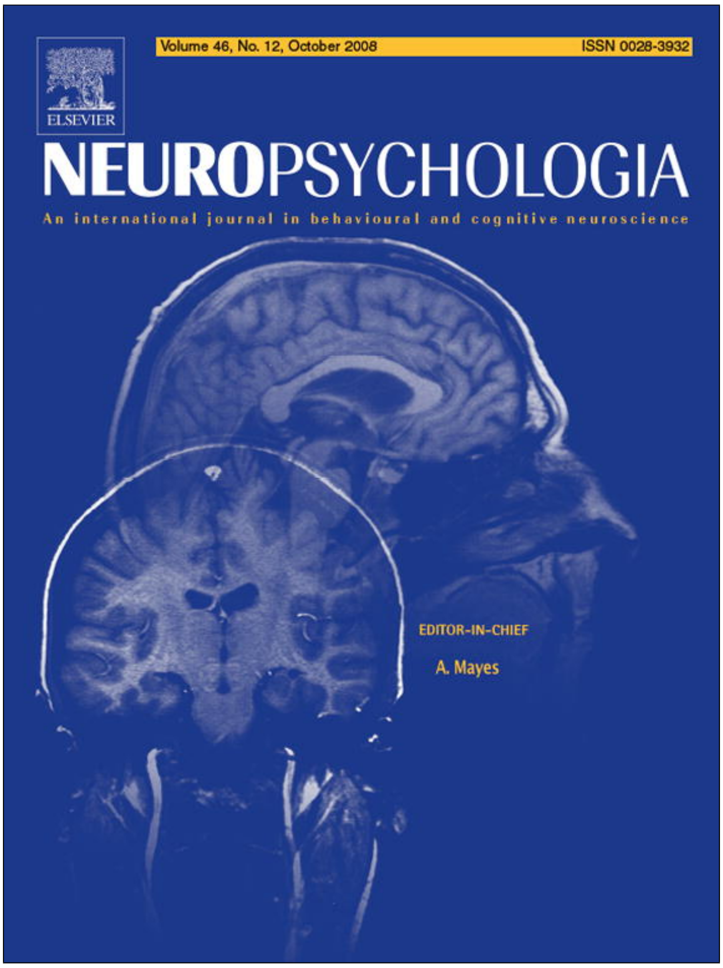

Volume 46, No. 12, October 2008
ISSN 0028-3932
ELSEVIER
NEUROPSYCHOLOGIA
An international journal in behavioural and cognitive neuroscience
EDITOR-IN-CHIEF
A. Mayes

Neuropsychologia 46 (2008) 2949–2957

Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia

The influence of prior record on moral judgment☆

Dorit Kliemann[a,b,*], Liane Young[b], Jonathan Scholz[b], Rebecca Saxe[b]

[a] *Department of Neuropsychology and Behavioral Neurobiology, Center for Cognitive Sciences, Hochschulring 18, Cognium Building, D-28359 Bremen, Germany*
[b] *Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139, USA*

ARTICLE INFO

Article history:
Received 30 January 2008
Received in revised form 29 April 2008
Accepted 5 June 2008
Available online 20 June 2008

Keywords:
Theory of Mind
Moral reasoning
Temporo-parietal junction
Economic game
fMRI

ABSTRACT

Repeat offenders are commonly given more severe sentences than first-time offenders for the same violations. Though this practice makes intuitive sense, the theory behind escalating penalties is disputed in both legal and economic theories. Here we investigate folk intuitions concerning the moral and intentional status of actions performed by people with positive versus negative prior records. We hypothesized that prior record would modulate both moral judgment and mental state reasoning. Subjects first engaged in an economic game with fair (positive prior record) and unfair (negative prior record) competitors and then read descriptions of their competitors' actions that resulted in either positive or negative outcomes. The descriptions left the competitors' mental states unstated. We found that subjects judged actions producing negative outcomes as more "intentional" and more "blameworthy" when performed by unfair competitors. Although explicit mental state evaluation was not required, moral judgments in this case were accompanied by increased activation in brain regions associated with mental state reasoning, including predominantly the right temporo-parietal junction (RTPJ). The magnitude of RTPJ activation was correlated with individual subjects' behavioural responses to unfair play in the game. These results thus provide insight for both legal theory and moral psychology.

1. Introduction

Repeat offenders commonly receive more severe sentences than first-time offenders for the same violations. This principle of escalating penalties with offense history is widespread in both criminal and civil law, in many countries and over many centuries (Durham, 1987). Moreover, the practice fits with common sense: intuitively, it seems "right" that persistent offenders receive more severe punishments. Nevertheless, both justice and economic models of the law advocate against escalating penalties. According to the justice model, punishment is justified only if the amount of punishment is proportional to the harm caused by the violation. Escalating penalties violate this rule, punishing repeat offenses disproportionately (Ashworth, 2005; Durham, 1987). According to the economic model, an optimal punishment regime is one in which the expected punishment for a violation equals the social cost of the violation. Expected punishment is a function of both the penalty once caught, and the probability of being caught. Since repeat offenders are more likely to be caught than first-time offenders, their expected punishment escalates even if the amount of the penalty does not (Dana, 2001; Emons, 2007).

In spite of these considerations, legal practice in the US over the past 30 years has tended towards increasing, rather than decreasing, reliance on prior record during sentencing, as in the "Three-Strikes" policy in California (Austin, Clark, Hardyman, & Henry, 2000). Many efforts have been made to account for this phenomenon (Ashworth, 2005; Dana, 2001). One theory, for example, treats escalating penalties as deterrence or preventative incapacitation: if the offender is incarcerated, he or she will be less able to commit another offense (Ashworth, 2005).

An alternative is that escalating penalties express society's moral condemnation of persistent wrongful action (Dana, 2001; Sunstein, 2005), regardless of utilitarian calculations. The current study investigates this alternative: do laypersons indeed judge first-time offenders as less blameworthy, and repeat offenders as more blameworthy, for the same harm caused? How are the effects of prior record related to other aspects of folk morality, such as attribution of intent to moral agents (Cushman, personal communication; Pizarro, Laney, Morris, & Loftus, 2006; Woolfolk, Doris, & Darley, 2006)? Specifically, does negative prior record lead subjects to attribute more intentionality to agents for causing negative outcomes; if so, is this effect a cause or a consequence of a change in moral judgment, i.e. increase in blame.

Consider the following example scenario: *Ashley works at the computer help desk and often friends bring their computers. Once,*

☆ The study was carried out at the Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology.

* Corresponding author at: Max-Planck-Institute for Human Development, Lentzeallee 94, 14195 Berlin, Germany. Tel.: +49 30 824 06 473.
E-mail address: kliemann@mpib-berlin.mpg.de (D. Kliemann).

