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The neural basis of the Machiavellians' decision making in fair and unfair situations

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ABSTRACT

Although previous research has revealed a number of social, cognitive and neural components of Machiavellians' decision making processes, less attention has been given to the neural correlates of the high Mach (HM) and low Mach (LM) people's responses to situations involving risks and costs imposed by others in interpersonal relationships. In the present study, we used an fMRI technique to examine individuals as they played the Trust game in fair and unfair situations. Our results revealed that the social environment involving opportunities for exploiting others may be more demanding for Machiavellians who showed elevated brain activities in the fair condition (where the partner made a cooperative initiation) but not in the unfair condition. Regarding the specific activated brain areas in the fair condition, the HM's anterior dorsolateral prefrontal cortex (DLPFC) was responding, which is likely to be involved in the inhibition of the prepotent social-emotional response to the partner's cooperative initiative. Furthermore, we found increased activity in the HM subjects' inferior frontal gyrus (IFG), compared to LMs, that plays a crucial role in the evaluation of the signals associated with the others' social behavior, especially when the player faces a cooperative partner. Alternatively, although Machiavellians are regarded as poor mind readers, inferior frontal gyrus may be effective in anticipating their partner's subsequent decisions in the social dilemma situation.

1. Introduction

Machiavellianism is frequently defined as a behavioral attitude and strategy in using others as devices for achieving the manipulators' own goals (Christie & Geis, 1970; Sutton & Keogh, 2001). It includes three core components: endorsement of deception and manipulation in interpersonal interactions, a cynical view of human nature (seeing others as weak and untrustworthy) and a disregard for conventional morality (Fehr, Samsom, & Paulhus, 1992; Hawley, 2006). Individuals with relatively high scores on Mach scales are referred as high Machs (HM), and are habitually considered as "Machiavellian persons" or "Machiavellians" (Christie & Geis, 1970; Jones & Paulhus, 2009). They have a tendency to be callous, selfish and malevolent in their interpersonal dealings (Paulhus & Williamas, 2002). They easily separate themselves from moral precepts, especially in situations that offer material rewards for breaking norms (Geis & Moon, 1981). In accordance with their egocentrism, they have lower ethical standards and stronger intentions to behave unethically in the future (Jones & Kavanagh, 1996). In contrary, low Mach (LM) persons are characterized by more emotional and ethical orientation.

HM persons are considered to be goal oriented rather than person oriented (Christie & Geis, 1970; Hawley, 2006). They are egoistic and cynical persons who are not likely to be concerned about other people beyond their own self-interest (Hawley, 2006; Jakobwitz & Egan, 2006). They are found to be emotionally detached in their interactions with others, with an interpersonal orientation described as cognitive as opposed to emotional (Austin, Farrelly, Black, & Moore, 2007; Christie & Geis, 1970). Their cold-mindedness has been shown by a recent study that found an association between Machiavellianism and the Interpersonal Schizotypy of a schizotypal personality scale (SPQ-B) that refers to distanced and cold behavior (Montag et al., 2015). Other studies have revealed that high Machs may have certain cognitive deficits, compared to LMs, especially for mentalization capacity, emotional intelligence and empathy. They perform poorly in various mindreading tests, show difficulties in expressing and understanding emotions, and sharing emotions with others

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(Ali & Chamorro-Premuzic, 2010; Lyons, Caldwell, & Shultz, 2010; Paal & Bereczkei, 2007; Wastell & Booth, 2003).

In spite of these cognitive deficits, Machiavellian persons were found to be very effective and successful in exploiting others in various interpersonal interactions, including a social dilemma situation, alliance formation, mate choice (Czibor & Bereczkei, 2012; Gunnthorsdottir, McCabe, & Smith, 2002). Several authors argue that one of the crucial Machiavellian characteristics underlying successful adaptation to the social environment is flexibility (Bereczkei, Deak, Papp, Perlaki, & Orsi, 2013; Jones & Paulhus, 2009). They easily leave an alliance when it is advantageous for them and are likely to steal from someone who trusts them (Christie & Geis, 1970; Harrell & Hartnagel, 1976; Wilson, Near, & Miller, 1998). They also frequently conceal their intentions in order to achieve their goals (Wilson, Near, & Miller, 1996). A recent "real life" study found that HM subjects were not likely to give assistance when they were not observed by others but increased their help to others when their group members could observe their behavior (Bereczkei, Birkas, & Kerekes, 2010). Compared to LM's, HM people were found to have a superior ability to evaluate the clues related to the behavior of group mates in a social dilemma situation and adjust their actual behavior accordingly (Czibor & Bereczkei, 2012).

These results on the Machiavellian persons' flexibility and context-dependent behavior require further analysis about the HM persons' cognitive capacity and the underlying neural mechanisms. The use of brain imaging techniques is advantageous because they can reveal the basic level of decision making processes, and, therefore, can confirm or falsify the particular findings of behavioral studies. Unfortunately, only a few brain imaging studies have been done in this field. A structural MRI analysis revealed significant positive differences for high versus low Machiavellianism in the basal ganglia, left prefrontal cortex, bilateral insula, and the right hippocampus (Verbeke et al., 2011). Spitzer and his colleagues (2007) found a strong correlation between Mach scores and the activity of lateral orbitofrontal cortex that is involved in detecting and evaluating the punishment threat. These abilities are likely to play an important role in the Machiavellians' response to threats of punishment that enabled them to earn higher profit by the end of the Ultimate game. Bereczkei and colleagues (2013) recently demonstrated increased neural activations in areas that are involved in inference making and reward-related decision making (inferior and middle frontal gyri, anterior insula, thalamus, anterior cingulate cortex). The authors suggested that Machiavellian persons – in spite of their poor performance in mentalization and emotional intelligence – may have cognitive heuristics that enable them to make predictions about future rewards in a basically risky and unpredictable situation.

The above mentioned studies have revealed certain social, cognitive and neural components that are involved in Machiavellians' decision making in various social dilemma situations. They showed how successfully Machiavellians respond to others' behavior (e.g. previous contributions) and situational demands (e.g. punishment). However, to date, they have not attempted to analyze a very important aspect of their social environment that may profoundly influence the decision to exploit others, such as the risks and costs imposed by others in an interpersonal relationship. What happens if subjects face partners who do not reciprocate at all or reciprocate less than what was previously received? Do HM and LM people behave differently in a situation where they receive an unfair offer from the partner? What neural correlates are involved in their decisions when facing correct and incorrect responses? Which of the responses represents a higher demand on their cognitive capacities and neural processes?

Scientific evidence suggests that people are very sensitive to being cheated and manipulated. A number of studies confirmed that individuals recognize and discriminate against non-reciprocators and punish them when they can (Cosmides, Barrett, & Tooby, 2010; Kovács-Bálint, Bereczkei, & Hernádi, 2013; Yamagishi, Tanifda, Mashima, Shimoma, & Kanazawa, 2003). Other studies found that a sense of fairness plays an important role in economic decision making. They have shown that unfair offers in various experimental games were associated with negative emotional responses and evoked punishment that may force the violators to obey social norms (Fehr & Fischbacher, 2004; Fehr & Gachter, 2002).

Studies focusing on the neural correlates of interpersonal relationships found elevated activities in certain brain areas that are responsible for detecting and answering unfair acts (Tabibnia, Satpute, & Lieberman, 2008). Some studies concerning norm violations stated that less fair offers in a social dilemma situation activated the bilateral insula which has been implicated in negative emotional states such as pain, fear, disgust (Dulebohn, Conlon, Sarinopulus, Davison, & McNamara, 2009; Rilling et al., 2002; Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003). Unfair offers also activated the dorsolateral prefrontal cortex that is often associated with goal maintenance and executive control, and the anterior cingulate cortex that is related to the detection of cognitive conflicts. Another study found that unreciprocated cooperation was associated with greater activity in the bilateral insula, left hippocampus and left lingual gyrus, compared with reciprocated cooperation (Rilling et al., 2008).

