Stoic Regulation: The Influence of Military Combat Training on Neurobehavioral Indices of Anger

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ABSTRACT

Military combat training, where stoic-like pedagogy promotes anger regulation, offers a paradigmatic case study for examining response to angering provocations and internalization of regulatory strategies. To this end, we conducted a prospective neuroimaging study prior to and towards the end of intensive infantry training of combat soldiers recruited to the Paratroopers Brigade of the Israel Defense Forces. A control group was recruited consisting of age matched volunteers who took part in one-year pre-army civil service programs. At each time-point, participants played a modified Ultimatum Game (UG) to which anger was further infused using interpersonal insults, while their brains were scanned using functional Magnetic Resonance Imaging. We previously showed that within the 60 participants of the first time-point (38 soldiers and 22 civilians) there were no differences in any of the anger measures including behavior, emotional reports and brain activations between soldiers and civilians. Specifically, we showed that all participants in the first time-point were mostly angry and rejected more offers as those offers became more unequal. Additionally, it was found that participants who gained more money reported less anger and more positive feelings, and had more ventromedial Prefrontal Cortex (vmPFC) and less Locus Coeruleus (LC) activation, while the reverse pattern was found for those participants who gained less money. Congruent with previous findings associating the vmPFC with implicit emotion regulation and the LC with arousal and aggression, we asserted that these two neurobehavioral response patterns reflected a regulated and an unbalanced profile of anger, respectively. Here we examined the results of the second time-point (29 soldiers and 17 civilians), which demonstrated that soldiers with a priori unbalanced anger profile displayed an increase in monetary gain, an increase in reported positive emotions, and an increase in vmPFC activation in response to the anger-infused UG at the end of combat training, thus presenting a regulated anger profile. Soldiers with a priori regulated profile displayed a marginal decrease in monetary gain and an increase in anger, but generally showed no differences compared to their angry colleagues from the first time-point. The civilians control group displayed no changes in any of the anger related measures between time-points. Findings support the formulation of Stoic pedagogy in military practice as a program that empowers anger regulation and suggest that an intense socio-cultural practice such as combat training styles one's mind and body in a fashion that decreases individual variability and produces uniform and regulated responses to anger.

Keywords: Anger; Aggression; Stoicism; Emotion Regulation; Ultimatum Game; Combat Training; fMRI; vmPFC

INTRODUCTION

It's not what happens to you, but how you react to it that matters.
Epictetus

Anger is a common emotion experienced on a daily basis and serves as a primary precursor to aggression and violence (Gilam & Hendler, 2015). Anger is considered an instinctive survival response inherent in all living creatures (Darwin, 1872; Panksepp, 1998), which triggers the fight feature of the fight or flight reaction in view of threatening situations (Cannon, 1927; Carver & Harmon-Jones, 2009). Humans however, are endowed with the mental flexibility that enables them to control and regulate their anger and adapt it to socially accepted norms (Averill, 1982; Berkowitz, 1990; Davidson, Putnam, & Larson, 2000; Gilam & Hendler, 2015; Gross, 1998). Yet, controlling, regulating or generally coping with one's anger is not an easy task. Difficulties in balancing levels of anger are apparent in normative development as well as in various pathological conditions (Potegal, Stemmler, & Spielberger, 2010). In fact, most people can probably testify that at under certain conditions they can lose control of their anger. Some theorists go as far as suggesting that a certain type of personality, referred to as Type A personality, is specifically prone to anger expression and aggressive reaction (Friedman, 1996). Various emotion regulation therapeutic and pedagogical programs exist to treat such emotional irregularities (Gross, 2015), yet over the years specialized anger management frameworks have been developed to train people to manage their anger in various phases of prevention, intervention and postvention of anger (Fernandez, 2010; Kassinove & Tafrate, 2002; Potter-Efron, 2005).

