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Outcome-oriented moral evaluation in terrorists

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As shown by the Office of the United Nations High Commissioner for Human Rights, terrorism is one of the most pernicious threats to contemporary societies[1]. In addition to obliterating the freedom and physical integrity of victims, terrorist practices can destabilize governments, undermine civil harmony and threaten economic development[1]. This is tragically corroborated by the recent history of Colombia, a country marked by escalations of paramilitary terrorist violence[2]. Although multiple disciplines are struggling to understand these atrocities, the contributions from cognitive science have been limited. Social cognition abilities[3–7] have been proposed as important variables in relation to criminal and violent profiles. Against this background, this study aimed to assess the moral judgements and social-cognitive profiles of 66 ex-combatants from a paramilitary terrorist group. We found that moral judgement in terrorists is abnormally guided by outcomes rather than by the integration of intentions and outcomes. This pattern was partially related to emotion recognition and proactive aggression scores but independent from other cognitive domains. In addition, moral judgement was the measure that best discriminated between terrorists and non-criminals.

With extreme violence escalating for more than 60 years, Colombia features one of the greatest insurgency rates in the world[8]. In particular, terrorism has become the main political and economic tool of paramilitary groups—illegal right-wing armed organizations first formed by state and landowners in response to guerrilla movements[2]. Their violent practices have grown so steeply that Colombia now has one of the highest levels of terrorism worldwide[8]. International Amnesty[9] estimates that, in the past two decades, at least 70,000 people have been killed by terrorists in this country. Thousands more have been victims of enforced disappearance, kidnapping and torture, mostly at the hands of paramilitary groups[2]. Paradoxically, the terrorists typically justify their actions in terms of moral imperatives[10,11]. Indeed, they have invoked the need for 'social cleansing', killing thousands of drug addicts, criminals, prostitutes, homosexuals and homeless individuals as part of a 'moral purification' campaign[12]. Thus, this population constitutes an invaluable model to assess the links between violent experiences and moral cognition.

Within a given social group, moral norms emerge from conventionally accepted values that guide adaptive behaviour[13]. In civilized social niches, individuals tend to attach greater importance to intentions than to outcomes in judging the morality of an action. Actions aiming to induce harm, regardless of their success, are typically deemed less morally permissible than those in which harm was neither intended nor inflicted, or merely accidental[14,15]. Although no study has assessed moral cognition in extreme terrorists, recent evidence shows that criminal psychopaths feature abnormally utilitarian personal moral judgements[16] and judge accidental harm as more permissible than non-psychopaths[17]. Moreover, when faced with moral dilemmas, psychopaths show reduced activity in brain regions associated to moral judgement[18]. By the same token, extreme terrorists could be distinctively characterized by deviant forms of moral cognition, arguably shaped by their particular cultural milieus. Specifically, if terrorists deem it morally appropriate to do whatever it takes in the pursuit of an aim, their moral judgements may be critically rooted in the success of an action rather than the probity of its underlying intention.

To address this issue, we evaluated 66 incarcerated members of an illegal armed paramilitary group, designated as a terrorist organization by multiple countries and organizations. All of them were convicted of murder, with a mean of 33 victims per subject. We also assessed 66 sociodemographically matched controls (non-criminals). Participants performed a well-characterized moral judgement task[14,15] (see Methods section) that disentangles the contributions of intentions and outcomes to moral judgement. The task included two conditions in which intentions and outcomes matched ('no harm intended or inflicted' and 'successfully attempted harm') and two in which these variables mismatched ('unsuccessfully attempted harm' and 'accidental harm') (see Fig. 1). Additional tasks were administered to assess relevant cognitive-affective domains (intellectual level, executive functions, aggressive behaviours and emotion recognition). Between-group comparisons were performed to determine the domains in which terrorists exhibited atypical performance. Results showed no significant differences in fluid intelligence, verbal intelligence quotient (IQ) or executive functions. However, scores on the Motives for Aggression Inventory (MAI) and the Situation and Aggressive Behavior Inventory (SABI) revealed a higher frequency of aggressive behaviours in terrorists than in non-criminals (Table 1). Terrorists also showed higher levels of proactive aggression than non-criminals as measured by the Reactive–Proactive Aggression Questionnaire (RPQ). No differences between groups were observed in the levels of reactive aggression (Table 1). In addition, terrorists exhibited lower scores in emotion recognition, with specific difficulties in detecting anger, sadness and disgust (Table 1).

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a

Accidental harm
Grace and her friend are taking a tour of a chemical plant. When Grace goes over to the coffee machine to pour some coffee, Grace's friend asks for some sugar in hers. **There is white powder in a container by the coffee. The white powder is a very toxic one left behind by a scientist, and therefore deadly when ingested in any form.** The container is labelled **'sugar'**, so Grace believes that the white powder by the coffee is **sugar** left out by the kitchen staff. Grace puts the substance in her friend's coffee. Her friend drinks the coffee and **dies**.

b

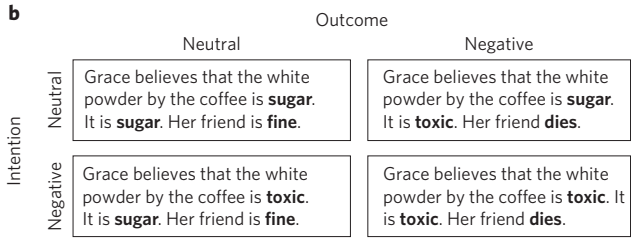

Figure 1 | Experimental design and stimuli. a, Illustrative text of an 'accidental harm' scenario. Bold sections indicate words that differed across conditions. **b**, Combination of intention (neutral versus negative) and outcome (neutral versus negative) factors yielding a 2 × 2 design with four conditions.