These studies suggest that people on both the behavioral and neural level are very sensitive to being cheated and are ready to evaluate and punish unfair responses. However, inferring from the previous studies, we assume that the Machiavellians' thinking is different: they would be sensitive primarily to cues from cooperators as potential victims. A lot of studies have confirmed that one of the main characteristics of Machiavellianism is cynicism toward others (Christie & Geis, 1970; Wilson et al., 1996). They typically attribute negative intentions to others and do not expect cooperation from them; they start out with the assumption that others will exploit them if they themselves fail to do so (Repacholi et al., 2003). They assume that other people are cheaters (Harrell, 1980) and believe that others will engage in unethical behavior such as feigning dissatisfaction with a service received in order to obtain a refund (Wirtz & Kum, 2004). They do not only have a broadly negative view of other people but, at the same time, they are more tolerant of unethical behavior in others (Murdrack, 1993). Jones and Paulhus (2009) argue that a "projective" logic underlies this attitude: e.g. workers who say they believe that others steal are the very ones who go on to steal from the company (Cunningham, Wong, & Barbee, 1994).

It is possible, then, that HM people are more likely to accept others' uncooperative behavior than LM's and even regard antisocial acts as "normal" in the interpersonal relationship. They do not expect a fair social contract in an exchange and would not be concerned too much about the partner's selfish decision. Conversely, a cooperative social environment may be highly demanding for them because it needs additional cognitive effort to evaluate the possible costs and benefits associated with their selfish response. If this is so, we expect that HM people show higher neural activities in fair social conditions (as "unusual" from their perspective), compared to unfair social conditions. More specifically, in the case of their partners' cooperative initiatives, they are supposed to recruit specific neural mechanisms that would enable them to make appropriate decisions against the prevailing reciprocity and equality norms. LM persons are expected to behave in the opposite manner: they should show an increase in brain activity when they face the partner's unfair reaction that they usually consider as an act that threatens their social relationship. Since they are more likely than HMs to obey social norms and expect cooperation, the partners' defection may elicit elevated activity in the relevant brain regions.

The Machiavellians' rejection of the partners' fair offer may involve inhibition processes against their possible immediate cooperative response to the partners' cooperative initiative. Several studies have revealed that certain brain regions are involved in the executive inhibition control network, such as the anterior cingulate gyrus, the superior and middle frontal gyri (as parts of dorsolateral prefrontal cortex), the inferior frontal gyrus, the insula, and the precuneus (Harris, McClure, van den Bos, Cohen, & Fiske, 2007; Polosan, Baciu, Perrone, Pichat, & Bougerot, 2011). In a study that examined a conflict between unwanted reflexive response and a complex volitional response, elevated activation was found in DLPFC, indicating the role of this brain area in response inhibition (Ettinger et al., 2008).

We can make alternative hypotheses on the specific neural mechanisms in association of Machiavellianism. It is possible that HM persons show an elevated activity of anterior cingulate cortex (ACC) that is considered as a conflict detector, especially when a dominant habitual response competes with the execution of an intended response (Dreisbach & Fischer, 2012; Piech et al., 2010). HM people may experience a conflict between a need to reciprocate the partner's generous offer (long-term benefit) and the need to take the high offer they received without returning it (short-term benefit). The dorsolateral prefrontal cortex (DLPFC) may also play a major role in response inhibition but in another way. This area has a general role in the evaluation of reward information and the acceptance of personal moral violation. (van den Bos, van Dijk, Westenberg, Rombouts, & Crone, 2009).

Furthermore, we predict that brain areas related to the anticipation of the partner's decisions will be crucial in the Machiavellians' exploiting behavior. A former study found that inferior frontal gyrus (IFG) plays a crucial role in adjusting the HMs' decisions to the others' actions in a social dilemma situation (Bereczkei et al. 2013). This brain area is known to be engaged in making predictive inferences during various tasks (Liakakis, Nickel, & Seitz, 2011). Therefore, we expect that IFG especially shows an elevated activity when the player with high scores on Mach scale faces a cooperative (fair) partner as a potential victim, compared to a selfish (unfair) partner.

In the present study, participants played a set of two-round Trust games. In the first round, the subject as player 1 (Investor) offers an amount of money and player 2 (computer) reciprocates in two possible ways. In the first condition, player 2 returns about the same amount of money that he or she had received previously (fair or correct condition). On the other hand, player 2 reciprocates a relatively little amount of money, only 30% of the sum received from player 1 (unfair or incorrect condition). In the second round, the computer begins the game as the first player by offering an average sum and the subject (player 2) makes a decision for the amount in return. In general, second players are more motivated to reciprocate when the first player proves to be cooperative and reciprocates an average or above average amount of money in the first round. However, as previously argued, we expect differences in the strategic decisions between low Mach and high Mach individuals: Machiavellians will tend to exploit their cooperative partner and increase their personal profit at the expense of mutual gain. In other words, the Machiavellian's financial success in the bargaining game is supposed to come from their self-interested strategy: they will "punish" the uncooperative partner by radically decreasing their own offer and exploit the cooperative partner by not reciprocating his or her previous trust. Non-Machiavellians are also expected to return less to an uncooperative partner but – contrary to Machiavellians – reciprocate the cooperative partner's fair offer.

2. Methods

2.1. Participants

The participants were selected from a large database ($N = 620$) of healthy university students, based on their scores on the Mach-IV questionnaire (Christie & Geis, 1970). This test consists of 20 items that contain short statements in connection with the rules and principles that may cover relationships with others. The subjects used a seven-point Likert scale to indicate the degree of agreement with each item. Former studies have frequently used separate categories on the Mach-scale for the purpose of comparing Machiavellian and non-Machiavellian people. (e.g. Burks, Carpenter, & Verhoogen, 2003; Christie & Geis 1970; Gunnthorsdottir et al., 2002). The reliability of the questionnaire has been found acceptable (Cronbach's alpha: 0.72) in this large sample.

Since the aim of our study is to compare low and high Mach groups, we divided the distribution of the original sample along the standard deviation above and below the mean. Subjects scoring $\leqslant$88 were defined as low Machs (LM), while those scoring $\geqslant$114 comprised the "high Mach" (HM) group. In accordance of these criteria, 44 right-handed participants agreed to volunteer and they were enrolled in the current research. Five subjects were excluded from the analysis due to different reasons (for movement artifacts, prior knowledge about the experiment, claustrophobic experiences inside the scanner and possible signs of hydrocephalus). One additional person was excluded because of lack of active voxels in his statistical map. The final sample consisted of 38 participants (20 males, 18 females), 22 in the LM group (11 males, 11 females) and 16 in the HM group (9 males, 7 females). The mean age was 23 ± 2.56 years for the total sample. The Cronbach alpha of Mach IV for the final sample was 0.76. ANOVA showed no significant difference in age either between the two groups or between genders (Mean $(M)_{\text{HM Males}} = 22.22$, Standard Deviation $(\text{SD})_{\text{HM Males}} = 2.11$; $M_{\text{LM Males}} = 24$, $\text{SD}_{\text{LM Males}} = 3.03$; $M_{\text{HM Females}} = 22.57$, $\text{SD}_{\text{HM Females}} = 2.23$; $M_{\text{LM Females}} = 22.91$, $\text{SD}_{\text{LM Females}} = 2.66$. Gender: $F(1,34) = 0.19$, $p > 0.05$; Group: $F(1,34) = 1.53$, $p > 0.05$. Gender × Group interaction: $F(1,34) = 0.71$, $p > 0.05$).

The sample was homogeneous in that all participants were full-time students of the University of Pécs. All of them gave their informed consent. None of them suffered from either neuropsychiatric disorders or were undergoing medical treatment. Ethical permission of the study was granted (the Regional Institutional Research Ethical Committee at the University of Pécs, No. 4429).