0028-3932/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.neuropsychologia.2008.06.010

Table 1
Story Task vignettes

Negative outcome story	Target sentence	Positive outcome story	Target sentence
Jessica once went on a camping trip with her ex-boyfriend. On the second day, there was a thunderstorm, and a big branch fell onto the tent, hitting him on the ankle. She wrapped an ace bandage tightly around the swelling ankle, which made the swelling get worse, and the pain even more intense	Jessica made her ex-boyfriend's swelling ankle worse when she wrapped it	Jessica once went on a camping trip with her ex-boyfriend. On the second day, there was a thunderstorm, and a big branch fell onto the tent, hitting him on the ankle. She wrapped the swelling ankle in a sheet that was soaked from the cold rainwater. The cold water numbed the pain and helped him recover	Jessica wrapped her ex-boyfriend's swelling ankle and it helped him to recover
Chris found someone else's clothes lying wet in the washing machine in the basement of his building. He put all of the clothes into the dryer and turned it on the regular cycle, shrinking his neighbor's new sweater four sizes	Chris shrank his neighbor's new sweater	Chris was doing his laundry very late at night, in the basement of his building. Mixed in with his own dry clothes were someone else's clothes. He kept folding until all the clothes were done: his own, and the stranger's	Chris folded some of the stranger's dry clothes

In each scenario, one of the ten competitors from the Game performed an action that either lead to a positive or a negative outcome. Scenarios did not explicitly state the agent's intentions or the action's moral status. Corresponding to each story, a target sentence was presented to ask for subject's rating of the intentional (Behavioural Experiment) or moral status (fMRI Experiment) of the action.

her ex-boyfriend brought his computer, which had crashed. Ashley restarted the computer, the hard-drive was re-formatted and all of Chris' files were lost. For actions resulting in a negative outcome (e.g., lost files on the computer) caused by an agent with a negative prior record (e.g., a negative prior personal experience with Ashley), we hypothesize that participants judge the agent as (1) more blameworthy and (2) having acted more intentionally, compared to agents with no prior record. If so, we further ask whether the increase in blame precedes or follows the increased attribution of intentionality. The current study investigated these questions, using behavioural and neuroimaging (functional magnetic resonance imaging, fMRI) methods.

Subjects read a series of short vignettes about an agent's action and the subsequent positive or negative outcome (Story Task). The stories left the mental states (e.g., thoughts, desires, intentions) of the agents unstated (for an example of the vignettes see Table 1), making both the moral and intentional status of the actions ambiguous. Subjects then judged the intentional status of the actions (Behavioural Experiment), or the moral status of the actions (fMRI Experiment).

To manipulate the perceived "prior record" of the agents in the stories, the subjects were exposed to a (purportedly) real social interaction (the Game) with the same agents prior to participating in the Story Task. The social interaction took place in the context of an economic game; fairness and trustworthiness are emotionally salient and morally valenced features of social behaviour that can be manipulated realistically in the lab (Berg, Dickhaut, & McCabe, 1995; Haselhuhn & Mellers, 2005; Koenigs & Tranel, 2007; Rabin, 1993; Singer, Kiebel et al., 2004; Singer et al., 2006). Subjects played against 10 competitors; half of the competitors played fairly (positive prior record), and the others played unfairly (negative prior record). We then assessed the influence of prior record on subjects' subsequent judgments about the competitors' actions in the Story Task.

In particular, we investigated the patterns, and neural correlates, of folk intuitions about the intentional status of repeat versus first-time offenses. To this end, subjects in the fMRI Experiment also performed a second task while in the scanner, designed to identify brain regions previously implicated in mental state reasoning or Theory of Mind (Baron-Cohen, Leslie, & Frith, 1985; Flavell, 1999; Leslie, Friedman, & German, 2004; Premack & Woodruff, 1978; Saxe, 2006; Saxe, Carey, & Kanwisher, 2004). Previous research on the neural basis of Theory of Mind has identified a consistent group of brain regions recruited when participants reason about another agent's beliefs, desires, and/or intentions: the temporo-parietal junction (bilaterally) (RTPJ, LTPJ), the precuneus (PC) and the medial prefrontal cortex (MPFC) (Fletcher et al., 1995; Gallagher et al., 2000; Ruby & Decety, 2003; Saxe & Kanwisher, 2003; Vogeley et al., 2001). Of these regions, the RTPJ appears to be the most selective for belief attribution (Aichhorn, Perner, Kronbichler, Staffen, & Ladurner, 2006; Saxe & Powell, 2006; Saxe & Wexler, 2005). We therefore hypothesized that the response profile in these brain regions, especially, the RTPJ, would provide evidence concerning the influence of prior record on mental state reasoning during moral judgment.

2. Methods

Subjects (fMRI Experiment: nine male, seventeen female, aged 19–33 years; Behavioural Experiment: three male, four female, aged 18–48 years) were naïve to experimental hypotheses, right-handed and recruited by email at the Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology (MIT). All subjects had normal or corrected-to-normal vision, were native English speakers, participated for payment and gave written informed consent in accordance with the requirements of MIT's Committee on the Use of Humans as Experimental Subjects. Each subject participated two sessions: the Game, and the Story Task.

2.1. Game

Subjects were told that they were recruited in groups of 10–12 people, who would not meet face to face, but would play the Game against each other over a computer network. When they arrived, subjects were met by an experimenter and taken to a hallway containing 12 experimental rooms, each labeled with the experiment name, and a subject number. Subjects were taken into one room containing a single computer and a sheet of paper, their photograph was taken, and they were given written instructions for the Game (described below). Subjects were informed that in the second experimental session, members of the group would read stories about one another. They were asked to provide two or three short stories that would be rewritten by the experimenters and later presented to the players. They were provided hints of possible story types (e.g., something nice you did for a stranger, something that turned out worse than expected).

After a few minutes, the experimenter returned, collected the stories, and showed the subject a page containing photographs of the 10 "other players". Subjects were asked to mark on the page whether they knew any of the people in the photographs. The photographs were taken from the FRI CVL database of face images (http://www.lrv.fri.uni-lj.si/facedb.html, Solina, Peer, Batagelj, Juvan, & Kovac, 2003) and showed six male and four female white college-aged faces. All subjects marked that they did not know any of the players. Then subjects were instructed to wait for a cue, on the screen, that everyone else was ready, and that the Game was about to begin. The experimenter then left the room, and within 2 min triggered the Game remotely.

Subjects then played 100 trials of repeated sequential economic investment game. For each trial, an Investor and a Trustee were chosen: the subject was ran-

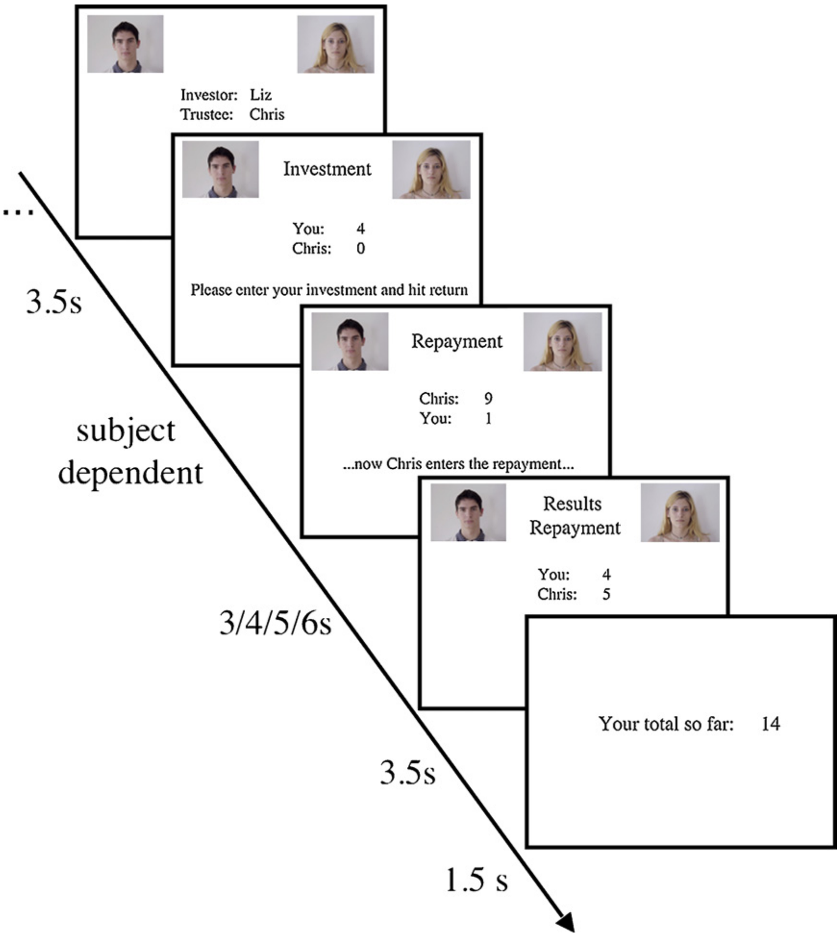


Fig. 1. Schematic representation of a single Game trial. First, role assignments are displayed for 3.5 s. The second screen asks for the investment (in this example trial, subject represents the Investor). The repayment screen then indicates, that the other player enters the repayment (jittered display time (3/4/5/6 s)). The next screen displays the results of the repayment for 3.5 s. Finally, subject's intermediate result of collected Money Units is displayed for 1.5 s.