The more important findings, however, concerned moral judgement. A mixed-effects 2 (group: terrorist versus non-criminals) × 2 (intention: neutral versus negative) × 2 (outcome: neutral versus negative) ANOVA revealed that both groups judged actions with neutral intentions and neutral outcomes as more permissible than actions with negative intentions and negative outcomes (main effects of intention ($F(1, 130) = 621.56$, $p < 0.01$, $\eta^2 = 0.82$) and outcome ($F(1, 130) = 468.2$, $p < 0.01$, $\eta^2 = 0.78$)). Furthermore, accidental harm was judged as more permissible than intentional harm (intention × outcome interaction ($F(1, 130) = 54.61$, $p < 0.01$, $\eta^2 = 0.3$)).

In addition, a significant three-way interaction was detected among intention, outcome and group ($F(1, 130) = 9.62$, $p < 0.01$, $\eta^2 = 0.09$). A post-hoc analysis (Tukey HSD, mean square error = 0.66, d.f. = 235.70) revealed that terrorists judged accidental harm as less permissible ($p < 0.01$) and attempted harm as more permissible ($p < 0.01$) than non-criminals. Neither of these conditions was affected by executive skills (accidental harm judgement: backward digit span ($p = 0.16$), verbal working memory ($p = 0.51$), abstraction capacity ($p = 0.89$); attempted harm judgement: backward digit span ($p = 0.3$), verbal working memory ($p = 0.5$), abstraction capacity ($p = 0.17$)). Also, no significant differences emerged in judgements of non-harm ($p = 0.14$) or successful attempt to harm ($p = 0.46$) (see Fig. 2a). The terrorists' moral judgements for no harm ($r = -0.014$, $p = 0.23$), accidental harm ($r = .016$, $p = 0.92$), unsuccessfully attempted harm ($r = -0.23$, $p = 0.17$) or successfully attempted harm ($r = 0.15$, $p = 0.21$) were not significantly associated to the time spent in prison.

In addition, to control for the effect of aggression, fluid intelligence, executive functions and emotion recognition on moral judgement, we reanalysed the data considering the following covariates: Raven's matrices, total scores from the INECO Frontal Screening battery (IFS), MAI and The Awareness of Social Inference Test (TASIT), and the SABI and RPQ subscales. Results showed that the three-way interaction among intention, outcome and group remained significant ($F(1, 122) = 4.01$, $p < 0.05$, $\eta^2 = 0.03$).

As in previous reports[19], paired-sample t-tests were used to compare within-group performance on the moral conditions in which terrorists differed from non-criminals. These comparisons revealed that non-criminals judged accidental harm as more permissible than attempted harm ($t(65) = 15.52$, $p < 0.01$). The opposite difference was observed in terrorists ($t(65) = -6.27$, $p < 0.01$), who judged attempted harm as more permissible than accidental harm.

To establish how specific these patterns were to terrorists, as opposed to other criminals, we administered the moral judgement task to a second control group of incarcerated murderers with no terrorist background (see Supplementary Information 1). This second group was matched for years of imprisonment, age, sex and education. Relative to both this sample and the first control group, terrorists judged accidental harm as less permissible and attempted harm as more permissible. No significant differences were observed between the two control groups in any condition (see Supplementary Information 2 and Supplementary Fig. 1).

Considering the marked distortions observed in terrorists' moral cognition, we conducted a multiple regression analysis to explore whether moral judgement was associated with performance in the other relevant domains. For this analysis, we estimated their overall moral judgement profile by calculating a global moral score. This score was represented by the average of the difference between raw scores for accidental and attempted harm and the maximum expected rating for each condition (7 and 1, respectively). Thus, we subtracted the accidental harm score from 7 and the attempted harm score from 1, and then we averaged both results. The higher this global score, the worse the sample's performance. We estimated a model in which the above global score was considered as the dependent variable, while group, Raven's matrices, IFS, MAI and TASIT total scores, and SABI and RPQ subscales were the predictors. This model ($F(9, 122) = 21.67$, $p < 0.01$) showed that RPQ proactive aggression score (beta = 0.23), total TASIT score (beta = −0.24) and group (beta = −0.50) predicted moral judgement, explaining 58% of the variance (Fig. 2b,c). Fluid intelligence, executive functions, reactive aggression and frequency of aggressive behaviours did not predict moral judgement performance. Standardized coefficients and significance levels are shown in Table 2.

In addition, a logistic regression was conducted to determine domains associated with group membership. This model included group as dependent variable and Raven's matrices, moral global score, IFS, MAI and TASIT total score, and SABI and RPQ subscales as covariates. The model showed that moral judgement global score was the only significant predictor of group membership (beta = −1.57, $p < 0.001$). Moreover, this model correctly predicted group membership for 89% of the terrorists and 83% of the non-criminals.