2.2. Experimental settings

Social interactions were modeled with a Trust Game (TG) (Fehr & Fischbacher, 2004). Two participants take part in the TG: one of them is the Investor, the other is the Trustee. The Investor has HUF 1000 (about 5 US dollars) as his or her initial amount of money, and decides how much of the HUF 1000 he or she would offer to the Trustee. The Experimenter triples this offer and transfers it to the Trustee. In the next step of the TG, the Trustee has the opportunity to return any amount back to the Investor. The participants played with actual money and they could take their earnings home. Throughout the whole game, the participants were given feedback on the screen about their own and their partner's transactions. The responses were carried out by a two-key MR-compatible response device in the participant's left and right hand. Presentation software ("Presentation" – www.neurobs.com) was used to present the stimuli and to log the responses and reaction times.

In the present study, the participants played two-round games with various conditions. Two main aspects were investigated in the task: 1. the participant's role in the Trust Game (either Investor

/indicated with yellow in Fig. 1./ or Trustee/indicated with either green or red depending on the type of offer); 2. the type of offer given by the putative "Partner" (either Fair /indicated with green/ or Unfair /indicated with red/).

As an Investor the participant started the game and offered an optional amount from 1000 HUF to the "Partner" (Fig. 1. OFFER), which was tripled by the "Experimenter" and transferred to the "Partner". In the second part of the round, the Partner (that is the Computer) could return some amount to the participant (Fig. 1. RETURN). Each OFFER and RETURN phase was followed by a FEEDBACK screen with the actual account balance both for the participant and the "Partner".

As a Trustee /in the green and red blocks/, the participant responded to either a fair or an unfair offer "given" by the Partner (who played the role of Investor in this turn). So, in the PERCEPTION phase, the participant could perceive the offer followed by the account screen (FEEDBACK), and then s/he had the opportunity to return from his/her account (RESPONSE). Each turn ended with a FEEDBACK screen for 15 s and a fixation cross (3 s) that drew the attention to the next round.

Participants' reaction time was measured in the RESPONSE phase as a Trustee responding to either a Fair /green/ or an Unfair offer /red/. Reaction time was also registered in a simple task as the control condition (CONTROL phase is indicated with blue in Fig. 1.). A number and a scale (100–900 with 100 units) were presented and the participants were instructed to set the cursor to the specific number that appeared on the screen.

In the Fair condition, the return was the same amount as the first player's offer ±10%. In the Unfair condition, the Trustee returned only 30% of the Investor's original offer ±10%. For example, when the Investor first gave HUF 450, the Trustee received HUF 1350 (3×450), but he or she returned only HUF 150 (30% of 450). In the second round, the computer started the game by offering an average amount of money, and the subjects (as Trustee) decided how much money they returned to the Investor, which obviously depended on the amount of the Investor's return in the first round (Fair vs. Unfair condition). The subjects believed they were playing with another person (and not with a computer). On the behavioral level, we measured the subjects' offers, returns and payoffs. On the neural level, we scanned the subjects' decision on how much money they return to the partner (RETURN) in the Fair and Unfair conditions.

2.3. Procedure and design

Participants were informed that they were playing several rounds of a TG with real peers. In fact, the responses from the social interaction partner were always defined by a computerized algorithm. However, the participants believed they played against real peers. Confirming this scenario, psychology BA students were asked to appear in the waiting room before the experiment, suggesting their readiness to participate in the procedure.

The computer script adjusted the return to the amount that was offered by the Investor in the first step of the TG. For example, if a subject as a first player (Investor) offered HUF 600 from the total amount of HUF 1000, the Trustee received a tripled amount (HUF 1800), and in the second step the computer script determined the Trustee's return, for example, at a +7% return rate, that is HUF 642 were given back to the Investor. The range of the return was ±10%, and the computer randomly selected it (e.g. +5%, −8%, +4%, +10%).

Before scanning, the participants could practice some rounds of the TG on a laptop computer to ensure that they understood the task. Before entering the scanning room, written informed consent was acquired from the subjects, and all metallic objects were removed according to the safety rules. In the scanner, participants were trained on how to use the response panel and respond within the allocated time. For transferring the given amount of money during the Trust Game subjects set their offers on a scale by using two buttons on the response panel; one for reducing the amount, and the other for increasing it. In each round, the default position of the cursor was set randomly to any of the nine possible locations on the scale. The scale was labeled with the actual amount (not%) and we also used a color bar for better perception of the cursor. (The same color bar appeared in the control condition when the participants had to set the scale to a specific number.)

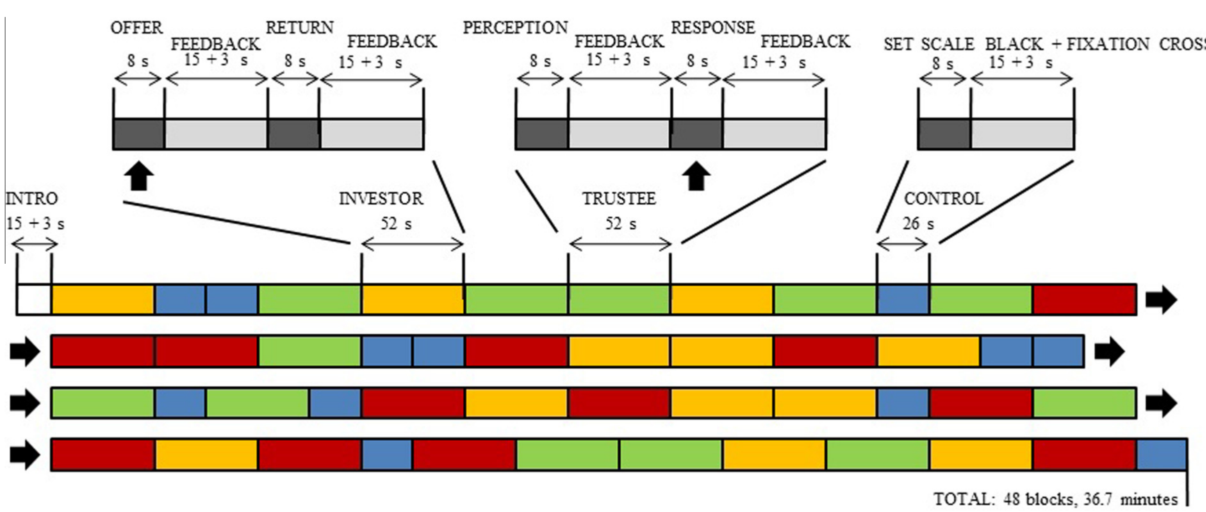

Fig. 1. Timeline of the Trust Game (TG). The fMRI experiment consisted of 12 investor blocks (yellow), 12 fair blocks (green), 12 unfair blocks (red) and 12 control blocks (blue). As an Investor the participant starts the game and can offer an optional amount from 1000 HUF to the "Partner" (OFFER), which is tripled by the "Experimenter" and transferred to the "Partner". In the second part of the round, the Partner (that is the Computer) can return some amount to the participant (RETURN). Each OFFER and RETURN phase is followed by a FEEDBACK screen with the actual account balance both for the participant and the "Partner". As a Trustee /in the green and red blocks/, the participant responds to either a fair or an unfair offer "given" by the Partner (who plays the role of Investor in this turn, that is the Computer) within 8 s. So, in the PERCEPTION phase, the participant perceives the offer followed by the account screen (FEEDBACK), and then s/he has the opportunity to return from his/her account (RESPONSE). Each turn ends with a FEEDBACK screen for 15 s displaying the final account of the round and a fixation cross (3 s) appeared that draws the attention to the next round. In the control unit, a number between 100 and 900 was presented in letters (e.g. three hundred) and the participants had to set the cursor of the response scale to that specific number (8 s). Then, a black screen was presented for 15 s and a fixation cross for another 3 s. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

The feedback screen displayed the account of the Participant on the left, and the account of the Partner on the right side. Participants could move the cursor to the right by pressing the right response button and move it to the left by pressing the left response button. The cursor moved one unit for each press in either direction, and at the same time, the amount changed by a fixed proportion. For example, pressing the left button once decreased the amount by one unit. Similarly, pressing the right button once increased the amount by one unit. The left end of the scale represented the minimal amount of 0 to offer, while the maximum amount appeared at the right end. The total amount to offer in each round was equally divided between the nine cut off points on the scale.