domly assigned to be either the Investor or the Trustee, and one of the other ten competitors was chosen to play the opposite role. Role assignments were initially displayed on the screen, along with both players' names and photographs (Fig. 1). On average, subjects played ten games against each competitor, five as Investor and five as Trustee. The Investor was assigned four Money Units (MUs), and chose to invest between one and four with the Trustee (Investment (I)). The invested amount of money was tripled ($I \times 3$) and given to the Trustee, who then decided what fraction of the tripled money to repay the Investor (Repayment (R), $R(I \times 3)$, rounded to the nearest integer), which was displayed on the screen. Then, the final distribution across players was displayed on the screen (e.g., Liz: 8, Chris: 4). Subjects were told that earning during the game would partly influence their final pay for the experiment, and that playing cooperatively with other players would maximize their earnings. (In fact, subjects earned almost exactly the same amount in the Game, and all subjects were paid the same.) Half of the competitors played unfairly as Trustee, resulting in final distributions skewed toward the subject ("unfair", R randomly selected between 0 and 1/4). The other half played fairly, resulting in equitable final distributions ("fair", R between 1/3 and 2/3). The assignment of specific face photographs to fair versus unfair play was counterbalances across subjects.

2.2. Story Task

In the second session, subjects first read short vignettes, each of which described an action of one of the players from the Game. The vignettes described an action that either lead to a positive or to a negative outcome (for examples see Table 1). Scenarios were designed to leave the moral status of the actions partly ambiguous: no information about the intentions or beliefs that led to the action was provided. For every player, two stories with a positive and two with a negative outcome were presented, resulting in 40 stories in total. Each specific story was attributed to a previously fair player for half of the subjects, and to a previously unfair player for the other half. The photograph and the name of the player accompanied each story to help subjects identify the player, and to serve as implicit reminders of their behaviour in the Game. Stories were presented across runs in a counterbalanced order across conditions (fair versus unfair player, positive versus negative outcome).

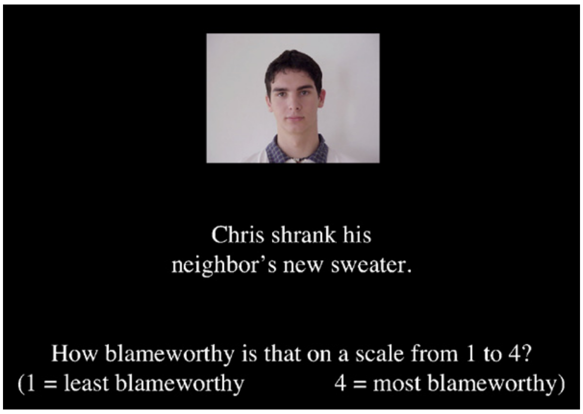
After reading all of these stories, subjects were told that they would have to make judgments about the actions described in these stories: either about the intentions of the person (Behavioural Experiment) or about the blame- or praiseworthiness of the action (fMRI Experiment). A short sentence summarizing the story's outcome was presented, accompanied by the player's photograph and name (Fig. 2). Sentences were presented in randomized order. Each sentence was presented for 8 s followed by 6, 8 or 10 s rest period. In the Behavioural Experiment, subjects were asked to judge "How intentional was the action?" on a scale from 1 (not intentional) to 4 (definitely intentional). In the fMRI Experiment, subjects were asked to judge "How blame-/praiseworthy is the action?" ("blameworthy" for negative outcomes, "praiseworthy" for positive outcomes) on a scale from 1 (least blame-/praiseworthy) to 4 (most blame-/praiseworthy). Subjects made their response on a keyboard (Behavioural Experiment) or button box (fMRI Experiment).

2.3. Behavioural Experiment

The Story Task was conducted in the same room as the Game, within 24 h of the Game session. Stimuli were presented via Matlab 7.3 (Mathworks) and Psychtoolbox extensions (http://www.psychtoolobox.org) running on an iMac in white font on black background.

2.4. fMRI Experiment

The Story Task was conducted in the scanner, within 48 h of the Game session. Subjects were scanned using a Siemens Magnetom Tim Trio 3T system (Siemens Medical Solutions, Erlangen, Germany) in the Athinoula A. Martinos Imaging Center at the McGovern Institute for Brain Research at MIT, using 30 4-mm-thick near-



Chris shrank his
neighbor's new sweater.

How blameworthy is that on a scale from 1 to 4?
(1 = least blameworthy 4 = most blameworthy)

Fig. 2. Stimuli for judging action's moral status (fMRI Experiment). Presentation of competitor's name, photograph and a short sentence summarizing the story's outcome. Subjects are asked to rate the action's blame- (for negative outcomes) or praiseworthiness (for positive outcomes) on a scale of 1 (least blame-/praiseworthy) to 4 (most blame-/praiseworthy).

axial slices with whole brain coverage (TR = 2 s, TE = 30 ms flip angle = 90°). Stimuli were presented in the scanner using a Hitachi (CP-X1200 series) projector displayed on a rear projection screen (Da-Lite) via Matlab 5.0/7.3 (Mathworks) and Psychtoolbox extensions (http://www.psychtoolobx.org) running on an Apple G4 laptop in white font on black background. Reaction time and response data were obtained during both MRI-experiments with a fiber-optic MR-safe button response box.

In addition to the Story Task, these subjects participated in a localizer experiment in the same scan session, contrasting reasoning about false non-moral beliefs (belief stories) with reasoning about non-social control situations (photograph stories), following the methods reported in Saxe and Kanwisher (2003, Experiment 2). Each story was presented for 10 s, followed by a short fill-in-the-blank question about the story (4 s). The stories were presented in counterbalanced order across runs and across subjects.

Following the scan session, subjects took a short recognition memory test in order to determine if they remember the behaviour of each player during the Game. Subjects had three response options (fair–neutral–unfair) to differentiate between fair and unfair players. The memory task was conducted on a MacBook laptop immediately after subjects came out of the scanner. Finally, there was a short debriefing period that included an assessment of whether the subjects actually believed that they were playing against real 'people' (yes–not sure–no).

The MRI data were analyzed with SPM2 (www.fil.ion.ucl.ac.uk/spm/) and in-house software. Individual subjects' data were motion corrected, normalized to the functional template (Montreal Neurological Institute Template) smoothed using a Gaussian filter (full width half maximum (FWHM) = 5 mm) and high pass filtered prior to further analysis. A slow event-related design was used and modeled by using a boxcar regressor to estimate the hemodynamic response for every condition. An event was a single presentation of a sentence that summarizes the action of the former story; the event-onset was defined by the onset of the text on the screen. Contrasts were calculated for each subject and then submitted to a second-order group random effects analyses.

