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ARTICLE

Lateral orbitofrontal cortex activity is modulated by group membership in situations of justified and unjustified violence

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ABSTRACT
The role of the orbitofrontal cortex (OFC) in moral decision-making is well established. However, OFC activity is highly context dependent. It is affected by the extent to which choices are morally justified and whom they concern. In the current study, we specifically focus on contextual factors and investigate the differential role of the OFC during justified and unjustified violence towards ingroup *versus* outgroup members. Muslims were chosen as the outgroup, as they are currently stereotypically seen as an outgroup and a potential threat by some Non-Muslims. Importantly, we also introduce a context where participants are the actual agents responsible for doing harm. During fMRI scanning, Non-Muslim participants had to decide to either shoot a Non-Muslim (*i.e.*, ingroup member) or Muslim (outgroup member) depending on whether they believed the target was holding a gun or an object. Neuroimaging results showed increased activation in the lateral OFC (lOFC) in the three contrasts that were distressing: 1) during unjustifiable killing; 2) when being killed; and 3) when confronted by an outgroup member with a gun. Together, these results provide important insights into the neurocognitive mechanisms involved in intergroup violence and highlight the critical role of the lOFC in context dependent social decision-making.

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Introduction

There is broad consensus that harming others is central to the moral domain (Gray, Young, & Watz, 2012), and that inflicting unjustified physical harm upon others is morally wrong (Cooney, 2009). However, in situations of extreme threat or conflict (such as warfare and the fight against terrorism), violence towards others can be perceived as "justified" when it is necessary to protect oneself and others from harm. Additionally, society regularly reinforces violence as being "justified" when certain individuals (such as enemy soldiers, criminals, and terrorists) are punished in a violent manner. In such circumstances, society condones violence through rationalizations such as "they asked for it" or "they deserve it" (Meyer, 1972). However, through this justification of violence, people are capable of committing cruelties with significantly less remorse and guilt compared to situations of unjustified violence (Bandura, 2002; Tangney, Stuewig, & Mashek, 2007).

In the current study, we aim to get a better understanding of this context-dependent moral cognition, by examining the neural mechanisms associated with perceived justified or unjustified violence against ingroup and outgroup members. Morality incorporates multiple dimensions, including knowledge, values, reputation, and relevant behaviours, and involves both unconscious and deliberate processes such as harm aversion, empathic concern, social emotions (e.g., guilt, remorse, and shame), theory of mind, executive functioning, and abstract reasoning (Decety & Cowell, 2017). Moral judgement is associated with a wide variety of brain regions including the orbitofrontal cortex, ventromedial prefrontal cortex, dorsomedial prefrontal cortex, precuneus, striatum, temporo-parietal junction, temporal pole, amygdala and cingulate cortex (Borg, Sinnott-Armstrong, Calhoun, & Kiehl, 2011; Eres, Louis, & Molenberghs, 2017; Fumagalli & Priori, 2012; Garrigan, Adlam, & Langdon, 2016). Depending on which type of moral judgement (*e.g.*, harm, dishonesty or disgust) is

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involved (Parkinson et al., 2011), depending on the intentions (intentional or unintentional) behind a "moral" action (Decety, Michalska, & Kinzler, 2012; Schaich Borg, Hynes, Van Horn, Grafton, & Sinnott-Armstrong, 2006), or praise or blame (Yoder & Decety, 2014), different neural systems and computations can be engaged. However, here we specifically focus on the effects of perceived justified or unjustified violence on the lateral orbitofrontal cortex. This brain area, as we review below, plays a central role in moral judgment and social decision-making and has been implicated in situations of (evaluating) punishment and harm-doing.

Previous research has revealed the importance of the orbitofrontal cortex (OFC) in situations of moral judgment and decision-making, as well as moral evaluations and affective responses that guide social conduct (Amodio, 2014; Wagner, N'Diave, Ethofer, & Vuilleumier, 2011). Damage to the OFC has been found to be associated with the reduced inhibition or correction of behavioural responses that have become unacceptable because of a change in the required response pattern (Rolls, 2004). This may cause an increase in immoral behaviour, as can be seen from patients with OFC dysfunction (due to developmental anomalies or injuries) who can be remarkably insensitive to social and moral norms, and therefore frequently display patterns of antisocial behaviour (Beer, John, Scabini, & Knight, 2006; Blair, 2004, 2007; Raine & Yang, 2006). In particular, OFC activity plays a central role in the display of *reactive* aggression, which occurs in response to frustration or threat (for a review, see Blair, 2004). Moreover, intentionally or unintentionally harming others – or perceiving others being harmed or in physical pain – has consistently been associated with activity in the OFC (among other regions such as the medial prefrontal cortex, insula and anterior cingulate cortex; Decety et al., 2012; Molenberghs et al., 2014; Molenberghs, Gapp, Wang, Louis, & Decety, 2016; Singer et al., 2004; Molenberghs et al., 2015; Xu, Zuo, Wang, & Han, 2009). Critically, activity in these regions can be modulated by the group membership of the victim (for reviews see: Amodio, 2014; Cikara & Van Bavel, 2014; Eres & Molenberghs, 2013; Han, 2015; Molenberghs, 2013).

The structure and functions of the OFC can be divided into medial and lateral streams. Meta-analyses have found the medial OFC (mOFC) to be associated with reward evaluation, while the lateral OFC (lOFC) is more related to the evaluation of punishment, and the inhibition of or change in ongoing behaviour (Berridge & Kringelbach, 2013; Elliott, Dolan, & Frith, 2000; Kringelbach & Rolls, 2004). This functional dissociation in OFC has been confirmed in several fMRI studies investigating moral scenarios in intergroup situations. For instance, a study by Beer et al. (2008) revealed that prejudiced attitudes involving negativity towards outgroup members (*e.g.*, African Americans) were associated with increased activation in the lOFC, while positive associations with (Caucasian) ingroup members were related to activation in the mOFC. Similarly, Molenberghs et al. (2014) asked participants to give punishments (electroshocks) or rewards (money) to either ingroup (*i.e.*, students from the same university) or outgroup (*i.e.*, students from a neighbouring university) members based on their responses on a trivia task. Results revealed that the mOFC was more active when participants rewarded others, while the lOFC was more active when participants punished others. Furthermore, when participants rewarded ingroup (*versus* outgroup) members, they displayed greater mOFC activity, whereas similar activity was found in the lOFC when participants punished ingroup *versus* outgroup members. The studies described above thus underscore the different processes associated with lOFC as compared to mOFC activity, and highlight the involvement of the lOFC in situations of (evaluating) punishment and harm-doing.

But what about more extreme situations? In war for example, when deciding to harm others, would the group membership of the target (*e.g.*, opposing soldier *versus* innocent civilian) lead to differential neural activation in the lOFC because one action is regarded as morally justified (*i.e.*, shooting an opposing soldier) while the other (*i.e.*, shooting an innocent civilian) is not? To address this question, Molenberghs et al. (2015) conducted an fMRI study in which participants were presented with video clips of a person shooting either an innocent civilian or an enemy soldier and were asked to imagine themselves as the perpetrator. The results showed that participants felt more guilt and displayed greater activation in the lOFC when imagining shooting civilians (*i.e.*, unjustified violence) compared to shooting enemy soldiers (justified violence).

In another fMRI study investigating the effect of group membership, participants viewed scenarios of an ingroup or outgroup member being attacked by either a member of the same group (*i.e.*, a fellow ingroup or fellow outgroup member) or another group (*i.e.*, an ingroup member being attacked by an outgroup member or vice versa). Results revealed increased lOFC activity as well as higher levels of self-reported moral sensitivity, when viewing outgroup attacks on ingroup members (Molenberghs et al., 2016). To summarize, it seems that the distress experienced in violent situations, for example when harming innocent people (Molenberghs et al., 2014, 2015), or when watching ingroup members being attacked by an outgroup member (Molenberghs et al., 2016), is accompanied by increased activation in the lOFC.

In the current study, we therefore focused on lOFC responses – and specifically tested hypotheses about lOFC activity itself – by introducing a context in which participants are the actual agents responsible for the harm done, and by increasing the social relevance of the groups. That is, participants in the previously described studies either *imagined* themselves as the perpetrators of violence (Molenberghs et al., 2015), only *observed* the actions of others (2016) or *had to* harm others (Molenberghs et al., 2014), instead of actively being the agent who is responsible for the moral *decision-making process* to harm or not. The sense of agency, which refers to the feeling of control over actions and their consequences (Balconi, 2010) is sensitive to moral responsibility, as the experience of agency is stronger for moral actions (Moretto, Walsh, & Haggard, 2011). Furthermore, agency is an important aspect in international legal systems. For instance, when someone kills another person, perceived agency and context can result in very different legal outcomes (*e.g*., legal self-defence, involuntary manslaughter or murder; for an overview of the literature on the sense of agency and why it matters, see Moore, 2016.)

Here we investigated how neural activity in the lOFC is associated with reflecting on the consequences of the *actively* made decision to harm others (in situations of both justified and unjustified violence). Furthermore, we examined how these decisions and underlying neural processes in the lOFC are influenced by the *group membership* of the target. To better flesh out the potential involvement of lOFC in intergroup bias in the context of actively doing harm, we chose two highly salient and socially relevant groups: Non-Muslims and Muslims. This choice was guided by the relevance of the latter group in contemporary Western society and the increased prejudice they face (particularly in relation to violence) on a daily basis (*e.g*., Dunn, Atie, Mapedzahama, Ozalp, & Aydogan, 2015), especially since the rise of violent extremist groups such as Al-Qaeda and Islamic State (Ameli & Merali, 2015; Dunn et al., 2015; Federal Bureau of Investigation, 2014; Horgan, 2014; Pew Research Center 2017; Roy, 2017). It is important to keep in mind that most violence is not committed by these violent extremist groups. For example, the global homicide rate is 15 times the death rate from terrorism (Institute for Economics and Peace, 2016). More starkly, in the US, figures from the Centre for Disease Control and Prevention show that, between 2001 and 2014, for every death attributable to terrorism (which includes both religiously and non-religiously motivated attacks), more than 1000 people died from fire arms (Bower, 2016).