At the beginning of the scanning procedure, an instruction slide (indicated as INTRO in Fig. 1) was shown for 15 s, then a black screen with a white fixation cross was presented for 3 s. On the Intro screen, we presented only one sentence as an introductory guidance for the participants: "The game starts soon", but it was not used in further analysis. In order to direct the participants' attention to the upcoming event, (right after the feedback screen) a white fixation cross in the middle of the black screen appeared 3 s prior to the upcoming event. The participants were instructed to make their offers and returns within 8 s that is short but enough time for decision. The scale appeared for the entire time of 8 s, and the feedback screen also appeared for the entire 15 s, there were no gaps or jitter in between. The timing was the same between the Subject as Investor and Subject as Trustee conditions, and we treated them as separate events.

The experiment consisted of 48 blocks (rounds) (see Fig. 1). There were three different types of events: 12 fair offers, 12 unfair offers, 12 control tasks. Additionally, we added 12 events when participants could make their own offer as Investor, but these were not included in the current analysis because the aim of this study was to investigate the neural response of a Trustee who responds to either a fair or an unfair offer given by the Investor. In the FAIR and UNFAIR type of blocks, the Investor (the computer) started the TG by offering either a fair or an unfair offer out of the HUF 1000. One TG unit started with the Investor's offer (8 s), followed by a feedback screen for 15 s showing the account of the two players after the Experimenter tripled the offered amount. Then, the white fixation cross was seen for 3 s as the cue for the upcoming event. Next, it was the participant's turn in the scanner as Trustee to make his or her offer to return to the Investor (8 s). At the end of the TG unit, a feedback screen was presented again with the final account of the round. In the control unit, the participants saw a number in letters between 100 and 900 (e.g. three hundred) and the task was to set the cursor to that specific number on the response scale (8 s). Then, a black screen was presented for 15 s and a fixation cross for 3 s. The schema of the experiment is presented in Fig. 1.

In our analysis, we used the 8 s period when participants (as Trustee) had the chance to return money to the Investor and compared it to the 8 s control condition (that involved the adjustment of the cursor to the amount shown on the screen) in the fair and unfair offers, respectively. (12 fair offers are colored in green, 12 unfair offers are colored in red in Fig. 1. The Investor rounds indicated in yellow were not analyzed in this paper).

At the end of the experiment the participants were invited for a short debriefing interview about their experiences during the Trust Game and the scanning procedure in general. They reported, among others, that they believed they had played with more than one partner (as the cover story instructed). Furthermore, in their post-scanning reports they attributed mental states and intentions to their partners, indicating they believed that they had played with human partners. Finally, they were paid the earned money.

2.4. Data acquisition and analysis

MRI data were acquired on a 3T scanner (MAGNETOM Trio, Siemens AG, Erlangen, Germany) at the Diagnostic Center of Pécs (Pécs, Hungary) equipped with a 12-channel head-coil. Functional MRI was based on a gradient-echo EPI sequence (TR/TE = 2000/36 ms, flip angle 76°, FOV = 230 mm $\times$ 230 mm, matrix = 92 $\times$ 92, ST = 4 mm, no gap) with a spatial resolution of 2.5 mm $\times$ 2.5 mm $\times$ 4 mm (23 slices with interleaved slice order) in an axial orientation parallel with the AC–PC plane. Motion correction was performed as specified by the manufacturer. Image processing was carried out by using SPM5 (http://www.fil.ion.ucl.ac.uk/spm) implemented in MATLAB (Version7.0.1.24704 [R14] Service Pack 1) (Mathworks Inc., Sherborn, MA). Images were corrected for motion, registered to the standard space at 2 $\times$ 2 $\times$ 2 mm, normalized to SPM5 template, and smoothed with a FWHM Gaussian kernel at 5 mm.

A first level analysis was computed subject-wise, using a general linear model with a hemodynamic response function modeling the responses to both fair and unfair offers. We used 12 investor blocks, 12 control rounds, 12 fair rounds and 12 unfair rounds. For the design matrix, the following regressors were used: 1. Response to Unfair offers, 2. Response to Fair offers, 3. Control condition, 4. Investor phase.

First-level contrasts of the LM and the HM groups were analyzed using a two-sample t test at the second level. A voxel-wise statistical significance of $p < 0.001$ (uncorrected) was applied, and all the statistical maps were corrected for FWE for fair and unfair conditions irrespective of the groups and cluster-wise significance ($p < 0.05$) for HM vs LM group comparison.

2.5. Behavioral measures

Participants' decisions were logged including reaction time. From the log-file data we calculated the two groups' mean offer in the fair and unfair rounds, respectively, and their final payoffs as the indicator of their success in the TG. The independent sample t test using SPSS 17.0 statistical software analyzed the behavioral measures of the LM and HM groups. We compared the Mach-IV scores, the money they offered as the Investor, the money they returned as Trustee and the money they gained by the end of the TG.

3. Results

3.1. Behavioral data

The paired sample t test showed that the amount of money offered by the Investor (presented by the computer) was significantly higher in the fair rounds than in the unfair rounds (343.3 ± 104.1 HUF vs. 59.6 ± 29.9 HUF, $t(22) = 17.72$, $p < 0.001$).

Compared to LM individuals, HM as player 1 (Investor) transferred a smaller amount of money to the Trustee over the game (528.6 ± 198.4 vs. 387.2 ± 217.6, ($t(37) = 2.12$, $p < 0.05$) and, as a second player, reciprocated less to the Investor (229.5 ± 43.4 vs. 153 ± 40.5, ($t(25) = 4.72$, $p < 0.001$). HM people gained a significantly higher profit at the end of the game than LMs (24260.5 ± 1265.8 vs. 22675.1 ± 1366.4, $t(37) = -3.71$, $p < 0.05$).

Considering the fair and unfair offers presented by the computer as player 2 in the first round, characteristic differences appeared between the HM and LM subjects' responses in the second round. The largest difference between the two groups was found in the reaction to the fair offers: HM individuals gave a significantly lower amount as a return compared to LM, after their partners had returned a relatively large (average) sum in the first part of the round (278.4 ± 77.2 vs. 393.3 ± 95.1, $t(37) = 4.05$,

$p < 0.05$). In other words, if player 1 (Investor) offered a correct amount, Machiavellian subjects (as player 2) transferred a smaller amount of money as a return, compared to non-Machiavellians.

At the same time, no significant difference was found in the case of unfair transactions: as a response to the partners' low contribution, both HMs and LMs reciprocated a very low amount of money with no significant difference between them (53.3 ± 29.6 vs. 64.5 ± 30, $t(37) = 1.16$, $p > 0.05$). In other words, when the partner (as player 1) made an unfair offer, both Machiavellian and non-Machiavellian subjects (as player 2) reduced their transfer on a similar way. Using 2 × 2 ANOVA (Repeated Measures), the interaction between Machiavellianism and fairness proved to be highly significant [$F(1,37) = 16.20$; $p < 0.001$].

As a result, in the rounds subsequent to those where the partners (computer) reciprocated only a little, HM people did not gain a significantly higher profit than LM (113 ± 30 vs. 129.2 ± 38.6, $t(37) = -1.47$, $p > 0.05$). However, HMs gained a much higher profit than LMs in the fair condition where their partner offered a correct amount in the previous round (892.1 ± 75.5 vs. 783.3 ± 94.2, $t(37) = -3.89$, $p < 0.05$). Fig. 2 shows the final payoff and the players' offers as Trustee.

The analysis of variance with Condition (fair, unfair) as within-subjects factor and Group (HM, LM) as between-subjects factor did not show significant difference between the two groups [Mean RT ± standard deviation in the fair condition for LM: 3.45 ± 0.68 s, for HM: 3.53 ± 0.82 s; in the unfair condition for LM: 3.16 ± 0.50 s. for the HM: 2.98 ± 0.88 s; $F(1,37) = 0.07$; $p > 0.05$; Partial Eta Squared = 0.002]. No interaction was found [$F(1,37) = 1.26$; $p > 0.05$; Partial Eta Squared = 0.03]. However, the reaction time in the unfair condition was shorter than in the fair condition (3.08 ± 0.69 s vs. 3.49 ± 0.73 s [$F(1,37) = 13.67$; $p < 0.01$; Partial Eta Squared = 0.27].