Based on the localizer whole brain contrast (false belief versus false photograph), Theory of Mind regions of interest (ROIs) in each participant were defined as clusters of contiguous voxels with a higher BOLD response during 'false belief' than 'false photograph' stories ($P < 0.0001$, uncorrected), within 5 mm of the peak voxel in anatomical areas implicated in Theory of Mind by previous studies: PC, middle MPFC (mMPFC), dorsal MPFC (dMPFC), ventral MPFC (vMPFC) and bilateral TPJ (Ciaramidaro et al., 2007; Fletcher et al., 1995; Gallagher et al., 2000; Gobbini, Koralek, Bryan, Montgomery, & Haxby, 2007; Ruby & Decety, 2003; Saxe, Carey et al., 2004; Saxe & Kanwisher, 2003; Saxe, Moran, Scholz, & Gabrieli, 2006; Saxe & Powell, 2006; Saxe, Xiao, Kovacs, Perrett, & Kanwisher, 2004; Vogeley et al., 2001; Young, Cushman, Hauser, & Saxe, 2007).

Within these ROIs, the average percent signal change (PSC) relative to rest baseline (PSC = 100 raw BOLD magnitude for (condition_fixation)/raw BOLD magnitude for fixation) was calculated for each condition at each time point (averaging across all voxels in the ROI and all blocks of the same condition). Adjusted for hemodynamic lag, PSC during stimuli presentation in each of the ROIs was compared across experimental conditions. Because the data defining the ROIs were independent from the data used in the fMRI Experiment, Type I errors were drastically reduced. All peak voxels are reported in Montreal Neurological Institute Coordinates.

Statistical analysis (Behavioural and fMRI Experiment) utilized post hoc paired-samples *t*-tests and repeated-measures ANOVAs, both conducted with an alpha level of 0.05.

3. Results

3.1. Game

Subjects detected and adapted to the difference between fair and unfair players very rapidly during the Game (see Fig. 3a). To determine the influence of player's fairness, we used a 2 × 2 (fairness [fair versus unfair] by half [first half versus second half of trials]) repeated-measures ANOVA on the subjects' investments. This analysis revealed significant main effects of fairness [$F_{(1,32)} = 161.67$; $P < 0.001$, partial $\eta^2 = 0.84$] and half [$F_{(1,32)} = 4.81$; $P = 0.036$; partial $\eta^2 = 0.13$], which were mediated by a significant interaction between the two factors [$F_{(1,32)} = 23.46$; $P < 0.001$; partial $\eta^2 = 0.48$]. Post hoc *t*-tests showed that the investments with fair players persisted at the same level over the course of the economic game [first half mean: 3.23/4; second half mean: 3.32/4]. By contrast, investments with unfair players significantly decreased from the first

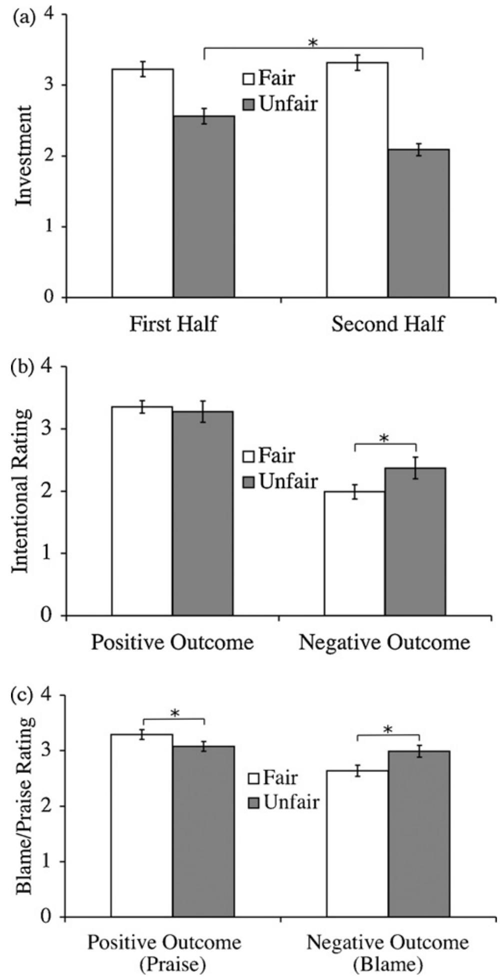


Fig. 3. Behavioural results. (a) Investment over the course of the Game. Subject's significantly decreased their investments with unfair players from the first to the second half of the Game ($n = 33$, $P < 0.001$), whereas investments with fair players leveled off. Error bars (+/−) correspond to standard error. (b) Rating of action's intentional status (Behavioural Experiment). Subjects judged that previously unfair players intended negative outcomes to a significantly greater degree than previously fair player ($n = 7$, $P = 0.008$). For positive outcomes, there was no effect of prior record (fairness): subjects judged all players to have intended positive actions to the same degree. Error bars (+/−) correspond to standard error. (c) Ratings of actions' moral status (fMRI Experiment). For negative outcomes, subjects judged previously unfair players as significantly more blameworthy than fair players for the same performed actions. There was a similar, but smaller, effect on praise for positive outcomes. Error bars (+/−) correspond to standard error.

to the second half [first half: 2.56; second half: 2.19; $t_{(32)} = 4.24$; $P < 0.001$]. Average investment was significantly higher with fair than with unfair players in both halves (first half [fair: 3.23; unfair: 2.56; $t_{(32)} = 9.01$; $P < 0.001$], second half [fair: 3.32; unfair: 2.19; $t_{(32)} = 11.67$; $P < 0.001$]).

3.2. Behavioural Experiment

Subjects were asked to evaluate the outcomes of players' actions on a scale from 'not intentional' (1) to 'definitely intentional' (4). To examine whether the outcome of the stories and the player's former fairness influenced subject's judgments, we conducted a 2 × 2 (fairness [fair versus unfair] by outcome [positive versus negative]) repeated-measures ANOVA. The analysis yielded a significant main effect of outcome [$F_{(1,6)} = 32.29$; $P = 0.001$; partial $\eta^2 = 0.84$] and a significant interaction of fairness and outcome [$F_{(1,6)} = 9.35$; $P = 0.02$; partial $\eta^2 = 0.61$]. In general, positive outcomes (mean: 3.3 of 4) were judged to be more intentional than negative outcomes (mean: 2.2 of 4). Subjects judged that both previously fair and previously unfair players intended the positive outcomes to the same degree (fair/positive: 3.35; unfair/positive: 3.28; $t_{(6)} = 0.59$; $P = 0.58$) (see Fig. 3b). By contrast, subjects judged that previously unfair players intended the negative outcomes to a significantly greater degree than previously fair players (fair/negative: 1.9; unfair/negative: 2.4; $t_{(6)} = -3.852$; $P = 0.008$). All seven subjects showed the same effect. There were no effects of condition on reaction times.

The magnitude of the fairness effect on judgments of negative stories' intentional status (the difference in judging the intentional status of negative actions for unfair versus fair) was furthermore positively correlated with the fairness effect on subjects' investments during the Game (the difference between investments with fair versus unfair players) [Pearson's $r = 0.81$; $P = 0.03$ (two-tailed)]. The more subjects differentiated between fair and unfair players in their investments, the more they judged that unfair players intended the negative outcomes more than fair players did.

3.3. fMRI Experiment, behavioural data

Subjects were asked to evaluate competitor's actions in the short stories on a scale from 'least blame-/praiseworthy' (1) to 'most blame-/praiseworthy' (4). To examine whether the outcome of the stories and the player's former fairness influenced subject's judgments, we conducted a 2 × 2 (fairness [fair versus unfair] by outcome [positive versus negative]) repeated-measures ANOVA. The analysis yielded a significant main effect of outcome [$F_{(1,25)} = 22.88$; $P < 0.001$; partial $\eta^2 = 0.49$] and a significant interaction of the two factors [$F_{(1,25)} = 12.97$; $P = 0.001$; partial $\eta^2 = 0.34$]. In general, praise-judgments (praise for positive outcomes, mean: 3.19 of 4) were higher than blame-judgments (blame for negative outcomes, mean: 2.81 of 4) (see Fig. 3c). When judging a story with a positive outcome, subjects judged previously fair players as deserving more praise than unfair players [fair/positive: 3.29; unfair/positive: 3.08; $t_{(25)} = 2.74$; $P = 0.01$]. By contrast, subjects judged previously unfair players as deserving more blame than fair players when their actions led to negative outcomes [fair/negative: 2.64; unfair/negative: 2.99; $t_{(25)} = 3.08$; $P = 0.005$]. Twenty-two of 26 subjects showed this effect of fairness on moral judgment of negative outcomes [Binomial Test; $P = 0.001$].