Anger management programs are reported to yield short and long term changes in patterns of angry and aggressive behavior (Blake & Hamrin, 2007; Potter-Efron, 2005). In such programs, four domains of intervention are generally outlined: cognitive reformulation to filter out unnecessary anger triggers (e.g. identifying and avoiding hostile thoughts), behavioral change of the actions taken during or after an anger episode (e.g. taking time-outs or learning to relax), affective modulation to prevent overstimulation and loss of control (e.g. exposure techniques teaching to remain calm when facing aversive stimuli), and personal growth by understanding the meaning of anger and aggression in a wider context (e.g. forgiveness practice). The changes promoted by these intervention programs induce modulations in cognitive, physiological and behavioral components during or after anger experience. However, the level of internalization of anger management strategies that such training programs can induce depends on their status and authority as socio-cultural institutions, as well as on their training pedagogy. Regardless of its moral end, military training, where Stoic-like pedagogy promotes behavioral and emotional regulation that aims to enhance the containment and control of anger (Darash, 2005; Sherman, 2007), offers a paradigmatic and institutionalized case study of such anger management programs. The aim of the current study was to investigate how military combat training influences the neurobehavioral substrates of anger.

1.1. Stoicism, military training and anger regulation

The core teaching of the Stoic philosophical school (Baltzly, 2010; Sherman, 2007) popular during the Hellenistic era (323-146 BC), taught the development of self-control and fortitude as the means by which to overcome and reject the destructive nature of emotions. Interpersonal emotions were particularly underlined, specifically anger which was claimed to be the most difficult to moderate. Echoing Epictetus's quotation above, the formulation of Stoicism states that by practicing self-discipline one may take command of his or her physiological, cognitive and behavioral responses and reactions to all events as they occur.

Contemporary military pedagogy nurtures a stoic-like attitude, focused on self-control and fortitude in view of emotionally salient events, especially in regards to anger, with the goal of forming combatants that will be dedicated to carry out their defined missions under life-threatening situations (Ben-Ari, 1998; Darash, 2005; Sherman, 2007). Emotions may thwart the performance of military tasks and on the battlefield anger is specifically regarded as a sign of vulnerability. Thus emotion- and anger- regulation are considered critical for combatants and therefore they become a common and important objective in military pedagogy. This is clearly demonstrated in the US Army Leadership Manual (2006) which has a whole section on emotional self-control. In fact, the manual quotes the 1917 Noncommissioned Officer's Manual, in that one "who loses his temper and flies into a tantrum has failed to obtain his first triumph in discipline" (there, page 52).

Indeed, training a combat soldier involves disciplined physical and psychological manipulations intended to maintain strength and endurance, and desensitize uncontrolled reactions (Ben-Ari, 1998; Darash, 2005; Lieblich, 1989; Sherman, 2007). Instrumental to this goal is a hierarchical authority responsible for implementing strong discipline and hazing. Hazing consists of a combination of treatments such as harassment, humiliation, insulting provocations, and physical and emotional degradation. Such manipulations trigger anger, fear and hostility, and while trainees are subjected to verbal and physical violence, they are themselves permanently on the verge of aggressive reactions. At the same time, as part of their professional practice and similarly to the four domains of intervention outlined in anger management programs: trainees must abstain from emotional storms (cognitive reformulation); trainees are punished for inappropriate reactions and uncontrolled outbursts (behavioral change); hazing can be thought of as an effective technique which trains soldiers to stay in control even under extreme conditions (affective modulation); and military lessons reflecting on outcomes of responses to combat incidents may advance contemplation on the disadvantages of uncontrolled anger outbursts in the wider context of problem solving (personal growth). Often publicly debated and morally condemned, the rational of this pedagogy can be thought of as an exposure technique which effectively prepares soldiers for extreme combat situations because while trainees are subjected to anger inducing manipulations, violent and egocentric manifestations of anger are sanctioned in favor of emotional control.

1.2. Neurobehavioral indices of anger

We recently created an interactive and realistic anger-provoking paradigm based on a modified version of the Ultimatum Game (UG; Güth, Schmittberger, & Schwarze, 1982), a social decision-making paradigm in which two players need to agree on how to split a sum of money between them. One player offers how to split the sum while the second decides whether to accept or reject the offer. If accepted, each player gains the allocated amount of the division, while if rejected both players lose the amount. Unequal offers of about 25% and below of the total sum are commonly rejected resulting in monetary loss for both players (Camerer, 2003). Such offers are regarded as unfair offers which violate social norms, elicit anger and thus result in an aggressive retribution at one's own personal cost (Pillutla & Murnighan, 1996; Xiao & Houser, 2005). Indeed, it was shown that anger mediated the relationship between the size of offers and rejection rates such that more anger resulted in increased rejections (Srivastava, Espinoza, & Fedorikhin, 2009). Moreover, emotion regulation studies indicate that regulating anger may be important to the acceptance of unfair offers and that people who are better able to regulate anger associated with such offers are more likely to accept and financially benefit from them (Grecucci & Sanfey, 2013). For example, explicitly instructing participants to use a cognitive emotion regulation strategy to down regulate anger associated with unfair offers resulted in increased acceptance rates (van't Wout, Chang, & Sanfey, 2010). Recent meta-analytic studies on the neural structures involved in processing unfair offers compared to fair offers (Feng, Luo, & Krueger, 2015; Gabay, Radua, Kempton, & Mehta, 2014) highlight various regions in the PFC, the cingulate cortex and the insula, among others, that have previously been associated with various anger-related contexts (Gilam & Hendler, 2015).