3.2. Neuroimaging data

First, we present the results of the two main contrasts (Fair – Control and Unfair – Control) irrespective of the two groups in order to have an insight to the activation pattern while the participants were performing the task (Table 1).

In the Fair condition (where the partner, that is, the computer, transferred an average amount of money in the former round), significant response was detected in the inferior, middle and superior frontal gyrus bilaterally, inferior and middle occipital gyrus bilaterally, right inferior temporal gyrus, cingulate gyrus bilaterally, inferior parietal lobule bilaterally, right insula, and the right thalamus.

In the Unfair condition (where the computer reciprocated only 30% of the subject's original offer), neural activation was found in the inferior and middle frontal gyrus bilaterally, right medial frontal gyrus, right inferior temporal gyrus, inferior and middle occipital gyrus bilaterally and inferior parietal lobule bilaterally.

Second, we compared the group activation of HM and LM participants in the following two contrasts: Fair – Control and Unfair – Control with two-sample t-test.

In the Fair – Control contrast, the analysis of the HM > LM comparison revealed that the signal was greater in the right inferior frontal gyrus, left middle and superior frontal gyrus, left inferior and middle temporal gyrus, right fusiform gyrus and bilateral precentral gyrus (Table 2 and Figs. 3 and 4). In response to the unfair offers, the HM group showed elevated activation in the left inferior and middle frontal gyrus (Table 2).

4. Discussion

In our present study, the participants played a set of two-round TG. The players' motivation to reciprocate trust is not only guided by goals to maximize personal outcomes but also by an evaluation of consequences for both themselves and others (Gintis, Bowles, Boyd, & Fehr, 2007). Former studies confirmed that HM persons are more likely than LMs to monitor the partner and adjust their own behavior accordingly to get reward. The aim of our present study was to find neural correlates of Machiavellian decision making in unfair and fair contexts of social dilemma situation.

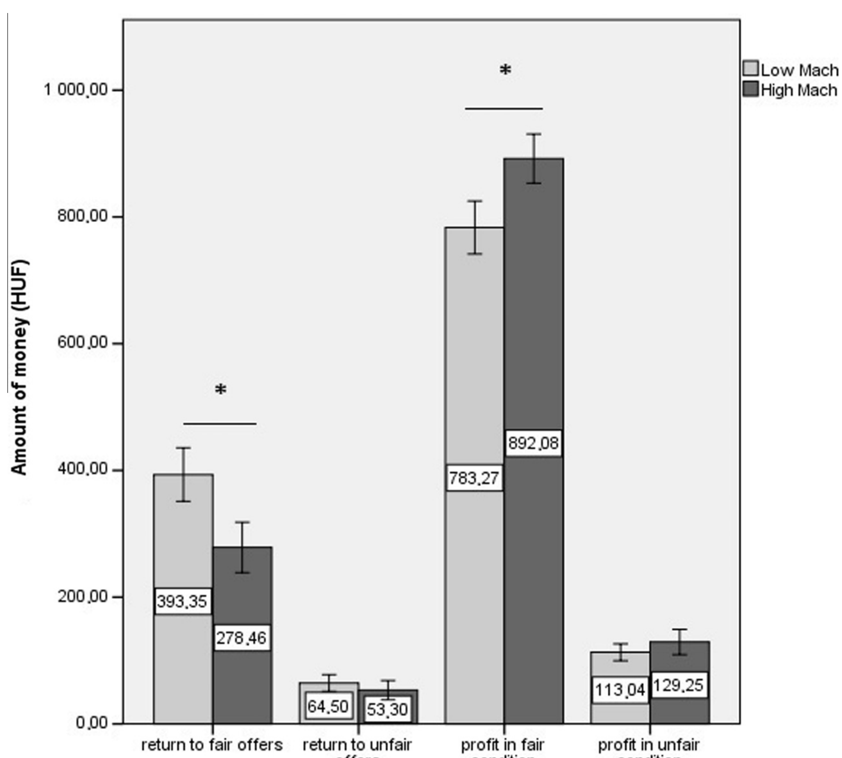

Fig. 2. High Mach and low Mach players' return offers and final payoff in fair and unfair conditions.

Table 1
Brain activation in response to fair/unfair offers irrespective of groups (HM/LM).

	Brodmann area	Number of voxels	T-value	Voxel coordinates (MNI)		
				x	y	z
Unfair > Control (all participants)						
R inferior temporal gyrus	BA 20	6	6.67	54	−56	−18
L inferior/middle occipital gyrus	BA 17-19	192	8.16	−28	−96	−6
R inferior/middle occipital gyrus	BA 17-19	168	9	30	−98	−6
R inferior/middle frontal gyrus	BA 9	4	7.32	48	10	24
L inferior/middle frontal gyrus	BA 9	7	6.97	−44	6	30
R inferior/middle frontal gyrus	BA 10/46	72	8.31	50	36	24
R medial frontal gyrus	BA 6/8	5	6.53	2	22	46
R inferior parietal lobule	BA 7/39/40	93	7.89	34	−58	48
L inferior parietal lobule	BA 7/40	22	8.02	−30	−58	46
Fair > Control (all participants)						
L inferior/middle occipital gyrus	BA 17-19	335	10.98	−34	−94	−10
R inferior/middle occipital gyrus	BA 17-19	319	10.38	28	−100	−4
R inferior temporal gyrus	BA 20	4	6.27	54	−56	−18
L inferior frontal gyrus	BA 47	14	6.51	−32	24	−8
R inferior frontal gyrus	BA 47	38	8.01	34	20	−6
R insula	BA 13	12	8.01	34	20	−6
R inferior/middle/superior frontal gyrus	BA 10	27	7.22	38	60	2
R inferior/middle/superior frontal gyrus	BA 9/10/46	119	10.12	46	42	30
L inferior/middle frontal gyrus	BA 9/46	43	7.78	−52	12	24
R thalamus		11	6.62	10	−8	0
L/R cingulate gyrus	BA 32	57	9.84	6	30	46
L/R cingulate gyrus	BA 23/24	34	8.23	6	−4	30
L/R medial frontal gyrus	BA 6/8	130	9.84	6	30	46
R inferior parietal lobule	BA 7/39/40	391	9.99	32	−62	46
L inferior parietal lobule	BA 7/40	187	9.2	−32	−56	46

FWE $p < 0.05$.

4.1. Differences in offers and payoffs

In accordance with the findings of former studies (Czibor & Bereczkei, 2012; Gunnthorsdottir et al., 2002), Machiavellian people gained a higher profit than non-Machiavellians by the end of the TG. This payoff was due to the exploitation of their partners: high Mach (HM) people took advantage of the partner's cooperative incentives. When the partner (computer) had reciprocated a relatively large amount of money in the first round (Fair condition), they substantially reduced their return offer in the subsequent round, compared to low Machs (LMs) who answered cooperativeness with cooperativeness. In the case of the partner's unfair offer, however, no significant differences were found between HMs and LMs in the amount of money they transferred as player 2. Consequently, the Machiavellians' larger payoff came from their double strategy toward their partners: they punished incorrect offers but did not reciprocate the correct offers. LMs behaved in another way: they appeared cooperative to the correct offers and uncooperative to the incorrect offers.

These results coincide with the findings of former studies which showed that Machiavellians behave in a self-interested way in that they manipulate others for personal gain (Jones & Paulhus, 2009; Wilson et al., 1996). In accordance with their egocentrism, they have lower ethical standards and stronger intentions to behave unethically in the future (Jones & Kavanagh, 1996). They are especially exploitative when the circumstances provide a predictable way to gain an advantage; for example, HMs were found to steal primarily from the trusting supervisors (and not from the suspicious ones) and stole greater amounts than LMs (Harrell & Hartnagel, 1976). In general, Machiavellian people are always ready to betray others when there is no chance for the other person to punish this behavior (Gunnthorsdottir et al., 2002; Jones & Paulhus, 2009).