Across individual subjects, the magnitude of the fairness effect on moral judgments of negative actions (the difference in assigned blame to negative actions of unfair versus fair players) was not correlated with the effect of fairness on investments [Pearson's $r = 0.021$; $P = 0.9$ (two-tailed)]. One factor that may have contributed to the absence of this effect was that, according to their responses in the debriefing, some of the subjects deliberately tried to avoid letting their judgments be biased by their memory of the competitor's fairness during the Game. If so, then responses during the experiment may underestimate the influence of prior fairness on moral intuitions for some subjects.

Table 2
Localizer experiment results

ROI	Individual ROIs			Whole brain contrast		
	x	*y*	*z*	*x*	*y*	*z*
RTPJ	54	−58	24	58	−56	32
LTPJ	−52	−60	28	−50	−60	32
PC	2	−52	38	6	−56	30
vMPFC	2	50	−7	2	52	−4
mMPFC	2	57	15	2	52	22
dMPFC	0	55	31	4	56	36

Average peak voxels for ROIs in Montreal Neurological Institute coordinates. The "Individual ROIs" columns show the average peak voxels for individual subjects' ROIs. The "Whole brain contrast" columns show the peak voxel in the same regions in the whole brain random effects group analysis.

We also analyzed subjects' reaction times by condition. The analysis revealed a significant main effect of outcome [$F_{(1,25)} = 6.8$; $P = 0.015$; partial $\eta^2 = 0.21$] and an interaction between fairness and outcome [$F_{(1,25)} = 5.12$; $P = 0.03$; partial $\eta^2 = 0.17$]. Subjects were significantly slower when judging previously fair players whose actions led to negative outcomes than to any other condition [all $P < 0.05$]. There were no effects of subject's gender on moral judgment.

After the scanner session, subjects rated the fairness of each subject on a scale of 1 ('unfair'), 2 ('neutral') to 3 ('fair'). The recognition memory task suggested that subjects could explicitly distinguish between fair and unfair players [fair: 2.52; unfair: 1.5; $t_{(24)} = 13.76$; $P < 0.001$]. Correlation analyses revealed that individual differences in explicit memory for fairness were not correlated with any behavioural or neural measure of moral judgment.

At the end of the experiment, a debriefing explored whether subjects believed that the players were 'real people'. Nine subjects did not believe that the competitors were "real", seven were "not sure" and ten subjects believed that they were playing with and reading stories about real people. Post hoc analyses revealed no significant effects of this variable on subjects' moral judgments, however, so all subjects contributed to the analyses below.

3.3.1. fMRI Experiment, imaging results

Our primary goal was to investigate the effect of prior record on the neural representation of the agent's thoughts and intentions, during moral judgments. To do so, we analyzed the fMRI results in individually defined regions of interest, based on the localizer experiment. As predicted, a whole brain random effects analysis of the localizer experiment replicated former studies' results (see Fig. 4a and b) (Gallagher et al., 2000; Gobbini et al., 2007; Perner, Aichhorn, Kronbichler, Staffen, & Ladurner, 2006; Saxe & Powell, 2006; Young et al., 2007): increased BOLD response during false belief, compared to false photograph stories was observed in bilateral TPJ, dMPFC, mMPFC, vMPFC and PC. We defined individual ROIs as follows: RTPJ (26/26 subjects), LTPJ (19/26), PC (24/26), mMPFC (15/26), dMPFC (20/26) and vMPFC (12/26) (Table 2). Inspection of the time-series revealed a late effect in raw PSC time courses of some regions (predominantly the RTPJ); the PSC in each ROI was therefore calculated for two time intervals: during the moral judgment (up to average RT, 5 s after sentence onset), and immediately after judgment. Allowing for the hemodynamic lag, these intervals were: during (Time1: 4–10 s) and after (Time2: 12–18 s) moral judgment. Each ROI's response was then analyzed using a 2 × 2 × 2 (fairness [fair versus unfair] by outcome [positive versus negative]

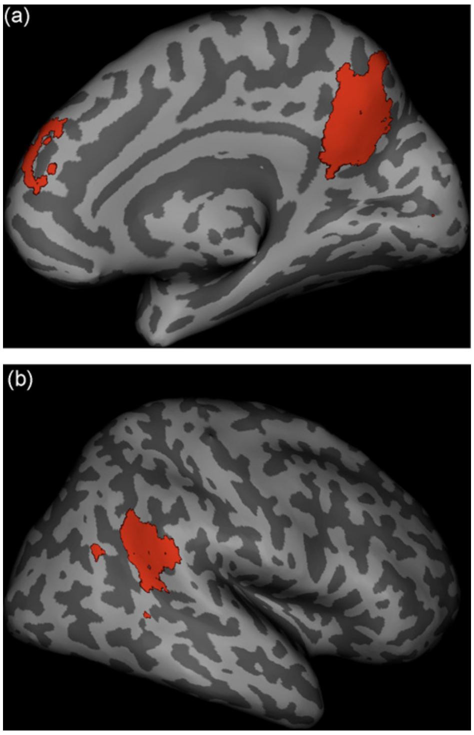


Fig. 4. Localizer task activations in the right hemisphere (group results, displayed on the inflated surface of a standard brain), showing regions where the BOLD signal was higher for (non-moral) stories about beliefs than about physical representations ($n = 26$, whole brain random effects analysis, $P = 0.0001$, uncorrected, $k > 20$). (a) Medial surface: PC and the MPFC and (b) lateral surface: RTPJ.

by time [Time1 versus Time2]) repeated-measures ANOVA of the average PSC.

The most robust effects of fairness were observed in the RTPJ. The response in this region showed a significant interaction of the three factors [$F_{(1,25)} = 8.19$; $P = 0.008$; partial $\eta^2 = 0.25$]. We therefore analyzed the response separately at Time1 and Time2. At Time1 there were no significant effects. Only after moral judgment (Time2), RTPJ showed a significant interaction between fairness and outcome [$F_{(1,25)} = 9.31$; $P = 0.005$; partial $\eta^2 = 0.27$]. In stories with negative outcomes, activation was significantly increased for previously unfair, as compared to fair players [unfair/negative: 0.09; fair/negative: −0.06; $t_{(25)} = -2.92$; $P = 0.007$] (see Fig. 5). Twenty of 26 subjects showed this pattern of response [Binomial Test; $P = 0.01$]. There was no effect of fairness on the response to positive outcomes.

Since there was some variation across individuals in the effect of fairness on the RTPJ response, we next investigated whether the magnitude of this effect was predicted by subject's behavioural performance during the Game and/or the fMRI Experiment. To test this hypothesis, we computed three difference scores for each subject:

(1) RTPJ difference: the difference in RTPJ response to negative outcomes at Time2, for unfair versus fair players.
(2) Investment difference: the difference between investments with fair versus unfair players during the Game (a measure of subject's original sensitivity to the fairness manipulation).
(3) Moral judgment difference: the difference between assigned blame to unfair versus fair players for negative actions in the Story Task.