By choosing Muslims as the outgroup (as in other studies focusing on stereotypes against an outgroup, *e. g*., African Americans: Correll, Park, & Wittenbrink, 2002; Correll, Urland, & Ito, 2006; Senholzi, Depue, Correll, Banich, & Ito, 2015; but also Muslims: Brown et al., 2013; Mange, Chun, Sharvit, & Belanger, 2012; Unkelback *et al*. 2008), we do not aim to further reinforce negative stereotypes (explicit or otherwise) toward the Muslim community, but to bring them to light to better understand how they form and persist. We think this is fundamental in order to formulate solutions directed to overcoming such stereotypes.

To investigate these questions, the current fMRI study employed a design inspired by a series of studies that use variations of the shooting bias paradigm (Correll et al., 2002, 2006; Mange et al., 2012; Senholzi et al., 2015; Unkelbach et al., 2008). Participants were required to imagine that they were a police officer and instructed to make quick shoot/don't shoot decisions in response to the presentation of armed and unarmed targets. As a result, situations of justified violence (shooting an armed target) and unjustified violence (shooting an unarmed target) were generated. Participants of Non-Muslim background were presented with targets of Non-Muslim and Muslim appearance. We specifically used images of stereotypical male Muslims as the outgroup and only used Non-Muslim participants, as the former group may be perceived as a potential threat by the latter group (Ciftci, 2012; Pew Research Center, 2011). Moreover, prior studies have reported a shooting bias for targets wearing Muslim headgear (Unkelbach et al., 2008) or when priming with Muslim or Arab categories (Mange et al., 2012). Further supporting the existence of prejudice against Muslims, Brown and colleagues (2013) found that portraits in Middle Eastern dress (wearing *shemagh* and *agal*, the scarf and rope famously worn by Yasser Arafat) were rated less positively. Accordingly, targets in our study represented members of the ingroup (here broadly referred to as Non-Muslims) or the outgroup (Muslims).

Moreover, extending on the previously mentioned studies, we examined the neural responses associated with participants' reflection on the consequences of their actions. That is, participants in our study received substantive feedback about the outcome of their decisions to shoot or not to shoot (*e.g*., whether the target killed was innocent or not and if they survived or died themselves), rather than receiving rewards or penalties in the form of points for correct and incorrect responses respectively. To ensure participants made enough errors so that we had enough trials to analyze in each of the conditions, we intentionally made the task much more difficult compared to these previous studies. This enabled us to go beyond previous research by examining participants' reflection on all possible outcomes of their own moral decisions. In short, our study extends previous research in several ways by: (1) examining lOFC activation when *actively* making moral decisions in an intergroup context, (2) using a stigmatized outgroup in today's Western society (exemplified by stereotypical male Muslim targets), and (3) specifically investigating the moment when participants reflect on the consequences of their moral decisions.

Considering the findings from Molenberghs et al. (2015), in which participants had to shoot others (civilians and soldiers), we predicted, *first*, that (perceived) unjustified *versus* justified violence (*i.e.*, shooting an unarmed *versus* an armed target) would result in increased activity in the lOFC. *Second*, we also examined lOFC activity in relation to being killed (when making the incorrect decision to not shoot an armed target) versus not being killed (when making the correct decision to not shoot an unarmed target). Because being shot/killed is a distressing experience, we also expected increased lOFC activation in this contrast. *Third*, because lOFC activity is associated with heightened moral sensitivity for outgroup attacks on ingroup members (Molenberghs et al., 2016), we expected increased lOFC activity when confronted with outgroup threats (*i.e.*, an armed outgroup member).

Furthermore, besides the main objective of examining lOFC function in relation to intergroup violence, we also conducted exploratory psychophysiological interaction analyses to examine possible functional connectivity differences between the predicted lOFC activity in these situations and activity in other regions of the brain. Finally, we predicted that participants would feel less guilty when shooting outgroup members but only when the violence is justified (i.e., when the target is armed). This is consistent with the idea that people are more likely to show prejudice when they have an excuse (Dovidio & Gaertner, 2004).

Methods

Participants

A total of 48 Non-Muslim individuals (35 females, M_{age} = 25.3 years, SD_{age} = 8.92) participated in the study. All participants were healthy, had normal to corrected-to-normal vision, and met the criteria for MRI scanning. All participants gave written informed consent upon arrival and were reimbursed $30 on completion of their participation. The study was approved by the Monash University Human Research Ethics Committee.

Materials

Shooting task

The experimental stimuli consisted of 72 images in which a male target with either a stereotypical Muslim (characteristic headgear, variously known as *taqiyah* or *kufi*, and, often a beard) or Caucasian Non-Muslim appearance, was either holding a gun or a non-lethal object (*e.g.*, a cell phone) in various backgrounds (Figure 1). The choice of headgear and the frequent use of a beard, together with the target's name during the feedback phase (comprising stereotypical names like Abdul, for a Muslim target), were intended to make the group membership of the Muslim targets clear to participants.

We understand that not all Muslims match this stereotype. However, in addition to being widely recognized, this stereotype commonly evokes more negative responses by non-Muslims. Previous research has, for example, revealed a shooting bias for targets wearing Muslim headgear (Unkelbach et al., 2008) or when primed with Muslim or Arab categories (Mange et al., 2012), which included personal names and other words such as veil and turban. A further study showed portraits of males in Middle Eastern dress (wearing *shemagh* and *agal*) were rated less positively than in Western attire (Brown et al., 2013). In addition, beards are an integral part of the way Muslims (as well as Arabs and people from the Middle East) are represented and perceived by non-Muslims, including as part of a discourse of fear, danger and terror (Culcasi & Gokmen, 2011).

Stimuli were categorized into one of four conditions, each comprising 18 images: 1) Muslim holding Gun (MG); 2) Muslim holding Object (MO); 3) Non-Muslim holding Gun (NMG); 4) Non-Muslim holding Object (NMO). All stimuli are included in Supplementary Materials.

The scanning session was divided into four functional runs, each of nine minutes' duration, with a structural scan acquired over five minutes in between the second and third run. Participants were presented (using E-prime 2.0) with a series of stimuli and instructed to imagine they were in a real-life situation in which they were a police officer who must make a shooting decision each time a target image is presented. It was stated that participants should provide a "shoot response" if they saw an armed target, and a "don't shoot" response if they saw an unarmed target, using a button response box. It was further explained

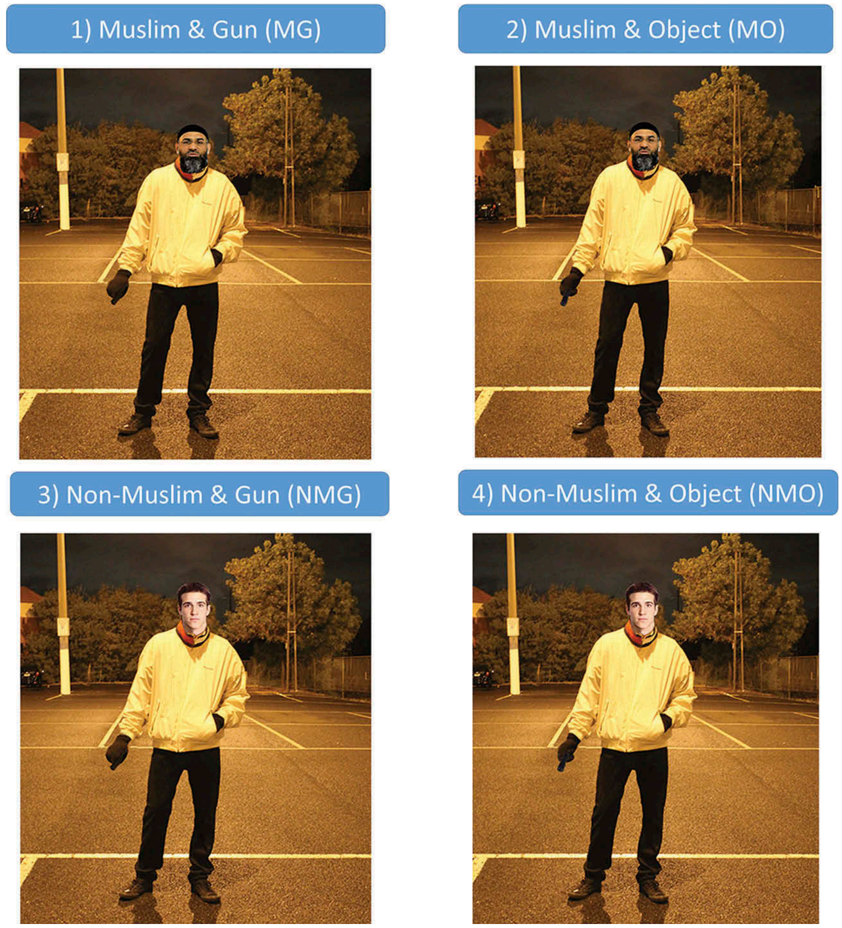

Figure 1. Example stimuli from each of the four types of stimuli used in the fMRI experiment.

that the response buttons would randomly alternate after each trial. Participants were requested to always respond (even in instances in which they were unsure) and do this as quickly as possible within a 3 second time frame.

Participants were told that they would receive feedback in each trial after a shooting decision was made. Upon the presentation of feedback, participants were asked to imagine how they would feel in real life about the decision they made. Four different types of feedback could be received: 1) "You fired the gun at (name) and saved your life"; 2) You did not fire the gun at (name) and he lived"; 3) "You fired the gun at (name) and ended his life"; 4) "You did not fire the gun at (name) and you died". We used Muslim and Caucasian sounding names for each respective group, together with a close-up picture of the target faces, as further marker of group membership. Feedback options 1 and 2 were correct decisions and presented in green colour. This indicated that the participant shot a target with a gun or did not shoot a target with an object respectively. Feedback options 3 and 4 were incorrect decisions and presented in red colour. This indicated that the participant shot a target with an object or did not shoot a target with a gun respectively.