Receiver operating characteristic (ROC) curves were calculated to test (i) whether any of the assessed domains successfully discriminated terrorists from non-criminals, and (ii) which of these domains yielded the best discrimination accuracy. The best discrimination between groups was afforded by global moral score (area under the curve 0.91, confidence interval CI: 0.85–0.96; $p < 0.01$). At a cut-off of 2.5 on the global moral score, sensitivity and specificity were 0.86 and 0.84, respectively (Fig. 2e). Fluid intelligence, executive functions, RPQ proactive aggression score, MAI, SABI and TASIT total scores did not accurately discriminate terrorists from non-criminals (Fig. 2e).

Given the high discrimination accuracy obtained by the moral global score, we tested whether moral judgement offered a better group classification than the combination of measures yielding group differences. For this purpose, the measures revealing differences between groups (RPQ proactive aggression score, SABI situations subscale, MAI and TASIT total scores), except for global moral score, were combined into a support vector machine (SVM) model (see details in Data analysis). This model achieved an average classification accuracy of 75%, a sensitivity of 0.79 and a specificity of 0.73. The area under the ROC curve calculated from the decision values produced by the SVM model was 0.71, indicating that the model has acceptable discrimination accuracy. However, a statistical comparison between the area under the ROC curves for the global moral score and the SVM model revealed that the former,

Table 1 | Demographic data, intellectual and executive functions, and aggression and emotion recognition assessments.

		Terrorists ($N = 66$) Mean [95% CI]	Controls ($N = 66$) Mean [95% CI]	p-values
Demographics	Age (years)	39.27 [37.98, 40.49]	39.24 [38.02, 40.52]	0.97
	Sex (F:M)	0:66	0:66	1.00
	Education (years)	7.89 [6.99, 8.79]	7.98 [7.18, 8.78]	0.88
Intellectual and executive functioning	Verbal intelligence	97.74 [95.59, 99.89]	99.86 [97.95, 101.77]	0.14
	Fluid intelligence	45.65 [44.51, 46.78]	44.80 [43.81, 45.78]	0.26
	IFS total score	22.98 [22.19, 23.77]	23.45 [22.82, 24.08]	0.35
	Motor series	2.95 [2.90, 3.00]	2.89 [2.80, 2.98]	0.23
	Conflicting instructions	2.78 [2.68, 2.88]	2.75 [2.63, 2.88]	0.70
	Motor inhibitory control	2.66 [2.49, 2.83]	2.54 [2.41, 2.67]	0.25
	Backward digits span	3.15 [2.91, 3.38]	3.39[3.22, 3.56]	0.09
	Verbal working memory	1.78 [1.68, 1.88]	1.89 [1.81, 1.97]	0.09
	Spatial working memory	3.06 [2.86, 3.35]	3.19 [3.06, 3.32]	0.18
	Abstraction capacity	2.72 [2.60, 2.85]	2.57[2.45, 2.69]	0.09
	Verbal inhibitory control	4.40 [4.02, 4.79]	4.34 [4.02, 4.67]	0.81
Aggression scales	MAI	34.53 [32.46, 36.59]	29.21 [27.62, 30.80]	<0.001
	SABI total score (s.d.)	24.09 (3.79)	22.01 (2.69)	<0.001
	SABI aggressive behaviours	9.21 [8.89, 9.52]	8.78 [8.46, 9.11]	0.06
	SABI situations	14.87 [14.09, 15.66]	13.37 [12.84, 13.91]	0.002
	RPQ proactive	4.34[3.17, 5.51]	1.45 [0.93, 1.97]	0.00001
	RPQ reactive	6.25 [5.24, 7.26]	5.42 [4.14, 6.70]	0.30
	RPQ total score	10.60 [8.53, 12.67]	6.87 [5.42, 8.32]	0.003
Emotion recognition	Fear	1.42 [1.23, 1.61]	1.75 [1.64, 1.87]	0.10
	Anger	1.45 [1.25, 1.65]	1.95 [1.90, 2.00]	<0.001
	Sadness	1.28 [1.08, 1.49]	1.93 [1.88, 1.99]	<0.001
	Surprise	1.34 [1.14, 1.54]	1.56 [1.39, 1.72]	0.70
	Disgust	1.18 [0.96, 1.40]	1.63 [1.51, 1.75]	0.003
	Total score	6.69 [5.91, 7.47]	8.84 [8.61, 9.07]	<0.001

by itself, showed better discrimination accuracy ($z = -2.27$, $p = 0.01$) (Fig. 2d).

In sum, our results provide evidence of distorted moral cognition in extreme terrorists. Whereas previous psychological examinations have used projective and self-report tests to characterize terrorist samples[20], this study used experimental tasks to assess moral cognition and other social-cognitive domains in paramilitary terrorists. The finding that moral judgement was the measure that best discriminated between groups, whereas other measures showed mild or null differences, suggests that distortion in this domain is a hallmark of the terrorist mindset. This approach to understanding terrorists' social-cognitive profiles has important legal and forensic implications.