We found that the RTPJ difference was positively correlated with the original investment difference [Pearson's $r = 0.45$; $P = 0.02$ (two-tailed)] (see Fig. 6). The more a subject differentiated between fair and unfair players during the initial Game, the more that subject's RTPJ would later differentiate between fair and unfair players, after moral judgments of negative outcomes. There was no correlation between the RTPJ difference and differences in moral judgments in the scanner [Pearson's $r = 0.66$; $P = 0.75$ (two-tailed)].

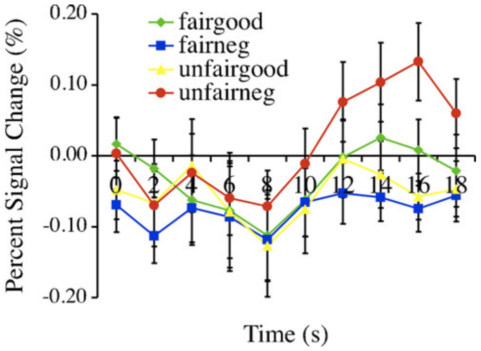


Fig. 5. Percent signal change from rest in the RTPJ over time. During Time1 (4–10 s) there were no significant differences between experimental conditions. In Time2 (12–18 s), RTPJ's response significantly increased after judging previously unfair players' actions that led to negative consequences (red) as compared to the same negative outcomes caused by fair players (blue) ($n = 26$, $P = 0.007$). There was no effect of fairness on the responses to positive outcomes. Error bars (+/−) correspond to standard error of the mean. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

Other Theory of Mind brain regions showed similar, but less robust, response profiles. In the PC, the 2 × 2 × 2 ANOVA revealed a marginally significant interaction of time (Time1 versus Time2) and outcome (positive versus negative) [$F_{(1,23)} = 4.06$; $P = 0.056$; partial $\eta^2 = 0.150$]. A separate analysis of each time suggested that the PC showed the same profile as the RTPJ, but less reliably. There were no effects of fairness or outcome at Time1. At Time2, the response was higher when unfair players' actions led to negative outcomes, as compared to positive outcomes [unfair/positive: −0.03; unfair/negative: 0.09; $t_{(23)} = -2.14$; $P = 0.043$].

Both the LTPJ [$F_{(1,18)} = 7.02\text{E}-02$; $P = 0.049$; partial $\eta^2 = 0.19$] and the dMPFC [$F_{(1,19)} = 4.51$; $P = 0.047$; partial $\eta^2 = 0.19$] showed a significant three-way interaction of time (Time1 versus Time2), fairness (fair versus unfair) and outcome (positive versus negative) in the 2 × 2 × 2 ANOVA. However, separate analysis of the two time intervals in both regions showed no significant effects at either time. Nevertheless the response in the LTPJ resembled that of the RTPJ and PC: the highest response was when unfair subject's action led to negative outcomes [fair/positive mean: 0.01; fair/negative mean: −0.01; unfair/positive mean: 0.04; unfair/negative mean: 0.15].

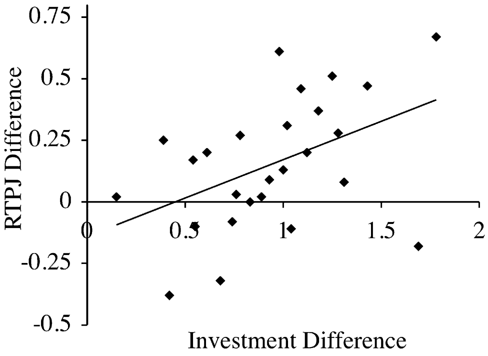


Fig. 6. Correlation of RTPJ difference and Investment difference. The more a subject differentiated between fair and unfair players during the Game, the more that same subject's RTPJ would later differentiate between fair and unfair competitors, after judging stories with negative outcomes.

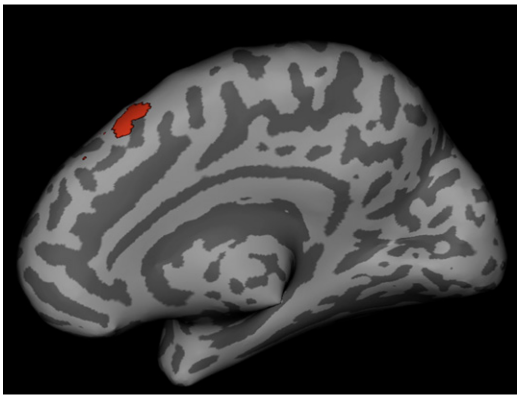


Fig. 7. Activation cluster in the dMPFC for negative > positive outcomes ($n = 26$, whole brain random effects analysis, $P = 0.001$, uncorrected, $k > 20$, global peak at $x = 4$, $y = 42$, $z = 46$).

The vMPFC and the mMPFC showed no significant main effects or interactions by condition, either in the 2 × 2 × 2 ANOVA, or in a collapsed analysis of both time intervals (4–18 s).

Finally, we conducted whole brain analyses of the Story Task directly. To investigate neural correlates of representing positive versus negative outcomes, we conducted a whole brain random effects analysis of the Story Task with two contrasts: (1) positive > negative and (2) negative > positive. The first contrast (positive > negative) produced no reliable regions of activation. The second contrast (negative > positive) revealed a significant cluster of activation in the dMPFC at $P < 0.001$ (global peak at $x = 4$, $y = 42$, $z = 46$) (see Fig. 7). Next, we used two contrasts to look for overall effects of prior record on processing of action outcomes: (3) fair > unfair, and (4) unfair > fair. These contrasts produced no reliable activations.

4. Discussion

The current study provides neural and behavioural clues concerning the role of prior record in both moral judgment and attributions of intention. As predicted, prior record influenced both of these aspects of social cognition: previously unfair competitors were judged to be more blameworthy (broadly mirroring legal practice) and to have acted more intentionally when causing negative outcomes, as compared to previously fair competitors. Neural activation in regions associated with mental state reasoning was also affected by prior record (e.g., fairness), as we discuss below.

Consistent with previous studies (Berg et al., 1995; de Quervain et al., 2004; Haselhuhn & Mellers, 2005; Singer, Kiebel, Winston, Dolan, & Frith, 2004; Singer et al., 2006), the economic game provided subjects with negative (unfair) and positive (fair) personal experiences with the competitors. During the Game, subjects quickly and selectively decreased their investments with unfair players. The resulting personal impressions were robust and enduring: previous experience with the other players subsequently biased moral judgments made up to 2 days later. Unfair players' harmful actions were judged to be both more intentional and more blameworthy, compared to judgments of the same actions when performed by fair players.

The bias in the moral judgment was accompanied by a distinctive neural response. Theory of Mind brain regions, especially the RTPJ, showed significantly higher BOLD response to harmful outcomes caused by unfair as opposed to fair players. There was no effect of prior record on response to positive outcomes, mirroring the pattern observed in judgments of intentionality. In addition, the differential response in the RTPJ was correlated with individual subjects' earlier discrimination of fair and unfair players during the economic game, emphasizing a link between the subjects' prior experience and mental state reasoning in the later moral judgment task.

We found no evidence for increased BOLD response, in the RTPJ or other Theory of Mind brain regions, to actions that violated prior expectations in general (e.g., positive outcomes produced by unfair players, negative outcomes produced by fair players). These results speak against the recent proposal that the role of the RTPJ in social tasks is in comparing predictions with incongruent outcomes and directing attention towards salient or unexpected events (Decety & Lamm, 2007). Decety and Lamm (2007)'s view was informed by the existence of a nearby region of RTPJ that is implicated in exogenous attention (the right inferior parietal component of the ventral attention network, Corbetta and Shulman (2002)). By contrast, we suggest that distinct regions within the RTPJ may be involved in attentional reorienting and Theory of Mind. Both Decety and Lamm (2007), and Scholz and colleagues (personal communication) observed approximately 10 mm of separation between peaks for the exogenous attention and Theory of Mind tasks. Although Decety and Lamm (2007) concluded that this difference was small in the context of their meta-analysis, Scholz and colleagues (personal communication) found that the same difference was reliable within individual subjects.