4.2. Cooperative social environment and Machiavellian intelligence

When comparing brain activities between HM and LM people, higher activities were characteristic of Machiavellians as an answer to the partner's previous cooperative offer. In other words, decisions in a social dilemma situation elicited higher neural responses in HMs than in LMs when the partner had returned a relatively high amount of money in the first round (Fair condition). Decision making in the other contexts of TG were associated with weak hemodynamic changes (cooperative offer for LMs and uncooperative offer for HMs), or no changes at all (uncooperative offer for LMs).

Integrating these behavioral and neuroimaging results, we suggest that a cooperative social environment is more demanding for HM than LM persons. Machiavellians with a cynical world view are likely to accept defection and regard antisocial behavior as "normal" in the social dilemma situation. Facing a cooperative interaction would need additional cognitive effort for them to evaluate the possible costs and benefits associated with their utilitarian problem solving. Furthermore, this kind of environment provides

Table 2
Brain activations registered in response to fair and unfair offers for the High Mach and Low Mach group, respectively (based on the following first level contrasts: Fair – Control; Unfair – Control).

	Brodmann area	Number of voxels	T-value	Voxel coordinates (MNI)		
				x	y	z
Unfair – Control						
Low Mach > High Mach						
n.s.						
High Mach > Low Mach						
L Inferior Frontal Gyrus	BA 47	5	3.81	−28	22	−22
L middle frontal gyrus	BA 10	3	4.04	−30	60	12
Fair – Control						
Low Mach > High Mach						
n.s.						
High Mach > Low Mach						
R fusiform gyrus	BA 37	16	5.22	48	−58	−12
L inferior/middle temporal gyrus	BA 37	13	4.18	−36	−68	4
R inferior frontal gyrus	BA 47	10	4.56	28	24	−12
L middle/superior frontal gyrus	BA 10	14	4.21	−28	58	4
R middle frontal gyrus	BA 10	5	3.61	34	62	6
R precentral gyrus	BA 4/6	34	4.69	62	−16	42
L precentral gyrus	BA 4/6	12	4.3	−60	−16	42

$p < 0.001$ uncorrected (cluster-level).

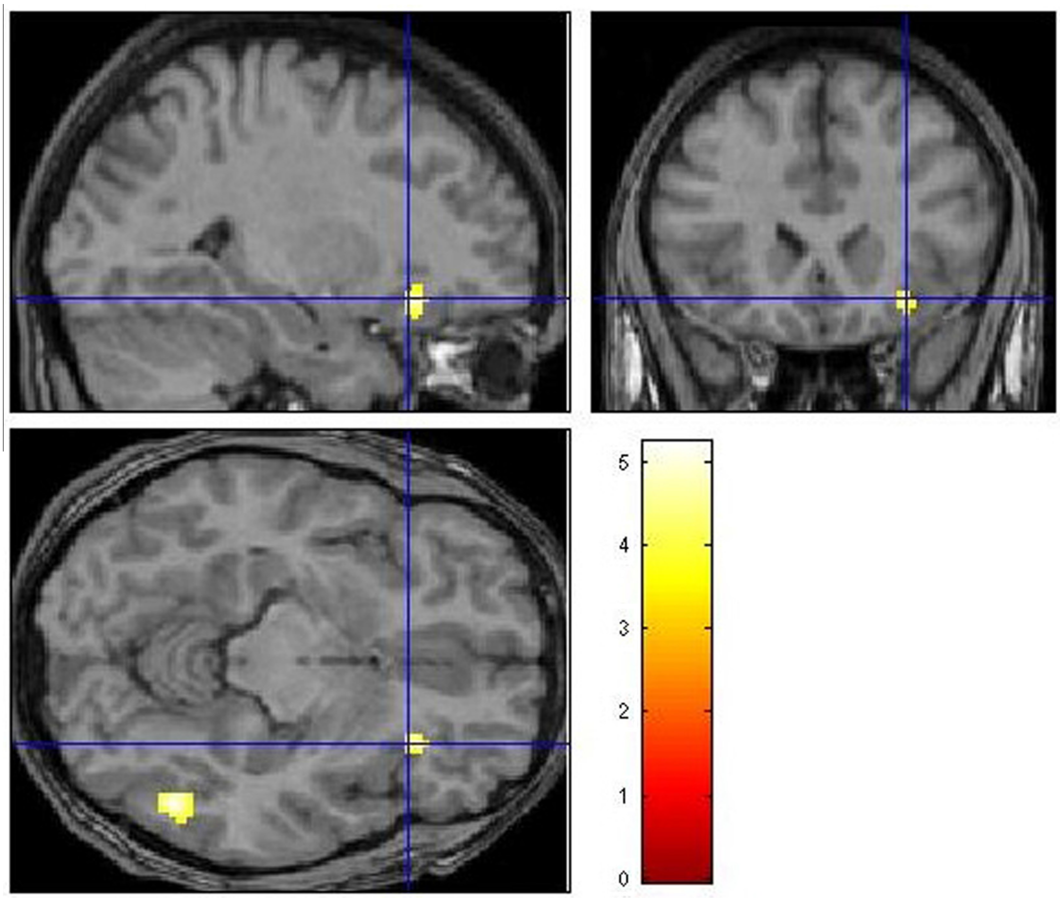

Fig. 3. Significantly higher activation in the right inferior frontal gyrus (MNI: 28, 22, −11) in the Fair-Control contrast for the HM group in comparison with the LM group.

great opportunities for exploiting the others. Cooperative partners are the "best" subjects of exploitation because the benefit for the second player is the largest when they are trusted by the first player but they do not reciprocate this trust. Machiavellian people with their strong self-oriented motivations may take advantage of the others' cooperative intentions. It is not surprising, then, that they gained significantly higher profit by the end of the game compared to non-Machiavellians.

During the game, the participants evaluate the others' intentions in the social exchange situation, calculate a cost/benefit ratio and make a decision on the appropriate strategy. For non-Machiavellians this decision is relatively simple: they return only a little when receiving a little and give a lot when they receive a lot. This is because they are more inclined to trust the others and are also more willing to meet the reciprocity norm. Machiavellians, on the contrary, should evaluate the fair situation in a utilitarian way: they have to inhibit the "automatic" emotional reaction to the partner's generous offer, and monitor the partner's previous steps. It is not surprising, then, that especially the dorsolateral prefrontal cortex and the inferior frontal gyrus are involved in the Machiavellians' decisions in the Fair condition (see below).

In general, Machiavellianism, like other forms of deception, must be an intensive task from cognitive point of view: it needs both to inhibit the disclosure of a true affair and to present a false affair (Ding, Gao, Fu, & Lee 2013). This kind of complex reasoning may correspond with our specific result on the elevated activity in the HM' middle temporal gyrus (mTG) that was reported to play a role in creative thinking. A recent study found that mTG was linked to the higher level of creativity, specifically divergent thinking (Wei et al., 2014).

Considering our behavioral data, it is not surprising that, although HM people gained a higher profit than LMs in both conditions of the TG, the payoff difference was significantly larger between them when the partner (computer) was cooperative than when it was not. Machiavellians took advantage of being trusted and successfully exploited those who appeared cooperative and started the game with a fair return.

4.3. Inhibition of prepotent social-emotional responses

What specific abilities and what particular brain regions are involved in the Machiavellian people's success in exploiting others?