The experiment consisted of 144 trials (36 trials per run). Each trial (Figure 2) began with a grey slide (1000 ms) followed by one of the target images (250 ms) and a masking slide (250 ms).[1] The question "What do you choose to do?" was then presented, requiring participants to choose a shooting response within 3000 ms. Subsequently, a white fixation cross

[1] To be able to examine the neural correlates associated with justified vs. unjustified shooting, an approximately equal amount of correct as well as incorrect responses were needed in the task to have sufficient power in each condition. Therefore, the paradigm was adjusted in such a way that participants would find it difficult to detect whether the target in each image was holding a gun or a non-lethal object. Results of extensive pilot testing outside the scanner found the parameters of the above paradigm optimal. The paradigm was further tested in 10 people (8 females; M_{age} = 23.2, SD = 2.7) and results revealed an average accuracy rate of 57.9% (SD = 0.09), which was significantly different from 50%, $t(9) = 2.85$, $p = .02$, but also indicated that the task was nevertheless difficult enough to have enough trials in each condition.

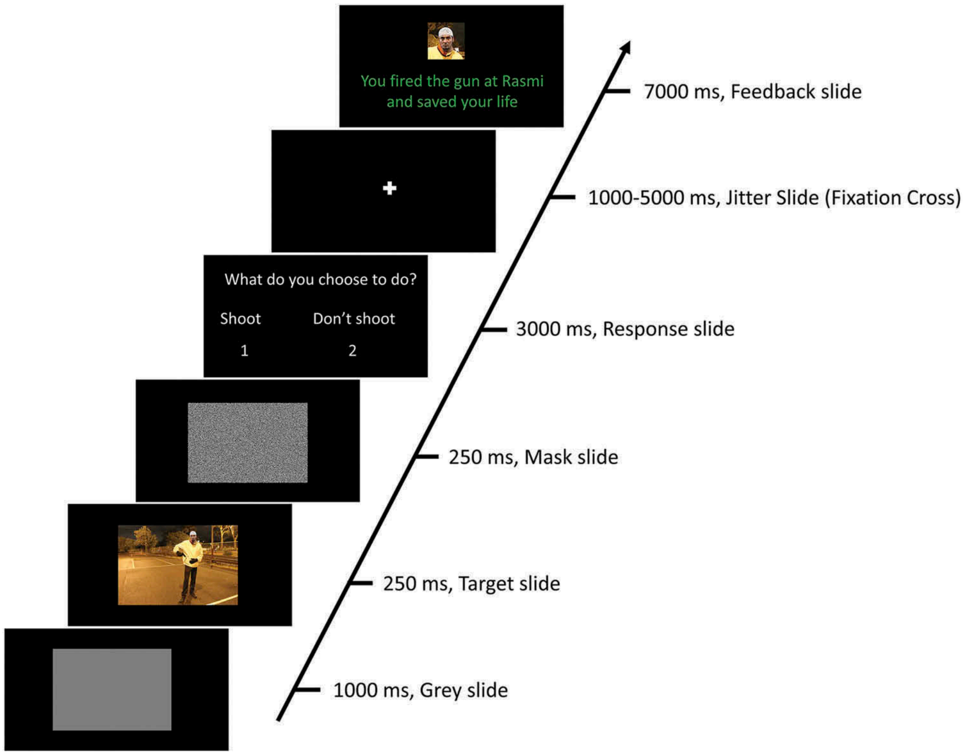

Figure 2. Schematic representation of a trial sequence during the fMRI experiment. Here an example is shown of the MGS (i.e., Muslim with a Gun was Shot) condition.

appeared on the screen (ranging between 1000–5000 ms, with an average duration of 3000 ms) followed by a feedback slide (7000 ms) requiring participants to read the statement provided (*e.g.*, "You fired the gun at (name) and saved your life") and imagine how they would feel about the decision made in a real-life context. This mental simulation of the situation was used to elicit neural activity that emulates a real-life experience, as demonstrated by prior neuroimaging research (*e.g.*, Decety & Porges, 2011; Molenberghs et al., 2015; Senholzi et al., 2015).

Evaluation of the stimuli

To further confirm that stimuli were correctly perceived as Muslim or Caucasian, we administered a *post-hoc* stimuli categorization questionnaire where we showed a new sample of participants (N = 20, 10 females; M_{age} = 21.85, SD_{age} = 2.3) the photos we used in the study together with their names. We then asked them to categorize the photos into Muslim, Caucasian or Not sure. Results showed participants categorized the stimuli with high accuracy: an average of 93% (SD = 13.6%) of Muslim and 91% (SD = 10%) of Caucasian stimuli were categorized correctly across participants. [One participant was excluded as they had an accuracy of 27% when categorizing Caucasian stimuli, which was an extreme score (<Q1 – 3 x IQR); however, this participant categorized the Muslim stimuli with 100% accuracy. When including this participant, the group accuracy in categorizing Caucasian stimuli was still high: 88%.]. No statistically significant difference in categorization was observed between Muslim and Caucasian stimuli, as revealed by a two-tailed paired T-test: $T(19) = 0.55$, $p = .58$ [even when including the extreme score, $T(20) = 1.09$, $p = .28$].

In the same questionnaire, we also asked participants to rate [on a 7-point scale that ranged from (1 = "disagree strongly" to 7 = "agree strongly")] all the photos we used in the study in terms of perceived masculinity, aggression and attractiveness, to consider the potential impact of these factors on our results. Wilcoxon signed rank sum tests revealed that Muslim and Caucasian stimuli did not statistically differ in terms of aggression (median Muslim = 4.32; median Caucasian = 3.95; $Z = 0.39$, $p = .69$) or masculinity (median Muslim = 5.32; median Caucasian = 5.25; $Z = 0.54$, $p = .59$). However, we found a statistically significant difference in attractiveness, with stereotypical Muslim stimuli (median = 3.02) considered less attractive than Caucasian stimuli (median = 4.57, $Z = 3.69$, $p = .001$).

Self-reports

Guilt

After the fMRI session, a Visual Analogue Scale (VAS) was used to measure potential feelings of guilt in relation to a series of shooting responses towards armed and unarmed targets supposedly made by participants during the experiment. Twenty stimuli depicting Muslim and Non-Muslim targets (10 each) from the experiment were accompanied by the statement "You shot this person who did not have a gun." (10 trials) or "You shot this person who had a gun." (10 trials). "How guilty did you feel about shooting him?". The level of guilt was specified by selecting a position along the scale, ranging from 1 (not guilty at all) to 100 (extremely guilty). Two difference *guilt bias* scores were calculated to determine whether there were differences in mean guilt felt towards shooting Non-Muslim and Muslim targets in situations of justified and unjustified violence respectively. Specifically, we computed a guilt score for shooting armed Non-Muslim targets *versus* armed Muslim targets (NMG-MG), and for shooting unarmed Non-Muslim targets *versus* unarmed Muslim targets (NMO – MO). Positive scores indicated that greater guilt was felt towards shooting Non-Muslims.

Group bias

To assess participants' self-reported explicit attitudes towards Muslims, we used the "Attitude towards Muslim Australians Scale" (ATMA; Griffiths & Pederson, 2009). The ATMA contained 16 items rated along a seven-point Likert scale (1 = "disagree strongly" to 7 = "agree strongly"). An example of a negative item is "Muslims do not respect freedom of speech", and an example of a positive item is "The majority of Muslims are law abiding citizens". Following reverse-coding of some items, a total score for prejudice was calculated by summarizing all scores, with higher scores indicating greater prejudice towards Muslims. The minimum possible score was 16 and the maximum possible score 112 (Griffiths & Pedersen, 2009).

Shooting bias

In addition to the guilt and group biases, we also calculated a shooting bias, based on performance during the task, as the difference score between the frequency of shooting Muslim and Non-Muslim targets.

Procedure

Participants were invited to attend two testing sessions. The first session involved completion of the explicit bias measure and a practice run of the fMRI task. The second session involved the MRI scanning and completion of the post-scan guilt measure. Prior to the start of the task during the second session, participants were reminded of the instructions for the experimental task: It was emphasized that they had to make a shooting decision in each trial, and that upon presentation of feedback, they were required to imagine how they would feel in real-life about the decision they had made. Further task instructions and the actual experiment were projected onto a screen at the back of the scanner bore, which participants could view via a mirror attached to the head coil. Foam pads were placed around the participant's head to reduce head movement. After the fMRI experiment, participants were instructed to complete the guilt feedback measure on a laptop outside the scanner room. Once completed, participants were fully debriefed.

Fmri data acquisition

A 3-Tesla Siemens Skyra MRI scanner with a 32-channel head volume coil was used to obtain the hemodynamic and anatomical data. Functional images were acquired with gradient echo planar imaging (EPI) with the following parameters: repetition time (TR) of 2.35 seconds, echo time (TE) of 30 ms, flip angle (FA) of 80º, 40 transversal slices with 76 × 76 voxels at 3 mm^2 in-plane resolution and a 20% distance factor in between the slices covered the whole brain. During each functional run 229 volumes were acquired (with the first three from each functional run discarded to allow for steady-state tissue magnetization). For correction of geometric distortion of functional images (Hutton et al., 2002) field maps were acquired with a gradient recalled echo sequence (TE = 4.92 and 7.38 ms, TR = 638 ms; matrix size = 64 × 64) using 42 slices covering the whole brain (voxel size 3 × 3 × 3 mm^3). A three-dimensional high resolution T_1-weighted whole brain structural image was also acquired after the second run for anatomical reference (TR = 2300 ms, TE = 2.07 ms, FA = 9º, 192 cube matrix, voxel size = 1 cubic mm, slice thickness = 1 mm).

Data analysis

Behavioural data analysis

Accuracy. To evaluate participants' accuracy rates during the task (with accurate responses consisting of shooting a target with a gun, and not shooting a target with an object), we conducted a repeated measures ANOVA with Group (Muslim, Non-Muslim) and Accuracy (Gun & Shoot, No Gun & Not Shoot) as within-participants variables.