Given this anatomical separation, we believe that the functional localizer approach used in the current study allowed us to identify and investigate the specific sub-region of the RTPJ implicated in Theory of Mind. In this region, we observed no effect of "violation of expectation" on the neural response. Instead, we observed selective enhancement of the response to negative outcome produced by previously unfair players, which we interpret below in terms of the interaction between Theory of Mind and moral judgment.

Recent behavioural research in moral psychology emphasized the importance of Theory of Mind in moral judgments (Cushman, Young, & Hauser, 2006; Koenigs et al., 2007; Mikhail, 2007; Pizarro, Uhlmann, & Salovey, 2003; Woolfolk et al., 2006). Cushman (personal communication) found that the agent's beliefs and desires are the first and second most important factors, respectively (followed by outcomes) in determining observers' moral judgments. Consistent with those results, we have previously reported that brain regions involved in Theory of Mind are systematically recruited during moral judgment. When beliefs were presented explicitly, the RTPJ, PC and LTPJ showed an initial response at the time the belief was presented that did not depend on the valence of the belief (negative versus neutral), and an additional response, at the time that the outcome was presented, that did depend on the valence of the outcome (Young et al., 2007; Young & Saxe, 2008). We concluded that Theory of Mind brain regions are involved in both the initial encoding of belief information, and the subsequent integration of beliefs with outcomes, in order to support mature moral judgment.

Unlike our previous experimental stimuli, though, in real life people's mental states, including their beliefs, are often not explicitly available, but must be inferred from other information (Young & Saxe, in press). We hypothesized that one key source of such information would be the observer's impressions of the actor's prior record, based on personal experience and/or knowledge of the actor's offense history (Nadelhoffer, 2004a, 2004b; Phelan & Sarkissian, 2008; Pizarro et al., 2006; Woolfolk et al., 2006). The behavioural results of the current experiment support this hypothesis. Subjects read vignettes that described actions with positive or negative actions, but did not explicitly state the beliefs or desires of the protagonists (Young & Saxe, in press). Nevertheless, subjects made systematically differential intentional attributions across conditions. Given a negative personal interaction, observers judged that the protagonist was more likely to have intended the negative outcomes, compared to judgments of the same outcomes following observers' positive personal experiences with the protagonist. Across individuals, judgments of the intentional status of actions were correlated with the effect of fairness on subjects' investments during the Game.

One unpredicted but robust finding was that the effect of fairness on the RTPJ response occurred late in the time-series, *after* moral judgments were made. We propose that after subjects judged the action to be blameworthy, they continued to consider the possible mental states of the protagonist. One possibility is that subjects first feel an impulse to blame previously unfair people for causing negative outcomes, and then subsequently seek to justify this impulse by attributing to them negative intentions (Cushman et al., 2006; Haidt, 2007).

The current results may thus be a specific instance of a general phenomenon, known as the Side-Effect Effect (S-E-E) (Knobe, 2003, 2004, 2006; Knobe & Burra, 2006; Leslie, Knobe, & Cohen, 2006), a recent puzzle in moral psychology. The Side-Effect Effect is the observation that when a protagonist's action causes a side-effect that is foreseen but not directly intended (i.e. the protagonist says "I don't care about [the side-effect]"), observers judge that the side-effect was "intentional" if the side-effect is negative, but not if the side-effect is positive. The S-E-E can be induced by changing a single word in the description of the side-effect (e.g., "harm" versus "help"). An elegant recent series of experiments shows that this effect is robust across many variations of the task format (Pettit & Knobe, 2008). Even 4-year-old children show an adult-like pattern of this effect (Leslie et al., 2006).

The S-E-E poses a challenge to a traditional model of folk morality, according to which Theory of Mind serves only as an *input* to moral judgment: observers try to establish whether the outcome was intended or not based on evidence about beliefs and desires, and then rely exclusively on this information to generate a moral judgment. Instead, it seems that moral judgment (whether the action is blameworthy or praiseworthy) also influences Theory of Mind judgment (whether the side-effect is perceived as having been brought about intentionally or not) (Knobe, 2005).

One interpretation of the S-E-E is that subjects first feel an impulse to blame the protagonist who knowingly caused the negative side-effect; in order to justify this impulse, subjects then attribute to the protagonist a clearer negative intention. This interpretation fits with two aspects of the current results: (1) the timing of the effect of fairness in the RTPJ, which emerged only after moral judgment and (2) the correlation between the magnitude of the effect in the RTPJ and the earlier investment during the Game. Both the S-E-E and the current fMRI results may therefore suggest a common psychological mechanism for post hoc blame justification (Nadelhoffer, 2004a, 2004b; Phelan & Sarkissian, 2008).

The current results may provide insight into the effects of prior record on intuitive moral judgment. Legal practice suggests a range of other factors that may also be relevant for folk morality. In the law, prior record has distinct consequences for severity of punishment (i.e. sentencing) versus for judgments of blameworthiness (i.e. conviction). The role of offense history is further modulated by the similarity of means and consequences between prior actions and the current accusation (i.e. habit or routine practice). These determinants of legal practice may have interesting psychological and neural implications. More generally, future research using cognitive neuroscience methods will help to characterize the common ground between folk morality and legal practice, as well as the specific contexts in which they diverge.

Acknowledgments

The authors are grateful to Josh Tenenbaum, John Mikhail, Christina Triantafyllou, Laura Schulz, Mike Frank, and Manfred Herrmann for their intellectual and technical support, and to Allen Mintz for help collecting the behavioural data. The fMRI data collection was supported by the NCRR (grant P41RR14075), the MIND Institute, and the Athinoula A. Martinos Center for Biomedical Imaging.

References

Aichhorn, M., Perner, J., Kronbichler, M., Staffen, W., & Ladurner, G. (2006). Do visual perspective tasks need theory of mind? *Neuroimage*, *30*(3), 1059–1068.

Ashworth, A. (2005). *Sentencing and criminal justice* (4 ed.). New York: Cambridge University Press.

Austin, J., Clark, J., Hardyman, P., & Henry, A. (2000). *Three strikes and you're out: the implementation and impart of strike laws*. U.S. Department of Justice.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition*, *21*(1), 37–46.

Berg, J., Dickhaut, J., & McCabe, K. (1995). Trust, reciprocity, and social history. *Games and Economic Behavior*, *10*, 122–142.

Ciaramidaro, A., Adenzato, M., Enrici, I., Erk, S., Pia, L., Bara, B. G., et al. (2007). The intentional network: How the brain reads varieties of intentions. *Neuropsychologia*, *45*(13), 3105–3113.

Corbetta, M., & Shulman, G. L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nature Reviews Neuroscience*, *3*(3), 201–215.

Cushman, F., Young, L., & Hauser, M. (2006). The role of conscious reasoning and intuition in moral judgment: Testing three principles of harm. *Psychological Science*, *17*(12), 1082–1089.

Dana, D. A. (2001). Rethinking the puzzle of escalating penalties for repeat offenders. *Yale Law Journal*, *110*, 733–783.

de Quervain, D. J., Fischbacher, U., Treyer, V., Schellhammer, M., Schnyder, U., Buck, A., et al. (2004). The neural basis of altruistic punishment. *Science*, *305*(5688), 1254–1258.

Decety, J., & Lamm, C. (2007). The role of the right temporoparietal junction in social interaction: How low-level computational processes contribute to meta-cognition. *Neuroscientist*, *13*(6), 580–593.