Adult moral judgement typically depends on the capacity to represent and integrate information about the intentions and consequences of actions[21]. In many cases, moral judgement is determined primarily by intention; however, when intention and outcome are in conflict, moral judgements are normally construed by considering both factors[22]. Here, terrorists exhibited the opposite pattern. Unlike non-criminals, they judged attempted harm by focusing on the neutral outcome rather than on the protagonist's negative intention. Similarly, they judged accidental harm by focusing on the negative outcome without considering the neutral intention. Surprisingly, this moral judgement pattern resembles that observed at early developmental stages[23,24] (see Supplementary Information 3 for a further discussion). Thus, our results suggest that the terrorists' moral judgement is characterized by an overreliance on outcomes rather than by the integration of intentions and outcomes.

This pattern opposes the widely described 'harm magnification effect'[25], which shows that people overestimate the damage caused by intentional harm compared with accidental harm, assigning more punishment and moral condemnation[25]. Indeed, terrorists judged attempted harm as more permissible and accidental harm as less permissible than did non-criminals. Moreover, unlike the latter, terrorists considered accidental harm to be more morally wrong than attempted harm. Previous studies have suggested that terrorists' behaviour is goal-directed[11]. The distorted moral judgement pattern observed here may be one of the factors related to such a tendency. This does not mean that terrorists are committed to a single focal goal. Instead, it suggests that our sample is characterized by a general tendency to focus more on the outcomes of actions than on the actions' underlying intentions. Also, when applied to terrorism, rational choice theory would assume that terrorist acts usually emanate from rational, conscious outcome-oriented decisions[26,27]. A rational choice is one that maximizes one's outcomes by choosing means that favour the attainment of prime goals with the least sacrifice of outcomes in terms of possible alternative goals[28]. This does not imply that the decision is morally permissible or that the means to achieve an outcome is behaviourally normal. Indeed, in our target population, violent behaviour would seem to be the principal means to pursue specific goals. In addition, although rational choice theory may be applied to the interpretation of organizational terrorist