Response times. To examine participants' response times during the task, we conducted a repeated measures ANOVA with Group (Muslim, Non-Muslim), Object (Gun, No Gun), and Shooting Decision (Shoot, Not Shoot) as within-participants variables.

Guilt. To examine participant's feelings of guilt when shooting unarmed *versus* armed targets, and whether the group membership of the targets affected these feelings, we conducted a repeated measures ANOVA with Group (Muslim, Non-Muslim) and Object (Gun, No Gun) as within-subjects variables.

Bias. Pearson's correlations were used to investigate the association between, on the one hand, explicit group bias and, on the other, shooting and guilt biases.

The above analyses included sex as a covariate of no interest (as we had an unbalanced design in this regard).

fMRI data analysis

SPM12 software (http://www.fil.ion.ucl.ac.uk/spm/) run through Matlab (https://www.mathworks.com/products/matlab.html) was used for pre-processing and statistical analysis of the imaging data. Functional images were initially corrected for geometric distortion using participants' field maps (Hutton et al., 2002; Jezzard & Balaban, 1995). To correct for head movement, images were then realigned to the first scan (of each run) via affine registration. This was followed by slice timing correction and co-registration with respect to the anatomical image. Structural scans and EPI images were then normalized to the MNI T_1-weighted standard template (Montreal Neuropsychological Institute) with a voxel size of $3 \times 3 \times 3$ mm^3. Before further analysis, all images were smoothed with an isotropic Gaussian kernel of 9 mm FWHM (full-width at half-maximum).

A general linear model was used to estimate regions of significant Blood Oxygen Level Dependent (BOLD) response across the whole brain at each voxel for each participant over the four runs. This model included event-related regressors for each of the eight conditions associated with feedback to participants: 1) MGS, Muslim with a Gun was Shot; 2) NMGS, Non-Muslim with a Gun was Shot; 3) MGNS, Muslim with a Gun was Not Shot; 4) NMGNS, Non-Muslim with a Gun was Not Shot; 5) MOS, Muslim with Object was Shot; 6) NMOS, Non-Muslim with Object was Shot; 7) MONS, Muslim with Object was Not Shot; 8) NMONS, Non-Muslim with Object was Not Shot. These feedback conditions comprised responses towards Muslim or Non-Muslim targets which were either "correct (or justified) shooting decisions" (*i.e.*, conditions 1 and 2 [MGS, NMGS]) or "incorrect (or unjustified) shooting decisions" (*i.e.*, conditions 5 and 6 [MOS, NMOS]), or conditions in which the participants were "being killed" or "not killed" (*i.e.*, because participants decided to not shoot a target with a gun *versus* to not shoot a target with an object; conditions 3 and 4 [MGNS, NMGNS] *versus* conditions 7 and 8 [MONS, NMONS]).

All events were convolved with a canonical haemodynamic response function and time-locked to the onset of the feedback slide with a duration of 7 seconds (same duration as the feedback slide). The feedback slide was also separated from the preceding stimuli by a jitter slide fixation cross with a range between 1000–5000 ms. This made sure that the involvement of processes other than participants' reflection on that feedback was kept to a minimum. Contrast images were generated at the individual level for all conditions (*versus* implicit baseline) with a fixed effects estimator. Given the prominent role of the lateral OFC in feelings of guilt (Molenberghs et al., 2015), we used a region of interest (ROI) approach to examine the difference in activation in left and right lOFC at the group level. Based on the peak coordinates described in Molenberghs et al. (2015), we created a 5 mm radius sphere around the left lOFC ($x = -33$, $y = 20$, $z = -11$) and right lOFC (33, 20, −11). We then extracted the % signal change from these regions using MarsBaR (http://marsbar.sourceforge.net/) for each participant to test whether "unjustified *versus* justified (incorrect *versus* correct) shooting decisions" (*i.e.*, [MOS + NMOS] − [MGS + NMGS]), and "being killed" *versus* "not being killed" (*i.e.*, [MGNS + NMGNS] − [MONS + NMONS]) are associated with greater activity in the lOFC. Additionally, the ROI analysis was used to examine the differences in lOFC activation between ingroup and outgroup members across situations of unjustified and justified violence. That is, in situations of justified violence (*i.e.*, correct shooting decisions), the contrast "shooting a Muslim with a gun" minus "shooting a Non-Muslim with a gun" (*i.e.*, MGS − NMGS) was examined. Conversely, in situations of unjustified violence (*i.e.*, incorrect shooting decisions), the contrast "shooting a Muslim with an object" minus "shooting a Non-Muslim with an object" (*i.e.*, MOS − NMOS) was examined. We used separate random effects (RFX) models to evaluate each of the above contrasts and included sex as a covariate of no interest.

Additionally, a whole brain RFX analysis was performed at the group level in SPM for the same contrasts (again including sex as a covariate). For all group-level whole-brain analyses, a Monte Carlo simulation was conducted to determine an appropriate cluster extent threshold while accounting for spatial autocorrelations (Forman et al., 1995) with the AFNI (version 17.0.11) tools 3dFWHMx and 3dClustSim. Results of our simulation with 20,000 independent iterations indicated that, for the activation analyses, given a voxel-wise intensity threshold of $p < .005$ and the group mask as search space, a cluster extent threshold of 111 contiguous voxels would be necessary to achieve an overall Type I error rate of $p < .05$, corrected for multiple comparisons.

Psychophysiological interaction analysis

Three effective connectivity analyses using psychophysiological interaction (PPI) were performed to estimate functional coupling between left and right lOFC (combined as one seed) and the rest of the brain, for the three contrasts for which we found activity in the lOFC (see Results): 1) unjustified shooting decisions *versus* justified shooting decisions: (MOS + NMOS) – (MGS + NMGS); 2) being killed *versus* not being killed (MGNS + NMGNS) – (MONS – NMONS); and 3) justified shooting decisions towards Muslims *versus* justified shooting decisions towards Non-Muslims (MGS – NMGS).

The physiological regressor in each PPI analysis was the activity within the bilateral lOFC seed region. For this seed region, time series were obtained by extracting the first principal component from all raw voxel time series in a 5 mm sphere centred around the peak coordinate described above. These time series were mean-corrected and high-pass filtered to remove low-frequency signal drifts. As the psychological regressor, we used the different contrasts that were vector coded and convolved with the haemodynamic response function. Vector coding for each contrast consisted of: 1 for incorrect shooting decisions *versus* −1 for correct shooting decisions; 1 for being killed *versus* −1 for not being killed, and 1 for correct shooting decisions towards Muslims *versus* −1 for correct shooting decisions towards Non-Muslims. Additionally, we included the interaction between the physiological and psychological factors as a third regressor. For each subject, these PPI analyses were thus carried out by creating a design matrix with the interaction term, the psychological factor, and the physiological factor as regressors. Subject-specific contrast images resulting from this were then entered into three RFX group analyses to identify if any brain areas

showed a significant increase in functional coupling with the bilateral lOFC during any of the contrasts (including sex as a covariate of no interest). Significant activity for the PPI analyses was estimated (same as for the whole-brain analyses with AFNI's 3dFWHMx and 3dClustSim tools) at $p < .05$ for clusters exceeding a spatial extent of 118 voxels after thresholding at $p < .005$.

Results

Behavioural results

Overall, participants decided to shoot on 51.6% of the trials (range = 25% – 85%, *SD* = 13.8%). On trials in which the target was holding a gun, participants decided to shoot 50.8% of the time (range = 23% – 83%, *SD* = 15.4%). On trials in which the target was holding an object, participants decided to shoot 52.1% of the time (range = 19% – 83%, *SD* = 14.0%). These results are consistent with our aim to increase the difficulty of the task to ensure that the number of correct and incorrect decisions were approximately even in each condition.

Accuracy

There was no main effect of gun holding status on accuracy [*i.e.*, participants were equally accurate in deciding to shoot armed targets (*M* = 50.8%, *SD* = 15.4%) and to withhold shooting unarmed targets (*M* = 47.6%, *SD* = 15.5%), $F(1,47) = 0.62$, $p = .43$]. Target's Group membership was not significant [shooting Muslim (*M* = 50.3%, *SD* = 16.4%) *versus* Non-Muslim (*M* = 48.1%, *SD* = 14.6%) targets, $F(1, 47) = 3.38$, $p = .07$]. There was no interaction effect between the two, $F(1, 47) = 1.41$, $p = .24$.

Response times

Participants were faster in deciding to shoot (*M* = 1011 ms, *SD* = 241 ms) than to not shoot (*M* = 1061 ms, *SD* = 257 ms), $F(1, 47) = 7.40$, $p = .009$. There was no main effect of Group membership, $F(1, 47) < 0.01$, $p = .96$, nor an interaction effect, $F(1, 47) = 0.43$, $p = .52$.

Guilt

Participants reported feeling more guilty when shooting unarmed targets (*M* = 82.80, *SD* = 13.75) compared to armed targets (*M* = 33.55, *SD* = 24.15), $F(1, 47) = 185.10$, $p < .001$. There was no main effect of group membership, $F(1, 47) = 0.96$, $p = .33$. The interaction effect was not significant; $F(1, 47) = 2.93$, $p = .09$. However, tests for simple effects revealed that when the target had a gun, participants felt more guilty when shooting Non-Muslim targets (*M* = 35.33, *SD* = 25.03) compared to Muslim targets (*M* = 31.77, *SD* = 24.47), $F(1, 47) = 5.14$, $p = .03$. Conversely, when the target was holding an object, participants felt equally guilty, when shooting Non-Muslim targets (M = 82.66, SD = 13.30) compared to Muslim targets (M = 82.94, SD = 18.34), F (1,47) = 0.01, p = .91.

Group bias

On average, participants reported an explicit bias score towards Muslims of 42.5 (SD = 16.71). Importantly, participants' explicit bias scores were positively correlated with their shooting bias during the task, $r(48)$ = .44, p = .002 (Figure 3A), and negatively predictive of with their guilt feelings, $r(48)$ = -.43, p = .002 (Figure 3B). Removal of one outlier did not alter the effects [$r(47)$ = .40, p = .006, and r (47) = -.39, p = .007, respectively].