Our modification of the UG induced genuine interpersonal anger by incorporating verbal negotiations after each offer and infusing these interactions with angering provocations by an obnoxious competitor (Gilam et al., 2015). We showed that when confronted with such provocations during functional Magnetic Resonance Imaging (fMRI), participants became progressively angry as the anger-infused UG evolved, especially during unfair offers. Results also replicated the classic UG findings showing that participants rejected more of the offers as they became more unequal. Additionally, it was found that participants that gained more money reported less anger and more positive feelings, had slower decision reaction times, had slower sympathetic response indicative of less sympathetic arousal, had more ventromedial Prefrontal Cortex (vmPFC) and less Locus Coeruleus (LC) activation, and the reverse pattern for those participants that gained less money. We asserted that these two neurobehavioral response patterns reflected a regulated and an unbalanced profile of anger, respectively. Strikingly, vmPFC activation contributed to increased gain by modulating the ongoing subjective emotional experience. This finding provided a model which triangulated neural, subjective and behavioral measures in the representation of anger and reflected a neural mechanism of anger regulation. This was further supported by the correlation found between vmPFC activation and an independent personality measure of the habitual use of emotion regulation. These results replicated previous findings associating the vmPFC with implicit emotion regulation (Etkin, Büchel, & Gross, 2015) and the LC with arousal and stress response in view of threat (Berridge, 2008; Valentino & Van Bockstaele, 2008) and thus also with propagating aggression (Haden & Scarpa, 2007; Haller, Makara, & Kruk, 1997).

1.3. Study objective and hypothesis

To examine the influence of military combat training on neurobehavioral indices of anger a prospective neuroimaging design was pursued, prior to and following intensive infantry training of combat soldiers. Regulation empowerment was assumed as an outcome of such training, following the stoic formulation of military indoctrination (Darash, 2005; Sherman, 2007). The study group therefore consisted of combat soldiers recruited from a Special Forces unit (*Duvdevan*) in the Paratroopers Brigade of the Israel Defense Forces (IDF), in which soldiers are specifically trained to internalize emotional regulation strategies, especially for anger, in order to cope with face-to-face life-threatening situations during a one-year period of combat training. A two time-point prospective experimental design enabled us to examine the effects of such training with regards to the experience of anger. A control group was recruited, consisting of age matched volunteers who took part in one-year pre-army civil service national programs.

All participants at both time-points performed the anger-infused UG. Pre-training results (extensively reported in Gilam et al., 2015) indicated no differences between soldiers and civilians in any of the neurobehavioral measurements related to anger at the first time-point. Post-training results are reported here in light of these pre-exposure findings, focusing on the differences between low-gain and high-gain participants. Thus, while it was expected and showed that no differences would be found between the study and control groups before training (first time-point), after the training period (second time-point) different patterns of anger experience would emerge such that the control group will exhibit no changes between time-points. However, low-gain soldiers reflecting an unbalanced anger profile will tend to exhibit a neurobehavioral pattern of anger associated with high-gain, while no changes would be detected for the high-gain soldiers who are considered to have anger regulation capabilities a-priori. Specifically, we hypothesized that an increase in gain, a more balanced emotional response and a modulation in brain response to anger, such as an increase in vmPFC activation and decrease in LC activation during unfair offers, would manifest amongst low-gain soldiers who pre-training had a tendency for more aggressive reactions, but not amongst high-gain soldiers, nor in all civilians.