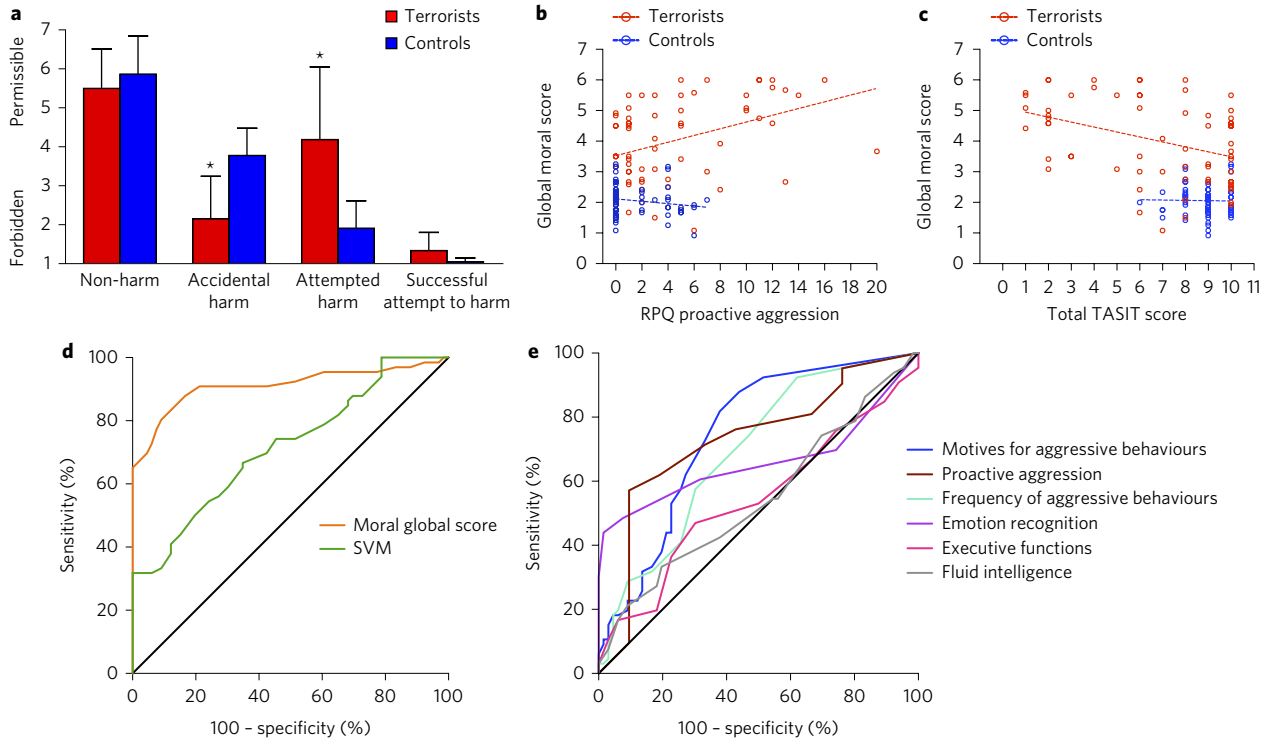

Figure 2 | Significant differences between groups, associations between moral judgement and other relevant factors, and ROC curve analyses. **a**, Moral judgements of terrorists ($N = 66$) and non-criminals ($N = 66$). Asterisks indicate significant differences ($p < 0.05$). Error bars represent standard deviations. **b**, Regression analysis with global moral score as the dependent variable and RPQ proactive aggression score as the significant predictor. **c**, Regression analysis with global moral score as the dependent variable and total TASIT score as the significant predictor. **d**, ROC curves for the global moral score and the SVM model. The global moral score yielded the best discrimination accuracy (area under the curve (AUC): 0.91, CI: 0.85–0.96; $p < 0.01$), followed by the SVM model (AUC: 0.78, CI: 0.70–0.86; $p < 0.01$). **e**, ROC curves for the attributes that did not show good discrimination accuracies. Motives for aggressive behaviours (AUC: 0.74, CI: 0.66–0.83; $p < 0.01$); RPQ proactive aggression score (AUC: 0.72, CI: 0.63–0.81; $p < 0.01$); frequency of aggressive behaviours (AUC: 0.69, CI: 0.60–0.78; $p < 0.01$); emotion recognition (AUC: 0.66, CI: 0.56–0.86; $p < 0.01$); executive functions (AUC: 0.54, CI: 0.44–0.64; $p = 0.39$); fluid intelligence (AUC: 0.54, CI: 0.44–0.64; $p = 0.37$).

behaviour[27], it may also be used to explain individual behaviour. In fact, this theory has been previously considered to explain criminal actions that do not imply an organizational structure. For example, it has been adopted as a framework to interpret individual criminal conducts, such as sexual assault[29,30] and theft[31]. According to this theory, sexual assault is the product of a rational decision[29]. In this case, the offenders' decisions would be based on the evaluation of the situational factors, legal consequences, and the perceived costs and benefits of the crime. Sexual assault cannot be objectively considered as a normal response to maximize an outcome. Thus, although our results are not odds with rational-choice theory, further studies should explore other factors related to violent behaviour as a means to achieve a specific goal.

Moreover, our results support the proposal[27] that terrorists can suppress instinctive and learned moral constraints against harming innocents, such as empathy, fairness and prosociality. This could be caused by intrinsic or acquired factors, and by individual or group forces. In addition, the profile observed in the terrorists may reflect their fixation on utopian visions whereby only (idealized) ends matter[32]. That is, their outcome-based moral judgements may be related to the belief that any action can be justified

insofar as it favours the accomplishment of a utopian aim. Although these speculations exceed the scope of our study, they open interesting avenues for future research.

In addition, it has been suggested that ideology may direct violence and terrorism against a well-defined enemy to achieve a specific goal. This view, however, does not fully apply to the terrorist group assessed here. A crucial point is that most ex-combatants joined paramilitary groups for economic reasons[33–36]. Only about 13% of ex-combatants had an ideological motivation for joining the paramilitary group[24]. These points suggest that, in our sample, the use of violence is not fully justified by ideology. Thus, it is unlikely that terrorist and other criminal acts (massacres, murder, theft, kidnapping and fraud) committed by these individuals were guided purely by their ideological convictions. Moreover, it is unlikely that

Table 2 | Standardized coefficients of the multiple regression model ($N = 122$).

Predictors	DV: moral global score	
	Beta coefficient	*p*-value
Group	−0.50	0.000
Fluid intelligence	−0.01	0.77
IFS total score	−0.03	0.57
MAI	0.57	0.44
SABI aggressive behaviours subscale	−0.06	0.29
SABI situations subscale	−0.01	0.88
RPQ proactive aggression	0.23	0.000
RPQ reactive aggression	0.06	0.32
TASIT total score	−0.24	0.000

DV, dependent variable; QMAA, Questionnaire of Moral Attitudes to Aggression; other abbreviations as in text.

outcome-based moral judgement observed in this terrorist group is related to its ideology. Future studies should investigate whether there is a relationship between the strength of terrorists' ideological convictions and their moral judgement patterns (see Supplementary Information 4).

The distorted outcome-based moral judgement pattern observed in terrorists may seem paradoxical if we consider that members of this paramilitary group typically justify their actions in terms of moral imperatives[10,11]. They have invoked the need, based on moral values, for so-called 'social cleansing', killing thousands of people. Although this is apparently contradictory, note that invoking an argument to justify an action does not necessarily mean believing in that argument. Indeed, moral justification may be a post-hoc strategy to save face or reduce personal responsibility. Evidence for this has been provided by numerous previous cognitive science studies[37–40].

The pattern of outcome-based moral judgement observed in terrorists does not seem related to language comprehension impairments, as all conditions involved similar verbal demands. Furthermore, as revealed by covariance analyses, it was not related to working memory or abstraction capacity impairments. In addition, the task employed has been previously used in Latin-American populations[19,41], which supports the cross-cultural validity of the moral scenarios considered.

Importantly, the specific moral cognition profile of terrorists differs from those previously observed in multiple populations via the same task[15,17,42]. For example, a previous study[17] using the same scenarios showed that criminal psychopaths judged accidental harm as more morally permissible than criminal non-psychopaths. This pattern is notably different from the one shown by terrorists. Although some members of paramilitary groups may exhibit psychopathic traits, their moral judgements are not explained by such a factor (see below). In this sense, an inconsistency has been noted between psychopathic personalities and the mutual commitment and cooperation evident within terrorist groups[43]. Moreover, there is little evidence that terrorists suffer from psychopathy[27], and it has been shown that criminal behaviour is a correlate, not a component, of psychopathy[44]. Thus, criminal psychopaths and terrorists seem to constitute cognitively different populations possessing distinctive moral judgement tendencies.