Fmri results

ROI and whole brain activation analyses

Unjustified versus justified shooting decisions. Incorrectly shooting an unarmed target (*i.e.*, unjustified violence) *versus* correctly shooting an armed target (*i.e.*, justified violence) led to greater % signal change in left (M = 0.014; SD = 0.024; $F(1, 47)$ = 15.83, p < .001) and right (M = 0.012; SD = 0.026; $F(1, 47)$ = 9.37, p = .002) lOFC ROIs. Whole brain analysis also revealed increased activity in bilateral lOFC extending into anterior insula and the inferior frontal gyrus (Table 1 and Figure 4b).

Being killed versus not being killed. Being killed (not shooting an armed target) *versus* not being killed (by not shooting an unarmed target) led to greater % signal change in left (M = 0.013; SD = 0.027; $F(1, 47)$ = 10.33, p = .001) and right (M = 0.010; SD = 0.027; F(1, 47) = *6.24*, p = .013) lOFC ROIs. The whole brain level analysis also revealed greater activity in left lOFC extending into left anterior insula and the adjacent inferior frontal gyrus. Additional increased activation was also found in the bilateral posterior medial prefrontal cortex (Table 1 and Figure 4c).

Table 1. Cluster size and associated peak values for the significant brain regions resulting from the whole brain activation analysis (cluster corrected at p < .05).

Contrast	Cluster size	Peak Z -value	Peak p -value	MNI coordinates x	y	z
Incorrect *versus* correct shooting decisions						
Left lateral orbitofrontal cortex, anterior insula, inferior frontal gyrus	181	4.53	<.001	−30	14	−10
Right lateral orbitofrontal cortex, anterior insula, inferior frontal gyrus	134	3.45	.001	51	26	5
Being killed *versus* not killed						
Left lateral orbitofrontal cortex, anterior insula, inferior frontal gyrus	183	4.56	<.001	−39	23	−10
Bilateral posterior medial prefrontal cortex	152	3.75	<.001	3	17	59

Justified shooting decisions towards muslims versus non-muslims. Correctly shooting armed Muslim targets *versus* Non-Muslim targets also led to greater % signal change in left (M = 0.010; SD = 0.034; F(1, 47) = 4.06, p = .046) and right (M = 0.013; SD = 0.036; $F(1,47)$ = 6.09, p = .014) lOFC ROIs. Whole brain analysis did not reveal significant differences in any other areas.

Unjustified shooting decisions towards muslims versus non-muslims. Incorrectly shooting (unarmed) Muslim targets *versus* (unarmed) Non-Muslim targets did not result in a different % signal change in left ($M = -2 \times 10^{-3}$; SD = 0.033; $F(1, 47)$ = 0.002, p = .965) or right ($M = 1 \times 10^{-4}$; SD = 0.036; $F(1, 47) = 5.68 \times 10^{-6}$, p = .998) lOFC ROIs. Whole brain analysis did not reveal significant differences in any other areas.

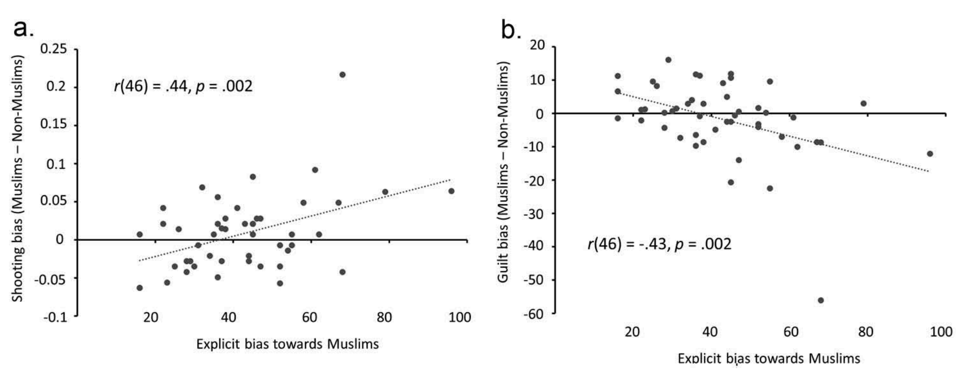

Figure 3. Correlation between explicit bias towards Muslims as measured by the Attitude towards Muslim Australian's (ATMA) Scale' and **A**. shooting bias (i.e., the difference score between the frequency of shooting Muslim and Non-Muslim targets) and **B**. guilt bias (i.e., the difference score between guilt felt towards shooting Muslim and Non-Muslim targets).

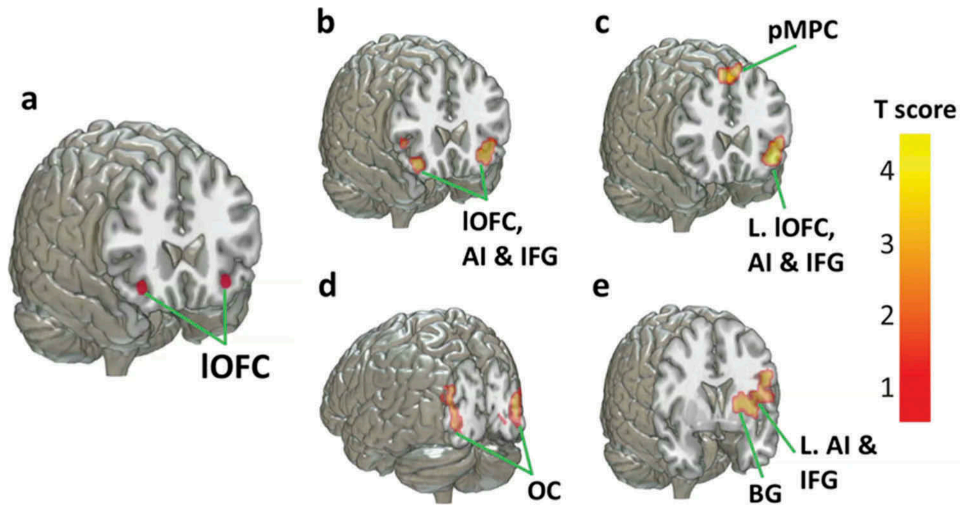

Figure 4. lOFC activation and PPI analyses. Mask of left and right OFC (red spheres) used in the ROI RFX and PPI analyses (a). Significant whole brain activity results for the contrasts: "unjustified versus justified shooting decisions" (b); and "being killed versus not killed" (c). Significant areas exhibiting increased coupling with bilateral lOFC for the contrasts: "being killed versus not killed" (d); and "justified shooting Muslims versus Non-Muslims" (e), as revealed by psychophysiological interaction (PPI) analysis. All results are cluster corrected at p < .05. Results are shown on the ch256 brain template and rendered using MRIcroGL (http://www.mccauslandcenter.sc.edu/mricrogl/home). Labels: Anterior Insula (AI), inferior frontal gyrus (IFG), lOFC (lateral orbitofrontal cortex), occipital cortex (OC), left (L), posterior middle prefrontal cortex (pMPC), basal ganglia (BG). **This is a dynamic figure for the online version of this paper**. The dynamic Figure can be viewed online as Supplementary Material.

Psychophysiological interaction (PPI) analyses

Effective connectivity analyses did not find a significant increase in coupling between bilateral lOFC and the "unjustified *versus* justified shooting" contrast. However, increased coupling was found between bilateral lOFC and bilateral middle occipital gyrus for the "being killed *versus* not being killed" contrast (Table 2 and Figure 4d); and a large area encompassing left middle insula, inferior frontal gyrus, Rolandic operculum, precentral gyrus, superior temporal lobe, putamen, pallidum and thalamus for the "justified shooting Muslim *versus* Non-Muslim targets" contrast (Table 2 and Figure 4e).

Table 2. Cluster size and associated peak values for the significant brain regions resulting from the psychophysiological interaction (PPI) analyses for each contrast (cluster corrected at $p < .05$).

Contrast	Cluster size	Peak Z -value	Peak *p* -value	MNI coordinates x	y	z
Being killed *versus* not killed						
Left middle and inferior occipital gyrus	132	4.17	<.001	−24	−97	2
Right middle and inferior occipital gyrus	121	3.80	<.001	18	−97	−1
Correctly shooting Muslims *versus* Non-Muslims						
Left middle insula, inferior frontal gyrus, Rolandic operculum, precentral gyrus, superior temporal lobe, putamen, pallidum and thalamus	632	3.94	<.001	−30	−7	5

Discussion

Soldiers and police officers often have to make split-second decisions to neutralize a potential threat in ambiguous situations. It is important that these decisions are made in an impartial way rather than based on explicit or implicit biases towards members of a specific religion, race or ethnicity. To better understand the neural processes involved in these decisions, the current study examined the neural activity associated with reflecting on the consequences of one's own choice to harm others, in situations perceived as justified and unjustified. Lateral OFC (lOFC) is an area previously shown to be a critical node in a range of behaviours including intentional harm (Decety et al., 2012; Minura, 2010; Molenberghs et al., 2014), unjustified violence, and experience of guilt (Molenberghs et al., 2015), as well as moral sensitivity towards outgroup attacks on ingroup members (Molenberghs et al., 2016). This study focused on the question of how activity in this area is influenced by the group membership of targets in situations of justified and unjustified violence within a context where participants are the actual agent responsible for doing harm. Participants were therefore asked to imagine being a police officer who had to make split-second decisions to either shoot or not shoot ingroup and outgroup (*i.e.*, Non-Muslim *versus* Muslim) targets who were either armed or holding a non-lethal object.

In line with our prediction, activation in lOFC increased when the armed target being shot was an outgroup *versus* an ingroup member (*i.e.*, the contrast MGS – NMGS). At first sight, this might seem counter-intuitive, as people felt less guilty about shooting an outgroup member with a gun. However, this particular finding coincides with our previous fMRI study in which we also found increased activation in lOFC when people watched an outgroup member attack another ingroup member (Molenberghs et al., 2016). That study found that people expressed greater moral sensitivity (*i.e.*, they were more upset, angrier, wanted to punish the attacker more, etc.) for outgroup attacks on ingroup members. The results thus confirm that the lOFC is highly sensitive for outgroup attacks on ingroup members. Moreover, the present finding extends lOFC involvement to situations where participants are themselves the potential victim of an outgroup attack.

