy and forgiveness. *The Journal of Social Psychology*, *145*(6), 673–685.

Tzieropoulos, H., De Peralta, R. G., Bossaerts, P., & Andino, S. L. G. (2010). The impact of disappointment in decision making: Inter-individual differences and electrical neuroimaging. *Frontiers in Human Neuroscience*, *4*, 235.

Van Overwalle, F. (2009). Social cognition and the brain: A meta-analysis. *Human Brain Mapping*, *30*(3), 829–858.

Van Vugt, M., De Cremer, D., & Janssen, D. P. (2007). Gender differences in cooperation and competition the Male-Warrior hypothesis. *Psychological Science*, *18*(1), 19–23.

Van't Wout, M., Kahn, R. S., Sanfey, A. G., & Aleman, A. (2006). Affective state and decision-making in the Ultimatum Game. *Experimental Brain Research*, *169*(4), 564–568.

Xiao, E., & Houser, D. (2005). Emotion expression in human punishment behavior. *Proceedings of the National Academy of Sciences*, *102*(20), 7398–7401.

Yanovitzky, I., & Stryker, J. (2001). Mass media, social norms, and health promotion efforts a longitudinal study of media effects on youth binge drinking. *Communication Research*, *28*(2), 208–239.

Yun, K. (2013). On the same wavelength: Face-to-face communication increases interpersonal neural synchronization. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, *33*(12), 5081–5082.

Zak, P. J., Kurzban, R., Ahmadi, S., Swerdloff, R. S., Park, J., Efremidze, L., & Matzner, W. (2009). Testosterone administration decreases generosity in the ultimatum game. *PLoS One*, *4*(12), e8330.