METHODS

Participants

Of the 60 male participants that performed the anger-induction task in the first time-point (Gilam et al., 2015), 46 participants were recruited and volunteered to take part in the second time-point, consisting of 29 soldiers (age *M*=18.86, *SD*=1.06 years, at time-point 1) and 17 civilians (age *M*=18.24, S*D*=0.44 years at time-point 1). As for the participants who did not partake in the second time-point: five civilians and one soldier chose not to continue due to personal reasons; six soldiers were excluded from the combat training course before its completion; and two soldiers had medical injuries which prevented their participation. Approximately one year passed in between time-points, at which time soldiers were about to complete their combat training but were not yet actively deployed and civilians were about to complete their civil service programs (Figure 1A). Both time points were approved by the Institutional Ethics Committee of the Tel-Aviv Sourasky Medical Center and of the IDF Medical Corps. Within the 60 participants of the first time point (38 soldiers and 22 civilians) there were no differences in any of the anger measures including behavior, emotional reports and brain activations. Low-gain (LG) and high-gain (HG) groups were defined based on the division of the first time-point, resulting in 14 LGs and 15 HGs for the study group and 5 LGs and 12 HGs for the control group (Table 1).

Several important issues should be noted about the soldiers and civilians comprising the participants. As for the soldiers, though much of their basic training is focused on teaching basic warfare capabilities to each soldier, team spirit and being part of a squad that works together is very much emphasized. As a result, soldiers are constantly spending time together as a group. In addition, the counter-terror combat course *Lotar*, notoriously known as the most physically difficult and disciplined part of Duvdevan training takes place during the Special Forces combat training period. The Lotar course is considered the "diploma" of Duvdevan training focusing on *Krav Maga* training, a noncompetitive self-defense technique with a key principle to counter attack and neutralize the opponent as quickly as possible. A landmark Krav Maga exercise in the Lotar course demands soldiers avoid any reaction while they are subjected to physical and verbal violence. This specific training of Duvdevan soldiers makes them especially apt to exert physical, cognitive and emotional control (Darash, 2005).

As for the civilians, they consisted of males who volunteered to take part in one of several one-year pre-army national civil service programs which entail living in small sized communes around the country and are involved in assisting disadvantaged communities, youth at risk, and various other civic projects. It was assumed that individuals that are willing to dedicate themselves to national concerns would share similar socio-educational background as combat-soldiers who are willing to risk their lives behind enemy lines. Moreover, conscription rates among graduates of pre-army national civil service programs are almost 100% and many continue on to infantry units. Importantly, civil service volunteers do not live in a disciplined environment comparable to that of the army. They may undergo specific courses related to the educational oriented program, such as to connect with children with special needs or how to teach them basic skills, but there is no training which may lead to specific proneness to emotional regulation.

Table 1.
Sample Size of Available Data by Type, Experimental Group and Gain Group

		#n		#n Civilians		#n Total
Time-Point	**Data Type**	**LGs**	**HGs**	**LGs**	**HGs**	
#1	**Behavior**	19	19	8	14	60
	Brain	18	15	8	13	54
#2	**Behavior**	14	15	5	12	46
	Brain	10	10	5	10	35

Note. The sample size diminished between time-points and also according to the type of data acquired. Our initial sample of 38 soldiers and 22 civilians decreased to 29 and 17 respectively at the second time point and an additional reduction in sample size occurred for the brain data due to excessive head movements. LGs=low gainers, HGs=high gainers.