Compared to LMs, we found increased activities in the HMs' anterior dorsolateral prefrontal cortex (superior and middle frontal gyri, BA10) when their partner (presented by the computer) gave a fair return in the previous round. In general, the dorsolateral prefrontal cortex is typically engaged when individuals make decisions in which there is a conflict between social norms and personal interests (Sanfey et al., 2003) or when individuals make decisions that may be counter to their own response tendencies (Rilling et al., 2002; Rilling et al., 2008). Several studies found that the superior and medial frontal gyri play an important role in conflict processing (Aarts, Roelofs, & Turennout, 2009; Liu et al., 2012; Milham & Banich, 2005; Woodward, Metzak, Meier, & Holroyd, 2008). One of them demonstrated that conflict resolution in a virtual situation of competition (Stroop effect) activated, among others, the anterior cingulate cortex (ACC) and the superior frontal gyrus (Polosan et al., 2011). The middle and inferior frontal gyri were found to play a role in preserving the previously experienced

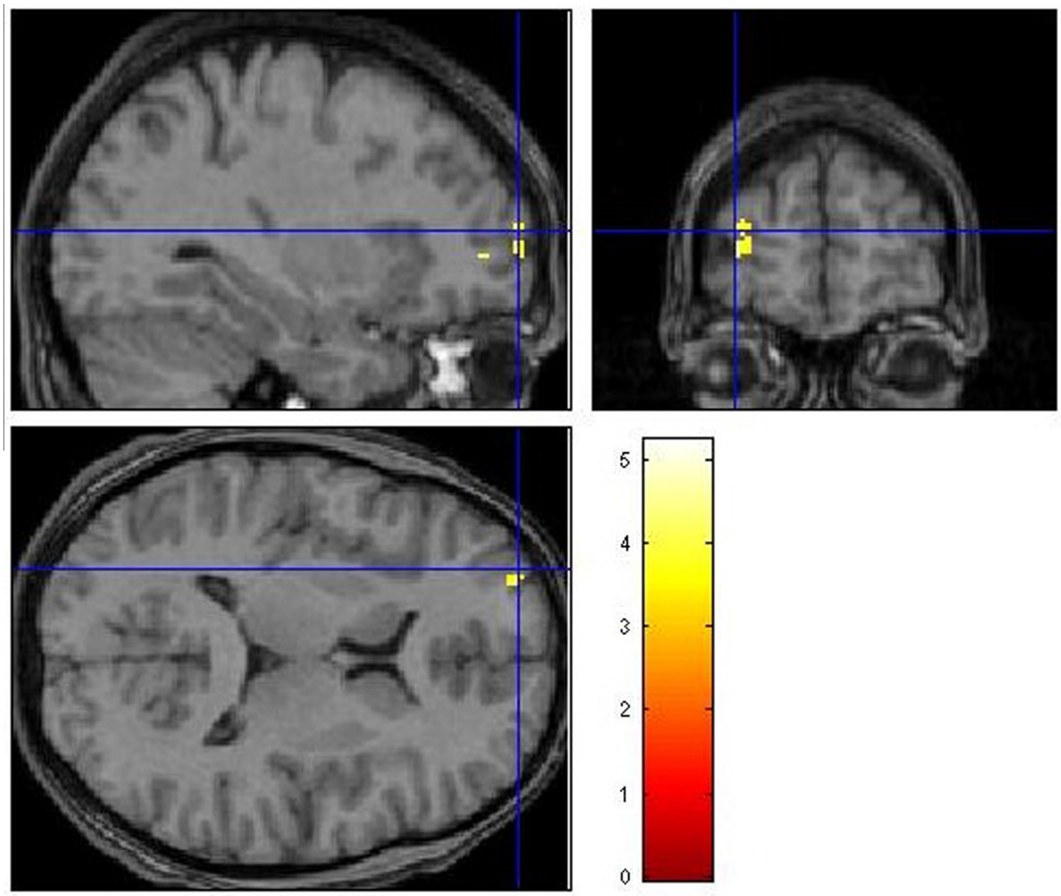

Fig. 4. Significantly higher activation in the left dorsolateral prefrontal cortex (left middle frontal gyrus and superior frontal gyrus) (MNI: −31, 59, 10) in the Fair-Control contrast for the HM group in comparison with the LM group.

conflict-based representations in the service of successful cognitive control (Kim, Johnson, & Gold, 2013).

These brain regions were activated in the moral dilemma situations (Reniers et al., 2012). A study revealed that when participants broke their promise about their subsequent behavior in a trust game, they showed greater activity in the dorsal prefrontal cortex, amygdala, and ACC (Baumgartner, Fischbacher, Feierabend, Lutz, & Fehr, 2009). Another study found that a personal moral dilemma (the "crying baby" dilemma) involved increased activity bilaterally in both the ACC (BA 24/32) and the anterior dorsolateral prefrontal cortex, including the middle frontal gyrus and the superior frontal gyrus (BA 10) (Greene, Nystrom, Engell, Darley, & Cohen, 2004). Both the ACC and the DLPFC were involved in cognitive conflict processes and the DLPFC played an important role in abstract reasoning processes in favor of utilitarian judgments, i.e. its increased activity is linked to the acceptance of personal moral violation. The authors suggested that personal moral violations elicit prepotent, negative social-emotional responses that drive people to deem such actions as inappropriate. In order to judge a personal moral violation to be appropriate one must overcome a prepotent response. It is possible that the conflict associated with a difficult moral decision was detected by the ACC, which then recruited control mechanisms in the DLPFC to help resolve the conflict in a self-oriented manner (Greene et al., 2004). In addition, the right DLPFC led to an increase in accepting unfair offers in the ultimatum game (Knoch, Pascual-Leone, Meyer, Treyer, & Fehr, 2006).

These results confirm the role of the DLPFC in inhibition processes that may be involved in the Machiavellian decision-making. As previously demonstrated, Machiavellian people are likely to judge moral violations to be appropriate, especially in situations that offer material reward for breaking norms (Christie & Geis, 1970). For gaining benefits, they may use cognitive control over emotions in accordance with their goals (Jones & Paulhus, 2009). Relying on abstract reasoning processes, they can overcome prepotent social-emotional responses and handle moral dilemmas in a utilitarian manner. Therefore, the increased activity in the HM people's DLPFC may be associated with the inhibition of the reciprocal answer to the partner's cooperative initiative. Machiavellian individuals may override their "spontaneous" cooperative reaction in a fair situation and maintain their self-oriented impulses in an unfair situation.

This interpretation would be supported by several other studies. A study revealed strong activities in the middle frontal gyrus and the inferior frontal gyrus in the inhibitory condition during a visual go/no-go task (Vidal, Mills, Pang, & Taylor, 2012). van den Bos et al. (2009) found that the ACC and the DLPFC were activated when player 2 reciprocated in a TG, even though the amount of money player 1 transferred was low. In other words, when the incentive to reciprocate was low, the ACC and the DLPFC were more engaged in reciprocal decision. The role of DLPFC in cognitive control during deception is supported by the study that found increased activity in the superior frontal gyrus was found when deceptive responses were contrasted with truthful responses (Langleben et al., 2002). A recent study found elevated activity in the dorsal prefrontal cortex in general, and the left superior frontal gyrus specifically, when participants were instructed to tell a lie rather than when they were instructed to tell the truth (Ding et al., 2013).

We found other brain areas that may be also involved in manipulation and deception via inhibitory processes. Compared to LMs, elevated activities were found in the HMs' inferior frontal gyrus (IFG, BA 47) and precentral gyrus (PrcG, BA 4/6) in the fair condition. Inferior frontal gyrus (BA 47) is reported to be involved in response inhibition (Padmala & Pessoa, 2010), and precentral gyrus is involved in carrying out stimulus–response associations (Brass, Wenke, Spengler, & Waszak, 2009). In a recent fMRI study, a brain network specifically involved in deliberate deception processing was revealed that included both IFG and PrcG (Kireev, Korotkov, Medvedeva, & Medvedev, 2013). These areas are specifically associated with deception execution but it is not clear how they are linked to the Machiavellian strategy. Future studies should investigate the possible role of these areas in inhibiting reciprocal answer and exploiting cooperative partners.