On the other hand, the pattern observed in terrorists resembles moral judgement impairments in patients with neurological disorders[19,45] (frontotemporal dementia), who present high levels of impulsivity as well as sociopathic and criminal traits[46,47]. This condition, too, is characterized by reduced reliance on information about a person's innocent or negative intentions and, hence, overreliance on the action's outcome for both attempted and accidental harm. Thus, moral judgement seems comparable, to some degree, between terrorists and subjects with damage in frontal and temporal regions involved in moral cognition. This loose comparison suggests a need for further research on the structural and functional brain correlates of moral judgement in terrorists.

It is also noteworthy that moral judgement in our target group was not associated with fluid intelligence or executive functions. This finding aligns with two strands of evidence. First, intellectual level does not necessarily correlate with moral reasoning abilities[48]. Second, deviant moral judgements may be present even in individuals with normal or above-average IQ[42]. Moreover, our results suggest a dissociation between fluid intelligence, executive functions and moral judgement, in line with a previous study[49] showing that intelligence is not associated with external aggression. Taken together, these data weaken the view that low fluid intelligence and executive functions are key factors related to aggression and offensive behaviour. However, given that the complexity of executive functions makes it impossible for a single test to evaluate this cognitive domain in its entirety, future studies should assess the terrorists' executive profile through an exhaustive neuropsychological battery.

We also found that scores on aggression scales measuring motives for aggression, frequency of aggressive behaviours or levels or reactive aggression were not related to moral judgement. However, levels of proactive aggression were significantly associated with moral judgement performance. This finding is consistent with research showing that participants who score higher on aggression measures (that is, total RPQ score) are more likely to favour utilitarian responses in moral dilemmas[50]. Also, our results align with previous evidence[51] revealing that moral judgement is related to proactive aggression but not to reactive aggression. Furthermore, although emotion recognition abilities were partially associated with moral judgement, they did not predict the terrorists' moral judgement pattern or discriminate between terrorists and non-criminals. In this sense, our findings corroborate behavioural research[15,52] suggesting that emotional processing deficits are associated with moral judgement impairments. Our results are also in line with neuroimaging studies[18,53,54] showing that key brain regions involved in emotion processing (for example the amygdala and ventromedial prefrontal cortex) are also relevant for this domain. Moreover, the amygdala seems to be crucial in supporting early detection of intentional harm[54].

Crucially, the logistic regression model showed that moral judgement was the only domain significantly associated with group membership. Furthermore, ROC curve analyses revealed that moral judgement was the measure with the best sensitivity and specificity to distinguish between terrorists and non-criminals. By the same token, the comparison with the SVM classification confirmed that moral judgement performance, by itself, was the best measure to classify the groups, even when compared with the combination of those domains revealing distorted performance in terrorists. Thus, deviant moral judgement seems to constitute the most prominent attribute of our terrorist sample. In brief, this result highlights the importance of evaluating moral judgement to characterize terrorist groups and to understand the socio-cognitive processes underlying their brutal acts.

From a translational perspective, our findings have legal and forensic implications. Sensitive instruments tapping socio-cognitive profiles could eventually contribute to characterize terrorist behaviour. Although our results do not suffice to determine whether moral judgement tasks could be used to identify those terrorists more likely to relapse or to predict who will become a terrorist, they do open the door to future research on moral cognition in terrorist groups. Future studies should test the predictive value of moral judgement and other social-cognitive tasks to identify dangerous insurgent individuals. In this sense, further cross-sectional and longitudinal studies are needed to test the predictive value of moral cognition tasks in the assessment of future aggressive behaviour and social adaptation. Moreover, terrorism is undeniably a dynamic phenomenon in which group processes, culture and socio-psychological factors are important to radicalization[55]. Therefore, future research on the topic should explore the relationship between these factors and social-cognitive domains.

More particularly, our results may have regional implications for the Colombian legal system, because most of the terrorists who participated in this study were freed last year. Given that no significant associations were found between the terrorists' moral judgement performance and the time spent in prison, their moral judgement pattern could hardly be explained by proximity to release. Indeed, if such a factor were biasing their performance, one would expect an effort towards more socially acceptable responses. In addition, moral reasoning is essential for proper social functioning and for preventing delinquent behaviour[56]. Because the terrorists in our sample exhibited skewed moral judgements, emotion recognition impairments and high levels of aggression, especial attention should be paid to them on release, especially in light of the high

levels of relapse reported among demobilized paramilitaries[28,30]. Psychological and social-cognitive interventions may be beneficial for these individuals. Also, further research should explore whether the terrorists' moral judgement changes during imprisonment or after release.

Finally, although psychopathy may be present to some degree in any group of delinquents, we cannot confirm whether these terrorists are psychopaths. However, two key aspects suggest that their socio-cognitive profile is not explained by psychopathy. First, not all psychopaths are involved in criminal behaviours[44,57], and no conclusive evidence exists linking such a trait with terrorism[27,58,59]. Second, our results showed that moral judgement distortions differ between terrorists and criminal psychopaths[17]. Still, future research should explore the prevalence of psychopathy in terrorist paramilitary groups.