However, no increase in lOFC activity was observed when participants shot an innocent outgroup versus ingroup member. Moreover, self-reported levels of guilt mirrored the lOFC response. Participants reported feeling less guilty when correctly shooting Muslim compared to Non-Muslim targets, but felt equally guilty when incorrectly shooting Muslim *versus* Non-Muslim unarmed targets. These findings thus expand on the previous literature by showing that increased lOFC sensitivity for outgroup attacks on ingroup members and reduced guilt for harming outgroup members occurs when the outgroup member is guilty: ingroup biases, therefore, do not always appear automatically, but they do if people can justify them. The findings are consistent with the concept of *aversive racism*. According to Gaertner and Dovidio (1986), under aversive racism, people tend to act non-prejudiced in situations that evoke strong social norms and where discrimination would be highly visible. However, discrimination can surface in situations where social and moral norms are not as discernible or when behaviour can be justified and rationalized on the basis of a factor other than race (Pearson, Dovidio, & Gaertner, 2009). In this case, people cannot justify feeling less guilty about killing an outgroup member when that person is innocent but when people have a reason to justify their ingroup bias (*i.e.*, the person had a gun and was threating my life) intergroup discrimination becomes evident.

Considered together, these results point to a heightened sensitivity towards attacks from outgroup members, which makes sense from an evolutionary perspective as outgroup attacks are more likely to pose an existential threat to ourselves and our group members' survival. Our findings may also help to understand a wide variety of observations in daily life, including not only people's responses to harming others but also their propensity to do so. Moreover, our behavioural measures included responses from the decision phase. Of particular relevance is our finding that participants' explicit bias towards Muslims was positively correlated with their shooting bias during the task. Our results may therefore shed some light on issues such as 1) why White police officers in the US might be more likely to shoot a Black person than a White person (Swaine, Laughland, Lartey, & McCarthy, 2015); 2) why we have surprisingly little problem with extrajudicial killings such as drone strikes targeting foreign terrorists (Pew Research Center, 2015); or 3) why Western media pay much more attention to Muslim terrorist attacks when they happen in Western countries (Borda, 2016).

The lOFC findings regarding the first two predictions (*i.e.*, unjustified *versus* justified shooting decisions and being killed *versus* not being killed) were largely consistent with what we would expect based on the previous literature. First, the increased lOFC activity for the unjustified *versus* justified shooting decisions contrast (*i.e.*, [MOS + NMOS] – [MGS + NMGS]) corresponds with our previous finding in which we showed increased lOFC activation for shooting innocent civilians *versus* soldiers (Molenberghs et al., 2015), with greater reactivity to harming innocent targets in each case. However, here we now also show that this effect is present when people are responsible for their own actions. Similarly, Xu and Inzlicht (2015) found greater event-related (brain) potentials (ERPs) associated with error detection (*i.e.*, error-related negativity; ERN) and error awareness (*i.e.*, error-related positivity; Pe) when making incorrect (unjustified) shooting decisions. Second, greater lOFC activity when thinking about being killed (because not shooting an armed target) *versus* not being killed (because not shooting an unarmed target; *i.e.*, the contrast [MGNS + NMGNS] – [MONS + NMONS]), is in line with the view that the lOFC is not necessarily specific for guilt or moral sensitivity. Instead, lOFC perhaps plays a more general role in feelings of displeasure and the anticipation of negative outcomes, as well as signalling the need to regulate or change current responses (Amodio & Frith, 2006; Domínguez, Taing, & Molenberghs, 2016; Hayes & Northoff, 2011; Kringelbach & Rolls, 2004; Rolls, 2004). This is an important new observation as it highlights the fact that different moral situations rely on similar domain general networks (Young & Dungan, 2012).

Whole brain analysis revealed that the contrasts "unjustified *versus* justified shooting" and "being killed *versus* not being killed" activated a cluster that spread from lOFC into the anterior insula (AI) and to the adjacent inferior frontal gyrus (IFG). These two later regions have been reliably associated with directly experiencing pain and empathic experience of others' pain (Lamm, Decety, & Singer, 2011). For example, in our previous study where people had to shock others, their involvement was interpreted as participants vicariously experiencing the pain they inflicted onto others (Molenberghs et al., 2014). Increased activation in these areas for unjustified *versus* justified shooting therefore suggests that the degree to which people empathize with the pain they cause to others is modulated by whether they feel the harm is justified or not. In the "being killed *versus* not being killed" contrast this increased activation in AI and IFG is interpreted as an amplified experience of the affective components of pain when being harmed.

The contrast "being killed *versus* not being killed" also activated bilateral posterior medial prefrontal cortex (pMPC). This area has been shown to play a key role in conflict detection when tracking differences between actual and expected states (Holroyd & Coles, 2002; Schultz & Dickinson, 2000). In the present context, pMPC may be representing the conflict between being killed (the actual state) and not being killed (the expected state), a self-relevant conflict of heightened significance.

Results from the PPI analyses show for the first time that the increase in hemodynamic response in lOFC is subserved by a connectivity pattern that varies with context. Specifically, increased coupling was found between lOFC and the left middle insula and basal ganglia (putamen and pallidum) for the contrast "justified shooting decisions towards Muslims *versus* Non-Muslims". The increased connectivity between lOFC and left middle insula is in line with the study of Molenberghs et al. (2016) that revealed a similar coupling when outgroup members attacked ingroup members.

The middle part of the insula, which also plays a role in coding sensory–motor features of painful stimulation (Wager & Barrett, 2017) has strong connections with the basal ganglia (Chikama, McFarland, Amaral, & Haber, 1997). While the latter is often involved in reward processing (Balleine, Delgado, & Hikosaka, 2007), it has also been shown to play a role in pain processing, particularly with regards the integration of motor, emotional, autonomic and cognitive responses to pain (Borsook, Upadhyay, Chudler, & Becerra, 2010). The basal ganglia and other structures revealed by the PPI analysis such as IFG, post-central gyrus (motor processing), Rolandic operculum (nociceptive processing) and thalamus (heightened arousal) thus seem to support lOFC in the sensory–motor representation of intense displeasure and distress in response to outgroup attacks.

The PPI analysis also showed the contrast "being killed *versus* not being killed" led to increased connectivity between lOFC and the bilateral middle and inferior occipital gyrus. The increased coupling with occipital cortex might suggest a re-imagining of the decision phase in order to better understand the incorrect decision or alternatively, increased visualisation associated with imagining one's own death. It should be noted that the interpretation of the PPI analyses is more speculative given that we did not have clear predictions about which regions would be involved. Future studies should therefore confirm the findings and further disentangle the effect of lOFC activity on self and target outcomes. In our current study, an error either leads to the target dying or the participant dying. However, what would happen to lOFC if an error led to both the victim and the participant being harmed?

The behavioural results of the current study did not reveal a shooter bias overall (*i.e.*, shooting outgroup members more often and/or shooting them more quickly) as could be expected based on prior research (Brown et al., 2013; Correll et al., 2002, 2006; Mange et al., 2012; Unkelbach et al., 2008). An explanation for this discrepancy could be that, compared to these earlier studies, it was much more difficult to detect the gun or the object in our design. The reason we made this much harder was to have a similar number of trials for our 'shoot' and 'not shoot' conditions for a comparable amount of power in all the conditions in our fMRI analyses. Additionally, though consistent with a social desirability effect, the overall explicit prejudice towards the target outgroup might have been too low in our sample to find a shooter bias effect (ATMA = 42.5, *versus* 58 in the original study; Griffiths & Pedersen, 2009). However, when we used participants' explicit bias as a regressor, we did find that it was positively correlated with their inclination to shoot Muslim targets and negatively correlated with their feelings of guilt when shooting Muslims.

When interpreting the results of this study it is important to consider that fMRI design constraints made it difficult for participants to distinguish whether targets during the decision phase had a gun or not. This could affect what it meant for participants to feel "guilty" about their shooting decisions. However, during the feedback phase, which was our focus, participants were able to reflect upon the consequences of their decisions with the knowledge that the target did or did not have a gun. Furthermore, we found that participants felt significantly guiltier after shooting an unarmed *versus* armed target. This shows that – even though it was difficult for participants to correctly decide whether to shoot or not, which we aimed for in order to ensure a similar number of correct and incorrect responses in the conditions – our manipulation of justified *versus* unjustified violence was effective.

We also need to acknowledge that we had an unbalanced design regarding females and males; however, we controlled for this by including sex as a covariate in the analyses. Future studies should include more male participants (and balanced group sizes) to better control any effect this factor may have. In addition, we found an attractiveness effect between stereotypical male Muslim and Caucasian stimuli, which could have impacted our findings. However, the difference for attractiveness between Muslim and Caucasian stimuli is not surprising. Prior research has found preferences to date ingroup partners (Lin & Lundquist, 2013; Potârcă & Mills, 2015), as well as exclusion of outgroup individuals in mate search (Herman & Campbell, 2012; Robnett & Feliciano, 2011). More relevant are findings indicating attractiveness biases for ingroup members (Agthe, Strobel, Spörrle, Pfundmair, & Maner, 2016; Burke, Nolan, Hayward, Russell, & Sulikowski, 2013; Rhodes et al., 2001). Thus, participants rating our Muslim stimuli as less attractive may be a reflection of this advantage for ingroup members, which may be considered as another way group membership influences the way we perceive others. Most importantly, aggression and masculinity were matched between ingroup and outgroup, which is important because these concepts are directly linked to perceived threats while attractiveness, to our knowledge, has no such link.

To conclude, the current investigation supports the involvement of the lOFC in moral decision-making regarding (justified and unjustified) intergroup violence. Our findings extend the literature by revealing how reflection on the decision-making process and associated feelings of displeasure brought about by the actual decision to harm others, are modulated by the group membership of the target. Our results also contribute to our understanding of the network supporting lOFC function. The findings thus have important implications for understanding the different perspectives people adopt in situations in which they have to decide to harm ingroup or outgroup members, which will ultimately lead to a deeper understanding of the neuroscience of ingroup bias.