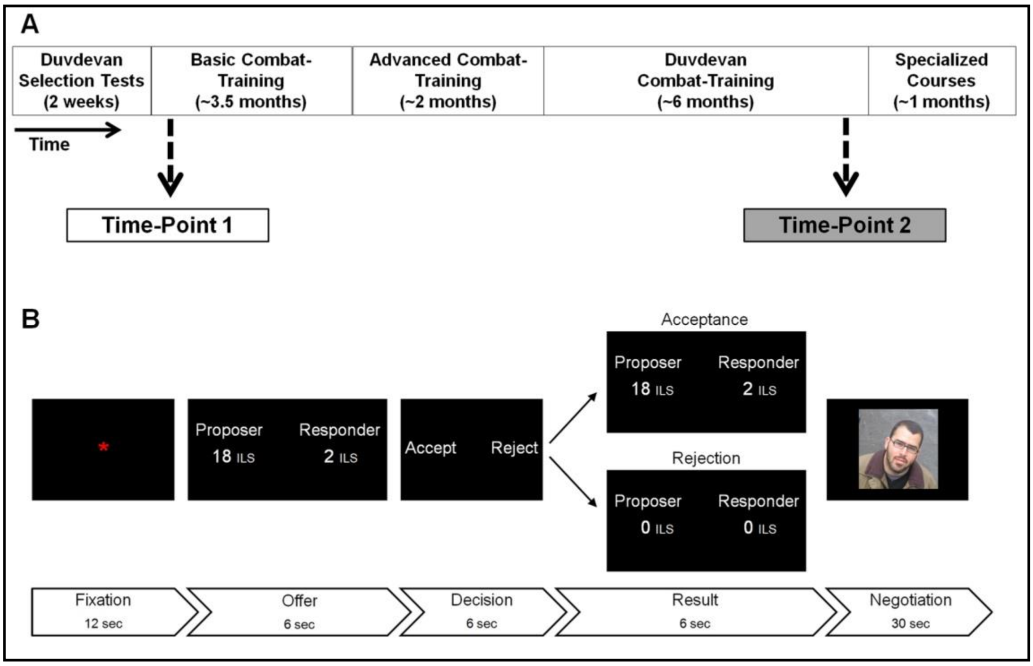

Figure 1. Soldiers' combat training time-course and one round of the anger-infused UG. (A) The timing of the first two time-points of the prospective study is also illustrated as relevant to the training time-course. (B) Each round of the anger-infused UG began with a fixation period, supposedly the time in which the proposer decided how to split the sum of 20 ILS. Participants then saw the offer, decided whether to accept or reject and then viewed the result of their decision. Verbal negotiations followed and began when a fictitious picture appeared, supposedly belonging to the other player. This sequence was repeated 10 times in total.

Anger induction

Anger was induced using the anger-infused UG previously described extensively (Gilam et al., 2015). Briefly, participants in the fMRI scanner played the responder in a 10-round repeated UG in which they had 30-second spontaneous verbal negotiations with a confederate proposer at the end of each round (Figure 1B). Unknown to participants, the proposer was a professional actor who improvised during negotiations with scripted provocations in concert with a predefined sequences of both fair (10:10, 11:9, 12:8) and unfair (2×15:5, 16:4, 17:3, 18:2, 2×19:1) offers allotted from a pot of 20 Israeli New Shekels (ILS; Table 2). Rejecting an offer was associated with an aggressive reaction while accepting an offer was associated with a conciliatory reaction. The scripted improvisations aimed to intensify the angry experience during negotiations by incorporating personal insults, violating norms of conduct and direct confrontations regarding the game. This manipulation reflected the importance of embedding social interactions when investigating emotional experiences (Gilam & Hendler, 2016).

We calculated the total-gain accumulated throughout the entire game and used that as an objective measure of individual differences reflecting the final outcome of the modified-UG. Though total-gain and overall acceptance rates are highly correlated (Gilam et al., 2015), total-gain is a more accurate measure for individual differences (e.g. one who accepted a 10:10 and 4:16 offers has a different gain but equal acceptance rate compared to one who accepted a 9:11 and 8:12 offers).

Table 2.
The Four Sequences of Offers used in the Anger-Infused UG

	1st fMRI scan					2nd fMRI scan				
Sequence	**1st offer**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**
1st	10:10	12:8	15:5	16:4	18:2	17:3	15:5	11:9	19:1	19:1
2nd	17:3	15:5	11:9	19:1	19:1	10:10	12:8	15:5	16:4	18:2
3rd	10:10	18:2	12:8	15:5	16:4	19:1	17:3	15:5	11:9	19:1
4th	19:1	17:3	15:5	11:9	19:1	10:10	18:2	12:8	15:5	16:4

Note. The four pre-determined sequences of offers used in the modified UG included the exact same 10 offers, allotted from a pot of 20 ILS. In order to minimize artifacts of head-movement, the sequences were divided into two seamless fMRI scans. The 1st and 2nd fMRI scans of the 1st sequence were switched in order in the 2nd sequence, while the 1st and 2nd fMRI scans of the 3rd sequence were switched in order in the 4th sequence.

To note, the proposer of offers was one of two different professional actors compared to the first time-point (counterbalanced between participants) and participants received the exact same offers as in the first time-point but in a different sequence: participants who played the 1st sequence in the first time-point played the 2nd sequence in the second time-point and vice-versa, and similarly participants who played the 3rd sequence in the first time-point played the 4th sequence in the second time-point and vice-versa. Since there were no differences between the two actors and the four sequences in all below indicated measures they were collapsed across all analyses (p-values>0.151). Also, in accordance with the Institutional Ethics Committee demands, there were no actual material payoffs.