In conclusion, this study provides evidence about the socio-cognitive profile of terrorists, showing that moral judgement is the measure that best distinguished between terrorists and non-criminals. In legal and cognitive settings, intentions are assessed and often used to evaluate others' actions. The capacity to represent and reason about intentions is crucial in judging whether others' actions are right or wrong, harmless or harmful, punishable or unpunishable[21]. However, our results reveal that terrorists judge others' actions by focusing on the outcomes, suggesting that their moral code prioritizes ends over means. Thus, impairments in processing intentions and in integrating them with actions' outcomes may be one of the key social cognitive factors underlying the cruel acts committed by terrorist paramilitary groups.

Methods

Participants. Our sample included 66 incarcerated paramilitary terrorists who participated in a collective demobilization from 2003 to 2006. The demobilization process is formally supported by Colombian statutory law 975/05 (*Ley de Justicia y Paz*, Justice and Peace Law)[60], which promotes social reinsertion of armed group members who contribute to national peace. The law offers reduced punishment by means of an 'alternative' sentence (suspension of existing sentences, to be replaced with imprisonment of no less than 5 and no more than 8 years) for beneficiaries who comply with basic demobilizing requirements. These individuals have not participated in any rehabilitation or reinsertion programme (see Supplementary Information 5).

All 66 terrorists declared having participated in illegal armed right-wing paramilitary groups and gave a full, voluntary deposition and confession of crimes involving terrorist acts. This unique sample is characterized by high levels of terrorism and insurgency as well as aggressive and disruptive behaviours. Indeed, the paramilitary group to which they belonged was designated as a terrorist organization by multiple countries — for example the United States and Canada — and organizations such as the European Union. All participants in this group were convicted of murder, with a mean of 33 victims per subject (most of them were accountable for several massacres, with death tolls sometimes exceeding 600 victims). They had also engaged in other crimes, such as theft, kidnapping and fraud. Each paramilitary was screened to exclude neurological disorders, axis I psychiatric conditions and drug consumption habits that might affect any of the target variables.

We also formed a control group comprising 66 healthy individuals from the same geographical region and with no terrorist background. These participants were matched in age, sex and years of education with the terrorists group (see Table 1). A neuropsychiatric interview confirmed that control subjects had no history of alcohol/drug abuse or neurologic or psychiatric disorders. All participants provided written informed consent in agreement with the Helsinki declaration. The Ethics Committee of the Autonomous University of the Caribe approved the study.

Instruments. *Intellectual level and executive function measures.* Intelligence was evaluated with the Wechsler Abbreviated Scale of Intelligence[61] (WASI), which includes vocabulary and similarities subtests and provides a verbal estimated IQ. Fluid intelligence was assessed via Raven's standard progressive matrices[62]. The maximum score on Raven's test is 60 points.

Executive functions were evaluated through the IFS battery[63], a brief and well-validated[63–67] instrument which includes several subtests tapping into various executive functions. This battery includes eight subtests: (i) motor programming (Luria series, 'fist, edge, palm'); (ii) inhibition (subjects are asked to hit the table once when the administrator hits it twice, or vice versa); (iii) motor inhibitory control; (iv) numerical working memory (backward digit span); (v) verbal working memory (months backwards); (vi) spatial working memory (modified Corsi tapping test); (vii) abstraction capacity (inferring the meaning of proverbs); and (viii) verbal inhibitory control (modified Hayling test). The maximum global score on the IFS is 30 points. This measure was selected given the limited time available to evaluate participants and its utility for detecting executive function impairments in different populations[63–66,68] (see Supplementary Information 6).

Aggression scales. All participants completed the MAI[69], consisting of 26 items for which participants are asked to choose between three options ('never or almost never', 'sometimes' or 'often') to indicate the frequency with which different motives (such as "You have to defend your ideas," or "You cannot control yourself") trigger aggressive behaviours. Scores on this inventory range between 26 and 78 points. Moreover, participants completed the SABI[69]. This questionnaire has two subscales. The aggressive behaviours subscale measures the frequency ('never or almost never', 'sometimes' or 'often') of different types of verbal and physical aggression (for example beatings, threats, attitudes or gestures of anger). This subscale has scores between 9 and 27 points. The situations subscale evaluates the frequency ('never or almost never', 'sometimes' or 'often') of aggressive behaviours in response to specific situations (for example, family problems, economic difficulties or health problems). Scores on these subscales are between 13 and 39 points.

In addition, participants completed the RPQ[70], a self-report scale developed to distinguish between reactive and proactive aggression. The scale consists of 23 items rated on a three-point scale (0 = never, 1 = sometimes, and 2 = often). A total of 11 items assess reactive aggression (for example "Reacted angrily when provoked by others"), and 12 items assess proactive aggression (for example "Hurt others to win a game"). We calculated scores of reactive or proactive aggression together with an overall score of total aggression (the sum of reactive and proactive aggression scores).

Emotion recognition assessment. Emotion recognition was evaluated through TASIT, a measure of social perception based on videotaped vignettes of everyday social interactions[71]. This task, which has been used previously with incarcerated samples[68], introduces contextual cues (such as prosody, facial movement or gestures) and additional processing demands (such as adequate speed of information processing, selective attention or social reasoning) that are not taxed when viewing static displays. We used a modified version of part 1, called the Emotion Evaluation Test (EET). The EET assesses recognition of spontaneous emotional expressions (fearful, surprised, sad, angry, and disgusted) as conveyed by professional actors interacting in everyday situations. Emotional meaning is indicated by speaker demeanour (voice, facial expression and gesture) together with the social situation. Some scenes involve a single actor who talks either on the phone or to the camera. Other scenes depict two actors, in which case participants are instructed to focus on one of them. All scripts are neutral in content and do not lend themselves to any particular emotion. The brief EET comprises 10 short (15–60 s) videotaped vignettes. After viewing each scene, the participant must choose from a forced-choice list the emotion expressed by the focused actor. The maximum global score is 10 points.