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Disclosure statement

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References

Agthe, M., Strobel, M., Spörrle, M., Pfundmair, M., & Maner, J. K. (2016). On the borders of harmful and helpful beauty biases: The biasing effects of physical attractiveness depend on sex and ethnicity. *Evolutionary Psychology*, *14* (2), 1–14. doi:10.1177/1474704916653968

Ameli, S. R., & Merali, A. (2015). *Environment of hate: The new normal for muslims in the UK*. London: Islamic Human Rights Commission. Retrieved 9 October 2017. from http://www.ihrc.org.uk/publications/reports/11559-environment-of-hate-the-new- normal-for-muslims-in-the-uk

Amodio, D. M. (2014). The neuroscience of prejudice and stereotyping. *Nature Reviews Neuroscience*, *5*(10), 1–13. doi:10.1038/nrn380

Amodio, D. M., & Frith, C. D. (2006). Meeting of minds: The medial frontal cortex and social cognition. *Nature Reviews Neuroscience*, *7*(4), 268–277. doi:10.1038/nrn1884

Balconi, M. (2010). *Neuropsychology of the sense of agency*. New York: Springer.

Balleine, B. W., Delgado, M. R., & Hikosaka, O. (2007). The role of the dorsal striatum in reward and decision-making. *The Journal of Neuroscience*, *27*(31), 8161–8165. doi:10.1523/JNEUROSCI.1554-07.2007

Bandura, A. (2002). Selective moral disengagement in the exercise of moral agency. *Journal of Moral Education*, *31* (2), 101–119. doi:10.1080/0305724022014322

Beer, J. S., John, O. P., Scabini, D., & Knight, R. T. (2006). Orbitofrontal cortex and social behavior: Integrating self-monitoring and emotion-cognition interactions. *Journal of Cognitive Neuroscience*, *18*(6), 871–879. doi:10.1162/jocn.2006.18.6.871

Beer, J. S., Stallen, M., Lombardo, M. V., Gonsalkorale, K., Cunningham, W. A., & Sherman, J. W. (2008). The

Quadruple Process model approach to examining the neural underpinnings of prejudice. *NeuroImage*, *43*(4), 775–783. doi:10.1016/j.neuroimage.2008.08.033

Berridge, K. C., & Kringelbach, M. L. (2013). Neuroscience of affect: Brain mechanisms of pleasure and displeasure. *Current Opinion in Neurobiology*, *23*, 294–303. doi:10.1016/j.conb.2013.01.017

Blair, R. J. R. (2004). The roles of orbital frontal cortex in the modulation of antisocial behaviour. *Brain and Cognition*, *55* (1), 198–208. doi:10.1016/S0278-2626(03)00276-8

Blair, R. J. R. (2007). Dysfunctions of medial and lateral orbitofrontal cortex in psychopathy. *Annals of the New York Academy of Sciences*, *1121*(1), 461–479. doi:10.1196/annals.1401.017

Borda, A. Z. (2016, May 18). Why we react differently to terror attacks depending on where they happen. *The Conversation*. https://theconversation.com/why-we-react-differently-to-terror-attacks-depending-on-where-they-happen-57389

Borg, J. S., Sinnott-Armstrong, W., Calhoun, V. D., & Kiehl, K. A. (2011). Neural basis of moral verdict and moral deliberation. *Social Neuroscience*, *6*(4), 398–413. doi:10.1080/17470919.2011.559363

Borsook, D., Upadhyay, J., Chudler, E. H., & Becerra, L. (2010). A key role of the basal ganglia in pain and analgesia - insights gained through human functional imaging. *Molecular Pain*, *6*(27). doi:10.1186/1744-8069-6-27

Bower, E. (2016) American deaths in terrorism vs. gun violence in one graph. CNN.Retrieved 9 October 2017 from http://edition.cnn.com/2016/10/03/us/terrorism-gun- violence/index.html.

Brown, L. M., Awad, G. H., Preas, E. J., Allen, V., Kenney, J., Roberts, S., & Lusk, L. B. (2013). Investigating prejudice toward men perceived to be Muslim: Cues of foreignness versus phenotype. *Journal of Applied Social Psychology*, *43*, S2. doi:10.1111/jasp.12015

Burke, D., Nolan, C., Hayward, W. G., Russell, R., & Sulikowski, D. (2013). Is there an own-race preference in attractiveness? *Evolutionary Psychology*, *11*(4), 855–872. doi:10.1177/147470491301100410

Chikama, M., McFarland, N. R., Amaral, D. G., & Haber, S. N. (1997). Insular cortical projections to functional regions of the striatum correlate with cortical cytoarchitectonic organization in the primate. *Journal of Neuroscience*, *15*, 9686–9705.

Ciftci, S. (2012). Islamophobia and threat perceptions: Explaining anti-muslim sentiment in the west. *Journal of Muslim Minority Affairs*, *32*(3), 293–309. doi:10.1080/13602004.2012.727291

Cikara, M., & Van Bavel, J. J. (2014). The neuroscience of intergroup relations an integrative review. *Perspectives on Psychological Science*, *9*(3), 245–274. doi:10.1177/1745691614527464

Cooney, M. (2009). *Is killing wrong?: A Study in Pure Sociology*. Charlottesville, VA: University of Virginia Press.

Correll, J., Park, B., & Wittenbrink, B. (2002). The police officer's dilemma: Using ethnicity to disambiguate potentially threatening individuals. *Journal of Personality and Social Psychology*, *83*, 1314–1329. doi:10.1037/0022-3514.83.6.1314

Correll, J., Urland, G. R., & Ito, T. A. (2006). Event-related potentials and the decision to shoot: The role of threat perception and cognitive control. *Journal of Experimental Social Psychology*, *42*, 120–128. doi:10.1016/j.jesp.2005.02.006

Culcasi, K., & Gokmen, M. (2011). The face of danger. *Aether: The Journal of Media Geography*, *8*, 82–96.

Decety, J., & Cowell, J. M. (2017). Interpersonal harm aversion as a necessary foundation for morality: A developmental neuroscience perspective. *Development and Psychopathology*, 1–12. doi:10.1017/S0954579417000530

Decety, J., Michalska, K. J., & Kinzler, K. D. (2012). The contribution of emotion and cognition to moral sensitivity: A neurodevelopmental study. *Cerebral Cortex*, *22*(1), 209–220. doi:10.1093/cercor/bhr111

Decety, J., & Porges, E. C. (2011). Imagining being the agent of actions that carry different moral consequences: An fMRI study. *Neuropsychologia*, *49*(11), 2994–3001. doi:10.1016/j.neuropsychologia.2011.06.024

Domínguez, D., Taing, J. F., & Molenberghs, S. A. P. (2016). Why do some find it hard to disagree? An fMRI study. *Frontiers in Human Neuroscience*, *9*, 718. doi:10.3389/fnhum.2015.00718

Dovidio, J. F., & Gaertner, S. L. (2004). Aversive racism. *Advances in Experimental Social Psychology*, *36*, 1–52. doi:10.1016/S0065-2601(04)36001-6

Dunn, K., Atie, R., Mapedzahama, V., Ozalp, M., & Aydogan, A. F. (2015). The resilience and ordinariness of Australian Muslims: Attitudes and experiences of Muslims Report. Retrieved from: https://www.uws.edu.au/__data/assets/pdf_file/0008/988793/12441_ text_challenging_racism_WEB.pdf

Elliott, R., Dolan, R. J., & Frith, C. D. (2000). Dissociable functions in the medial and lateral orbitofrontal cortex: Evidence from human neuroimaging studies. *Cerebral Cortex*, *10*(3), 308–317. doi:10.1093/cercor/10.3.308

Eres, R., Louis, W. R., & Molenberghs, P. (2017). Common and distinct neural networks involved in fMRI studies investigating morality: An ALE meta-analysis. *Social Neuroscience*, 1–15. doi:10.1080/17470919.2017.1357657

Eres, R., & Molenberghs, P. (2013). The influence of group membership on the neural correlates involved in empathy. *Frontiers in Human Neuroscience*, *7*, 176. doi:10.3389/fnhum.2013.00176

Federal Bureau of Investigation. (2014). *Hate Crime Statistics, 2013*. United States Department of Justice. Retrieved 9 October 2017 from https://ucr.fbi.gov/hate-crime/2013.

Forman, S. D., Cohen, J. D., Fitzgerald, M., Eddy, W. F., Mintun, M. A., & Noll, D. C. (1995). Improved assessment of significant activation in functional magnetic resonance imaging (fMRI): Use of a cluster-size threshold. *Magnetic Resonance in Medicine*, *33*, 636–647. doi:10.1002/(ISSN)1522-2594

Fumagalli, M., & Priori, A. (2012). Functional and clinical neuroanatomy of morality. *Brain*, *135*(7), 2006–2021. doi:10.1093/brain/awr334

Gaertner, S. L., & Dovidio, J. F. (1986). The aversive form of racism. In S. L. Gaertner & J. F. Dovidio (Eds.), *Prejudice, discrimination, and racism* (pp. 61–89). New York: Academic Press.

Garrigan, B., Adlam, A. L., & Langdon, P. E. (2016). The neural correlates of moral decision-making: A systematic review and meta-analysis of moral evaluations and response decision judgements. *Brain and Cognition*, *108*, 88–97. doi:10.1016/j.bandc.2016.07.007

Gray, K., Young, L., & Watz, A. (2012). Mind perception is the essence of morality. *Psychological Inquiry*, *23*, 101–124. doi:10.1080/1047840X.2012.651387

Griffiths, B., & Pedersen, A. (2009). Prejudice and the function of attitudes relating to Muslim Australians and Indigenous Australians. *Australian Journal of Psychology*, *61*(4), 228–238. doi:10.1080/00049530902748275

Han, S. (2015). Intergroup relationship and empathy for others' pain: A social neuroscience approach. In J. Warnick. & D. Landis (Eds.), *Neuroscience in Intercultural Contexts* (pp. 31-47). New York, NY: Springer.