These results could be compared with findings of brain imaging studies using Trust games in various bargaining and social dilemma situations. Several studies have reported that caudate nucleus, an area involved in reward learning and the related trial-and-error feedback, plays a crucial role in the social partner's decision to reciprocate or not reciprocate cooperation (Delgado, Frank, & Phelps 2005; King-Casas et al., 2005; Phan et al., 2010; Rilling et al., 2002; Rilling et al., 2008). In contrary, we did not find caudate activation as a neural correlate of the players' decisions in the present study. This difference may come from the different experimental procedures. The other studies adapted a multiround format of TG in which the same two individuals played across several rounds. This condition may allow players to build up both long-term cooperation and moral reputation. Indeed, these studies found that reciprocated cooperation activated the caudate nucleus, whereas unreciprocated cooperation deactivated this area. In our study, however, subjects were told that they would play with different partners in the subsequent single games. In this condition, there was no chance to shape a long-term relationship based on trust and reciprocity, and to use trial-and-error learning to anticipate future reward. This may be the reason why we did not find higher activation in caudate nucleus when comparing either the Fair – Unfair situations (Table 1) or the HM and LM groups (Table 2). Moreover, another fMRI study failed to observe a correlation between Machiavelli scores and caudate activity that suggests a highly complex – and yet hardly comprehended – relationships between Machiavellianism and reward-seeking (Spitzer et al., 2007).

At the same time, some of the studies using Trust game found elevated activation in the same brain areas as we demonstrated in the present experiment. For example, Delgado and colleagues (2005) revealed elevated activity in middle frontal gyrus when subjects made a decision whether to trust hypothetical trading partners in Trust game. Another study has revealed that breaking the promise, made prior to the decision phase in Trust game, was associated with increased activation in the DLPFC and ACC, suggesting that the dishonest act involves an emotional conflict due to the suppression of the honest response (Baumgartner et al., 2009).

4.4. Monitoring others

Besides inhibition of the prepotent response, abusing the partner's cooperative intentions is likely to need a capability of (keeping track the others' behavior). Although, in the light of the former studies, Machiavellians do not show superior mentalizing abilities (Ali & Chamorro-Premuzic, 2010; Lyons et al., 2010; Paal & Bereczkei, 2007), several recent studies have revealed that HMs permanently monitor their partner in the social dilemma situations (Bereczkei & Czibor, 2014; Czibor & Bereczkei, 2012). They take the behavior of their playmates into account to a greater degree than low Machs, and adjust their behavior accordingly in order to gain the most in a particular social situation. More precisely, the HM persons' decisions are strongly influenced by the situational factors, such as the number of the altruists in the group and their partners' previous actions, whereas the decisions of LMs are rather influenced by personality traits. In accord with these results, a recent study found that, compared to LMs, the HM players during the decision-making phase of the Trust game showed a higher activity in the inferior frontal gyrus (Bereczkei et al., 2013). The authors speculated that inferior frontal gyrus may be involved in the selection of information among competitive alternatives in a social dilemma situation and play a crucial role in evaluation of the social cues.

Our results of the present study indicate that this brain area is especially active when HM persons receive a high amount of money (fair condition) from the partner (computer), whereas no stronger activity was found in this neural circuit if the other player transferred a very low sum (unfair condition). It is possible that inferior frontal gyrus plays a crucial role in the evaluation of the signals associated with the others' social behavior, and show an elevated activity when the player faces a cooperative partner as a potential victim. It may be involved in analyzing the behavioral output of their partners and guiding rational thinking in the process of decision-making. As a consequence, this brain area may enable Machiavellians to properly adapt to the challenges of environmental circumstances in order to maximize their profit.

This assumption coincide with the former findings that emphasize the role of IFG in the uncertainty assessment, risk perception, and reward expectancy (Chang, Yarkoni, Khaw, & Sanfey, 2012; Craig, 2009; Polosan et al., 2011). The inferior frontal gyrus is involved in goal directed cognition, e.g. making predictive inferences during various tasks (Liakakis et al., 2011; Virtue, Haberman, Clansy, Parrish & Beeman, 2006). A study, using a conflict resolution task, found that right inferior frontal gyrus may be related to reward-expectancy required in social competition as the participant played in order to win. According to the authors, the activation of this area may reflect the subjects' effort to observe the competitors' action (Polosan et al., 2011).

Alternatively, inferior frontal gyrus may be effective in analyzing the intentionality of the partners' behavior and anticipating their subsequent decisions in the social dilemma situation. The IFG has been demonstrated as being an important part of neuronal networks that are related to perspective-taking, mentalization, and sharing mental states. Several studies revealed that the activation of this brain area, corresponding with behavioral data, is involved in analyzing intentionality of the partner's behavior during social interaction, and rational reasoning during decision-making (Liakakis et al., 2011; Steinmann et al., 2014; Sutter, 2007).

Since we found elevated activities in IFG in the HMs' decision making process in the fair situation, we would conclude that HM subjects employ more mentalizing abilities in the exchange process than LMs. They could anticipate the partner's behavior and adjust their behavior to the anticipated decision. However, this interpretation may be weakened by the results of various psychological studies that unambiguously confirmed that Machiavellians have a worse than average mind-reading ability (Ali & Chamorro-Premuzic, 2010; Lyons et al., 2010; Paal & Bereczkei, 2007).

As a possible solution to this controversy, we suggest that Machiavellian persons may have a superior capacity in certain process of mentalization but it is limited to the "lower-level" cognitive mechanisms of mindreading, rather than "higher" ones. On the one hand, we have to take consider that both the present study and a former one (Bereczkei et al., 2013) did not find differences between HM and LM persons in the activities of brain areas, such as medial prefrontal cortex and temporo-parietal junction that have been reported as the main components of the theory of mind network (Legrand & Ruby, 2009). The activation of these areas was negatively correlated with Machiavellianism in another recent study that used ToM (mentalizing) stories and visual stimuli of various emotional states (Bagozzi et al., 2013). On the other hand, several recent studies have revealed, as mentioned before, that Machiavellians are very sensitive to the signals of social context and take the behavior of their partners into consideration to a greater extent when making a decision than did non-Machiavellians (Bereczkei & Czibor, 2014; Czibor & Bereczkei, 2012). It is possible, that Machiavellian individuals have a limited theory of mind that enables them to infer the partners' overt intentions and goals, monitors the others' behavior, and plans a future action in the hope of the material and social benefit.

5. Summary

Various social interactions involve executive mental processes such as decision making, mental flexibility, suppression of irrelevant responses and the ability to evaluate the others' behavioral output (Polosan et al., 2011). For the sake of successful exploitation, people with high scores on the Mach scale are more likely to follow their partners' decisions than those with low scores (Czibor & Bereczkei, 2012). They evaluate the changing strategies of their opponents and adjust their decisions accordingly. It is not surprising, then, that Machiavellian exploitation potentially requires crucial cognitive processes, such as reasoning and decision making. A former study found that decisions in social dilemma situations elicited higher neural response in HMs than in LMs (Bereczkei et al., 2013). In the present study, we assumed that a social environment involving opportunities for exploiting others may be more demanding for persons with stronger manipulative attitudes. In other words, Machiavellianism, like other forms of deception, needs to recruit more neural resources than a honest behavior, especially when manipulators face cooperative partner as a potential victim. Machiavellians have to inhibit the norm of reciprocity and, additionally, generate an opposite response. Indeed, we found higher neural activities in HM people in a social dilemma situation where the partner made a cooperative initiative, that is, when the partner returned a relatively high amount of money in the previous round. When the others reveal their motivation to engage in mutual cooperation, reciprocating less may be an efficient strategy for gaining higher profit, and Machiavellians in fact get a larger amount of money than non-Machiavellians under such a circumstance.

Competing for resources and gaining high profit by the end of the game requires an inhibition of cooperative tendencies and a permanent monitoring of the partner. Accordingly, we found elevated activities in the HMs' anterior DLPFC and inferior frontal gyrus, compared to LMs. These brain regions are probably involved in the Machiavellians' decision to follow the partner's steps in the social dilemma situation, reject the partner's cooperative initiative and overcome their own emotional responses. An important question that should be answered in future research is how Machiavellian persons regulate their emotional states and what neural structures are involved in their ''cool-headed'' behavior.

Acknowledgments

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