Moral judgement task. Moral judgement was assessed through a previously reported protocol[15,19]. Participants were presented with 24 scenarios involving two individuals. Each scenario was presented as a written story and featured four variations following a 2 × 2 design: (1) the protagonist either harmed another person (negative outcome) or did no harm to him/her (neutral outcome); (2) the protagonists either believed that they would cause harm (negative intention) or believed that they would cause no harm (neutral intention). Each possible belief was true for one outcome and false for the other outcome. Thus, the four scenarios were (1) no harm, (2) accidental harm, (3) unsuccessfully attempted harm, and (4) successfully attempted harm (see Fig. 1). This experimental manipulation allows one to dissociate intentions and outcomes, so that some of the combinations of variables do not entail bad intentions (no harm and accidental harm), while others do (attempted harm and successfully attempted harm), and some of them have pernicious outcomes (accidental harm and successfully attempted harm), but others do not (no harm and attempted harm). Thus, the attempted harm and successfully attempted harm clearly involve moral violations based on unjustified aggressions.

After reading each story, the participants rated the scenario on a Likert scale ranging from totally forbidden (1) to totally permissible (7). In total, six trials of each of the four conditions were presented. The stimuli were presented in pseudorandom order, and the conditions were counterbalanced across participants. To decrease working memory load, the whole text remained visible until the trial was completed. This instrument has been widely used on both neurotypical and patient populations[17,19,42,45,72–77], and it has also been administered to incarcerated psychopaths[17] (see more information on the task's validity in Supplementary Information 7).

Data analysis. Demographic, neuropsychological, and experimental data were compared between groups with ANOVA and Tukey's HSD post-hoc tests (when appropriate). The assumption of normality was verified using the Shapiro–Wilk test. Data also met the assumption of homogeneity of variance, assessed with

Levene's test. Following the procedure reported elsewhere[17,19,42,45,73–77], moral judgement data was analysed via a 2 (intention: neutral, negative) × 2 (outcome: neutral, negative) × 2 (group: terrorists, non-criminals) repeated-measures ANOVA. Considering that terrorists showed a non-significant trend ($p = 0.09$) for lower working memory and abstraction capacity, we applied ANCOVA tests adjusted for IFS scores on these domains to control for their influence on moral judgements. We reported only effects that were still significant after covariation.

Paired-sample *t*-tests were used to compare intra-group performance on the moral conditions in which terrorists differed from non-criminals. We estimated overall moral judgement impairment by calculating a global moral score. Also, we conducted a multiple regression analysis to explore whether moral judgement was associated with other relevant domains. We estimated a model in which the above global score was considered as the dependent variable. The following variables were included as predictors: group, Raven's matrices, IFS, MAI, SABI and RPQ subscales, and TASIT total scores.

We conducted ROC curve analyses, which are useful to assess the effectiveness of a given test in classifying individuals as belonging within one group or the other[78], and it allows comparing the discrimination accuracy of two or more tests[79]. Specifically, we employed these analyses to test (i) whether any of the assessed domains successfully discriminated terrorists from non-criminals, and (ii) which of these domains yielded the best discrimination accuracy. The variables included in ROC curve analyses were Raven's matrices, IFS, MAI, SABI and TASIT total scores, the RPQ proactive aggression score, and the moral judgement global score. The area under the ROC curve was used as a measure of discriminatory accuracy.

In addition, we tested whether moral judgement offers a better group classification than the combination of measures yielding group differences. Using the latter measures, we implemented a SVM to classify terrorists and non-criminals. SVM is a supervised classification algorithm rooted in statistical learning theory[80], in which input data are classified into two classes (for example terrorists and non-criminals). Conceptually, input vectors are mapped to a higher-dimensional feature space using kernel special functions. Classification is performed by constructing a hyperplane in the feature space that optimally discriminates between the two classes of the training data by maximizing the margin between the two data clusters[80]. The variables (sensitive measures which discriminate between groups) included in the SVM analysis were MAI, SABI and TASIT total scores, and the RPQ proactive aggression score (see Results section for the measures' selection criteria). The SVM analysis was implemented through the WEKA software package[81], with 10-fold cross validation and a radial basis kernel function. An additional ROC curve was then calculated from the decision values produced by the SVM model. Finally, using a Mann–Whitney test, we assessed the statistical difference between the area under the ROC curve for the moral global score and that for the SVM model.

Data availability. The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Author contributions

S.B., E.H. and A.I. developed the study concept and the study design; E.H. performed testing and data collection; S.B. and A.M.G. performed the data analysis and interpretation under the supervision of A.I.; S.B., E.H., L.Y. and A.I. drafted the manuscript; and A.I., A.M.G., F.M. and L.Y. provided critical revisions. All authors approved the final version of the manuscript for submission.

Additional information

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Competing interests

The authors declare no competing interests.