Hayes, D. J., & Northoff, G. (2011). Identifying a network of brain regions involved in aversion-related processing: A cross-species translational investigation. *Frontiers in Integrative Neuroscience*, *5*, 49. doi:10.3389/fnint.2011.00049

Herman, M. R., & Campbell, M. E. (2012). I wouldn't, but you can: Attitudes toward interracial relationships. *Social Science Research*, *41*(2), 343–358. doi:10.1016/j.ssresearch.2011.11.007

Holroyd, C. B., & Coles, M. G. (2002). The neural basis of human error processing: Reinforcement learning, dopamine, and the error-related negativity. *Psychologist Reviews*, *109*, 679–709. doi:10.1037/0033-295X.109.4.679.

Horgan, J. (2014). *The Psychology of Terrorism* (2nd ed. ed.). New York, NY: Routledge.

Hutton, C., Bork, A., Josephs, O., Deichmann, R., Ashburner, J., & Turner, R. (2002). Image distortion correction in fMRI: A quantitative evaluation. *NeuroImage*, *16*(1), 217–240. doi:10.1006/nimg.2001.1054

Institute for Economics and Peace. (2016). *Global Terrorism Index*. The University of Maryland. Retrieved 9 October 2017 from http://economicsandpeace.org/wp-content/uploads/2016/11/Global-Terrorism-Index-2016.2.pdf.

Jezzard, P., & Balaban, R. S. (1995). Correction for geometric distortions in echoplanar images from B0 field variations. *Magnetic Resonance in Medicine*, *34*, 65–73. doi:10.1002/mrm.1910340111

Kringelbach, M. L., & Rolls, E. T. (2004). The functional neuroanatomy of the human orbitofrontal cortex: Evidence from neuroimaging and neuropsychology. Progress in. *Neurobiology*, *72*, 341–372.

Lamm, C., Decety, J., & Singer, T. (2011). Meta-analytic evidence for common and distinct neural networks associated with directly experienced pain and empathy for pain. *NeuroImage*, *54*(3), 2492–2502. doi:10.1016/j.neuroimage.2010.10.014

Lin, K. H., & Lundquist, J. (2013). Mate selection in cyberspace: The intersection of race, gender, and education. *American Journal of Sociology*, *119*(1), 183–215. doi:10.1086/673129

Mange, J., Chun, W. Y., Sharvit, K., & Belanger, J. J. (2012). Thinking about Arabs and Muslims makes Americans shoot faster: Effects of category accessibility on aggressive responses in a shooter paradigm. *European Journal of Social Psychology*, *42*(5), 552–556. doi:10.1002/ejsp.1883

Meyer, T. (1972). Effects of viewing justified and unjustified real film violence on aggressive behavior. *Journal of Personality and Social Psychology*, *23*(1), 21–29. doi:10.1037/h0032868

Mimura, M. (2010). The role of orbitofrontal cortex in moral judgment. *Clinical Neurology*, *50*(11), 1007–1009. doi:10.5692/clinicalneurol.50.1007

Molenberghs, P. (2013). The neuroscience of in-group bias. *Neuroscience and Biobehavioral Reviews*, *37*, 1530–1536. doi:10.1016/j.neubiorev.2013.06.002

Molenberghs, P., Bosworth, R., Nott, Z., Louis, W. R., Smith, J. R., Amiot, C. E., … Decety, J. (2014). The influence of group membership and individual differences in psychopathy and perspective taking on neural responses when punishing and rewarding others. *Human Brain Mapping*, *35*, 4989–4999. doi:10.1002/hbm.22527

Molenberghs, P., Gapp, J., Wang, B., Louis, W. R., & Decety, J. (2016). Increased moral sensitivity for outgroup perpetrators harming ingroup members. *Cerebral Cortex*, *26*(1), 225–233. doi:10.1093/cercor/bhu195

Molenberghs, P., Ogilvie, C., Louis, W., Decety, J., Bagnall, J., & Bain, P. (2015). The neural correlates of justified and unjustified killing: An fMRI study. *Social Cognitive and Affective Neuroscience*, *10*, 1397–1404. doi:10.1093/scan/nsv027

Moore, J. W. (2016). What is the sense of agency and why does it matter? *Frontiers in Psychology*, *7*, 1272. doi:10.3389/fpsyg.2016.01272

Moretto, G., Walsh, E., & Haggard, P. (2011). Experience of agency and sense of responsibility. *Consciousness and Cognition*, *20* (4), 1847–1854. doi:10.1016/j.concog.2011.08.014

Parkinson, C., Sinnott-Armstrong, W., Koralus, P. E., Mendelovici, A., McGeer, V., & Wheatley, T. (2011). Is morality unified? Evidence that distinct neural systems underlie moral judgments of harm, dishonesty, and disgust. *Journal of Cognitive Neuroscience*, *23*(10), 3162–3180. doi:10.1162/jocn_a_00017

Pearson, A. R., Dovidio, J. F., & Gaertner, S. L. (2009). The nature of contemporary prejudice: Insights from aversive racism. *Social and Personality Psychology Compass*, *3*(3), 314–338. doi:10.1111/spco.2009.3.issue-3

Pew Research Center (2011, July 21). Common concerns about islamic extremism: Muslim-western tensions persist. Retrieved from http://www.pewglobal.org/files/2011/07/Pew-Global-Attitudes-Muslim-Western-Relations-FINAL-FOR-PRINT-July-21-2011.pdf

Pew Research Center (2015, May 28). Public continues to back U.S. drone attacks. Retrieved from http://www.people-press.org/2015/05/28/public-continues-to-back-u-s-drone-attacks/2/.

Pew Research Center (2017) "U.S. Muslims concerned about their place in society, but continue to believe in the American dream." Retrieved 9 October 2017 from http://assets.pewresearch.org/wp-content/uploads/sites/11/2017/07/25171611/U.S.-MUSLIMS-FULL-REPORT.pdf.

Potârcă, G., & Mills, M. (2015). Racial preferences in online dating across European countries. *European Sociological Review*, *31*(3), 326–341. doi:10.1093/esr/jcu093

Raine, A., & Yang, Y. (2006). Neural foundations to moral reasoning and antisocial behavior. *Social Cognitive and Affective Neuroscience*, *1*(3), 203–213. doi:10.1093/scan/nsl033

Rhodes, G., Yoshikawa, S., Clark, A., Lee, K., McKay, R., & Akamatsu, S. (2001). Attractiveness of facial averageness and symmetry in non-Western cultures: In search of biologically based standards of beauty. *Perception*, *30*(5), 611–625. doi:10.1068/p3123

Robnett, B., & Feliciano, C. (2011). Patterns of racial-ethnic exclusion by internet daters. *Social Forces*, *89*(3), 807–828. doi:10.1093/sf/89.3.807

Rolls, E. T. (2004). The functions of the orbitofrontal cortex. *Brain and Cognition*, *55*(1), 11–29. doi:10.1016/S0278-2626(03)00277-X

Roy, O. (2017). *Jihad and death: The global appeal of Islamic State*. London: C. Hurst & Co.

Schaich Borg, J., Hynes, C., Van Horn, J., Grafton, S., & Sinnott-Armstrong, W. (2006). Consequences, action, and intention as factors in moral judgments: An fMRI investigation. *Journal of Cognitive Neuroscience*, *5*, 803–817. doi:10.1162/jocn.2006.18.5.803

Schultz, W., & Dickinson, A. (2000). Neuronal coding of prediction errors. *Annual Review of Neuroscience*, *23*, 473–500. doi:10.1146/annurev.neuro.23.1.473

Senholzi, K. B., Depue, B. E., Correll, J., Banich, M. T., & Ito, T. A. (2015). Brain activation underlying threat detection to targets of different races. *Social Neuroscience*, *10*(6), 651–662. doi:10.1080/17470919.2015.1091380

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*, 1157–1162. doi:10.1126/science.1093535

Swaine, J., Laughland, O., Lartey, J., & McCarthy, C. (2015, January 1). The Counted. Young black men killed by US police at highest rate in year of 1,134 deaths. *The Guardian*. Retrieved from https://www.theguardian.com/us-news/2015/dec/31/the-counted-police-killings-2015-young-black-men

Tangney, J. P., Stuewig, J., & Mashek, D. J. (2007). Moral emotions and moral behavior. *Annual Review of Psychology*, *58*(1), 345–372. doi:10.1146/annurev.psych.56.091103.070145

Unkelbach, C., Forgas, J. P., & Denson, T. F. (2008). The turban effect: The influence of Muslim headgear and induced affect on aggressive responses in the shooter bias paradigm. *Journal of Experimental Social Psychology*, *44*(5), 1409–1413. doi:10.1016/j.jesp.2008.04.003

Wagner, T. D., & Barrett, L. F. (2017). From affect to control: Functional specialization of the insula in motivation and regulation. *bioRxiv*. doi:10.1101/102368

Wagner, U., N'Diave, K., Ethofer, T., & Vuilleumier, P. (2011). Guilt-specific processing in the prefrontal cortex. *Cerebral Cortex*, *21*(11), 2461–2470. doi:10.1093/cercor/bhr016

Xu, X., & Inzlicht, M. (2015). Neurophysiological responses to gunshooting errors. *International Journal of Psychophysiology*, *95*(3), 247–253. doi:10.1016/j.ijpsycho.2014.10.015

Xu, X., Zuo, X., Wang, X., & Han, S. (2009). Do you feel my pain? Racial group membership modulates empathic neural responses. *The Journal of Neuroscience*, *29*(26), 8525–8529. doi:10.1523/JNEUROSCI.2418-09.2009

Yoder, K. J., & Decety, J. (2014). The good, the bad, and the just: Justice sensitivity predicts neural response during moral evaluation of actions performed by others. *The Journal of Neuroscience*, *34*(12), 4161–4166. doi:10.1523/JNEUROSCI.4648-13.2014

Young, L., & Dungan, J. (2012). Where in the brain is morality? Everywhere and maybe nowhere. *Social Neuroscience*, *7*(1), 1–10. doi:10.1080/17470919.2011.569146