Durham, A. M. (1987). Justice in sentencing: The role of prior record of criminal involvement. *The Journal of Criminal Law and Criminology*, *78*(3), 614–643.

Emons, W. (2007). Escalating penalties for repeat offenders. *International Review of Law and Economics*, *27*(2), 170–178.

Flavell, J. H. (1999). Cognitive development: Children's knowledge about the mind. *Annual Review of Psychology*, *50*, 21–45.

Fletcher, P. C., Happe, F., Frith, U., Baker, S. C., Dolan, R. J., Frackowiak, R. S., et al. (1995). Other minds in the brain: A functional imaging study of "theory of mind" in story comprehension. *Cognition*, *57*(2), 109–128.

Gallagher, H. L., Happe, F., Brunswick, N., Fletcher, P. C., Frith, U., & Frith, C. D. (2000). Reading the mind in cartoons and stories: An fMRI study of 'theory of mind' in verbal and nonverbal tasks. *Neuropsychologia*, *38*(1), 11–21.

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.

Haidt, J. (2007). The new synthesis in moral psychology. *Science*, *316*(5827), 998–1002.

Haselhuhn, M. P., & Mellers, B. A. (2005). Emotions and cooperation in economic games. *Cognitive Brain Research*, *23*(1), 24–33.

Knobe, J. (2003). Intentional action and side-effects in ordinary language. *Analysis*, *63*, 190–193.

Knobe, J. (2004). Intention, intentional action and moral considerations. *Analysis*, *64*, 181–187.

Knobe, J. (2005). Theory of mind and moral cognition: Exploring the connections. *Trends in Cognitive Sciences*, *9*(8), 357–359.

Knobe, J. (2006). The concept of intentional action: A case study in the use of folk psychology. *Philosophical Studies*, *130*, 203–231.

Knobe, J., & Burra, A. (2006). Intention and intentional action: A cross cultural study. *Journal of Culture and Cognition*, *6*, 113–132.

Koenigs, M., & Tranel, D. (2007). Irrational economic decision-making after ventromedial prefrontal damage: Evidence from the Ultimatum Game. *The Journal of Neuroscience*, *27*(4), 951–956.

Koenigs, M., Young, L., Adolphs, R., Tranel, D., Cushman, F., Hauser, M., et al. (2007). Damage to the prefrontal cortex increases utilitarian moral judgements. *Nature*, *446*(7138), 908–911.

Leslie, A. M., Friedman, O., & German, T. P. (2004). Core mechanisms in "theory of mind". *Trends in Cognitive Sciences*, *8*(12), 528–533.

Leslie, A. M., Knobe, J., & Cohen, A. (2006). Acting intentionally and the side-effect effect. *Psychological Science*, *17*(5), 421–427.

Mikhail, J. (2007). Universal moral grammar: Theory, evidence and the future. *Trends in Cognitive Sciences*, *11*(4), 143–152.

Nadelhoffer, T. (2004a). Blame, badness and intentional action: A reply to Knobe and Medlow. *Journal of Theoretical and Philosophical Psychology*, *24*, 259–269.

Nadelhoffer, T. (2004b). On praise, side effects, and folk ascriptions of intentionality. *Journal of Theoretical and Philosophical Psychology*, *24*, 196–213.

Perner, J., Aichhorn, M., Kronbichler, M., Staffen, W., & Ladurner, G. (2006). Thinking of mental representations: The roles of left and right temporo-parietal junction. In Saxe & Baron-Cohen (Eds.), *Social neuroscience* (pp. 245–258). New York: Psychology Press.

Pettit, D., & Knobe, J. (2008). *The pervasive impact of moral judgment*. UNC-Chapel Hill.

Phelan, M., & Sarkissian, H. (2008). The folk strike back; or, why you didn't do it intentionally, though it was bad and you knew it. *Philosophical Studies*, *138*(2), 291–298.

Pizarro, D., Uhlmann, E., & Salovey, P. (2003). Asymmetry in judgments of moral blame and praise: The role of perceived metadesires. *Psychological Science*, *14*(3), 267–272.

Pizarro, D. A., Laney, C., Morris, E. K., & Loftus, E. F. (2006). Ripple effects in memory: Judgments of moral blame can distort memory for events. *Memory and Cognition*, *34*(3), 550–555.

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences*, *1*(4), 515–526.

Rabin, M. (1993). Incorporating fairness into game theory and economics. *The American Economic Review*, *83*(5), 1281–1302.

Ruby, P., & Decety, J. (2003). What you believe versus what you think they believe: A neuroimaging study of conceptual perspective-taking. *European Journal of Neuroscience*, *17*(11), 2475–2480.

Saxe, R. (2006). Uniquely human social cognition. *Current Opinion in Neurobiology*, *16*(2), 235–239.

Saxe, R., Carey, S., & Kanwisher, N. (2004). Understanding other minds: Linking developmental psychology and functional neuroimaging. *Annual Review of Psychology*, *55*, 87–124.

Saxe, R., & Kanwisher, N. (2003). People thinking about thinking people. The role of the temporo-parietal junction in "theory of mind". *NeuroImage*, *19*(4), 1835–1842.

Saxe, R., Moran, J. M., Scholz, J., & Gabrieli, J. (2006). Overlapping and non-overlapping brain regions for theory of mind and self reflection in individual subjects. *Social Cognitive and Affective Neuroscience*, *1*(3), 229–234.

Saxe, R., & Powell, L. J. (2006). It's the thought that counts: Specific brain regions for one component of theory of mind. *Psychological Science*, *17*(8), 692–699.

Saxe, R., & Wexler, A. (2005). Making sense of another mind: The role of the right temporo-parietal junction. *Neuropsychologia*, *43*(10), 1391–1399.

Saxe, R., Xiao, D. K., Kovacs, G., Perrett, D. I., & Kanwisher, N. (2004). A region of right posterior superior temporal sulcus responds to observed intentional actions. *Neuropsychologia*, *42*(11), 1435–1446.

Singer, T., Kiebel, S. J., Winston, J. S., Dolan, R. J., & Frith, C. D. (2004). Brain responses to the acquired moral status of faces. *Neuron*, *41*(4), 653–662.

Singer, T., Seymour, B., O'Doherty, J., Kaube, H., Dolan, R. J., & Frith, C. D. (2004). Empathy for pain involves the affective but not sensory components of pain. *Science*, *303*(5661), 1157–1162.

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.

Solina, F., Peer, P., Batagelj, B., Juvan, S., & Kovac, J. (2003, March 10–11 2003). *Color-based face detection in the "15 seconds of fame" art installation.* Paper presented at the Conference on Computer Vision/Computer Graphics Collaboration for Model-based Imaging, Rendering, image Analysis and Graphical special Effects, France.

Sunstein, C. (2005). Moral heuristics. *Behavioural and Brain Sciences*, *28*, 531–573.

Vogeley, K., Bussfeld, P., Newen, A., Herrmann, S., Happe, F., Falkai, P., et al. (2001). Mind reading: Neural mechanisms of theory of mind and self-perspective. *Neuroimage*, *14*(1), 170–181.

Woolfolk, R. L., Doris, J. M., & Darley, J. M. (2006). Identification, situational constraint, and social cognition: Studies in the attribution of moral responsibility. *Cognition*, *100*(2), 283–301.

Young, L., Cushman, F., Hauser, M., & Saxe, R. (2007). The neural basis of the interaction between theory of mind and moral judgment. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(20), 8235–8240.

Young, L., & Saxe, R. (2008). The neural basis of belief encoding and integration for moral judgment. *Neuroimage*, *40*, 1912–1920.

Young, L., & Saxe, R. (in press). An fMRI investigation of spontaneous mental state inference for moral judgment. *Journal of Cognitive Neuroscience*.