Emotion rating

We used a post-scan emotional report scheme consisting of a round-by-round iteration of the Geneva Emotion Wheel (GEW; Scherer, 2005). The GEW comprises 16 emotions arranged in a circular pattern based on two axes, valence (positive/negative) and potency (high/low): Pride, Elation, Happiness, Satisfaction, Relief, Hope, Interest, Surprise, Anger, Hostility, Contempt, Disgust, Shame/Guilt, Boredom, Sadness and Anxiety. In our version participants received a print-out of 30 screen-shots tracing each offer, result and negotiation periods in the exact sequence of UG-rounds played in the scanner and in accordance with their actual decisions. Adjacent to each print-screen participants were instructed to rate each of the 16 GEW-emotions on a 7-point intensity scale from 0 (none) to 6 (very high), in relation to how they felt in that exact period during the actual game in the scanner.

Following findings from the first time-point (Gilam et al., 2015), an anger cluster of emotion was calculated based on the average of angry feelings which included Anger, Hostility, Contempt and Disgust. In addition, a cluster of positive feelings was calculated based on the average of all positive emotions. Using these two clusters, a standardized emotional valence index (EVI) was calculated that incorporated both emotion clusters: (positive cluster - anger cluster) / (positive cluster + anger cluster). A positive EVI indicated that more positive and less anger emotions were reported while a negative EVI indicated the reverse. These measures were computed for each participant that participated in both time-points.

fMRI acquisition, preprocessing and analysis

Brain imaging was performed by a GE 3T Signa Excite scanner using an 8-channel head coil at the Wohl Institute for Advanced Imaging, Tel-Aviv Sourasky Medical Center. Functional whole-brain scans were performed with gradient echo-planar imaging (EPI) sequence of functional T2*-weighted images (TR/TE=3,000/35ms; flip angle=90 º; FOV=200 × 200 mm; slice thickness=3mm; no gap; 39 interleaved top-to-bottom axial slices per volume). Anatomical T1-weighted 3D axial spoiled gradient (SPGR) echo sequences (TR/TE=7.92/2.98ms; flip angle=15º; FOV=256 × 256 mm; slice thickness=1mm) were acquired to provide high-resolution structural images. To note, our modified UG was divided into two seamless fMRI scans to reduce head-movement artifacts.

Preprocessing and statistical analyses were conducted using BrainVoyager QX version 2.4 (Brain Innovation). Each scan began with 10 volumes (30 seconds) of blank screen which were removed to allow for signal equilibrium. Subsequently, slice scan time correction was performed using cubic-spline interpolation. Head motions were corrected by rigid body transformations, using 3 translation and 3 rotation parameters and the first image served as a reference volume. Trilinear interpolation was applied to detect head motions and sinc interpolation was used to correct them. Five soldiers and one civilian were discarded from subsequent brain analyses due to excessive head-movements (4mm/4°) in the first time-point, as previously reported (Gilam et al., 2015), and for the same reason an additional four soldiers and one civilian were discarded from analyses of the second time-point. Therefore, the final sample used for brain analyses for both time-points included 20 soldiers and 15 civilians (Table 1). The temporal smoothing process included linear trend removal and usage of high pass filter of 1/128 Hz. Functional maps were manually coregistered to corresponding structural maps and together they were incorporated into 3D data sets through trilinear interpolation. The complete data set was transformed into Talairach space and spatially smoothed with an isotropic 6mm FWHM Gaussian kernel.

Exploratory comparison of the two time-points was based on a random-effects General Linear Model (GLM) which included four regressors for each period of the game (offer, decision, result, negotiation), repeated twice to differentiate between fair and unfair rounds, and repeated again to differentiate between time-points. These regressors were convolved with a canonical hemodynamic response function. Additional nuisance regressors included the head-movement realignment parameters and the time course of averaged activity in cortical white-matter. The fixation period was used as baseline. A grey matter mask and a correction for temporal autocorrelations using a second-order autoregressive model were also used. Statistical analysis was conducted on the unfair-offer periods which were shown to induce more anger. The BOLD brain activity during the unfair offer period was then submitted to a 2 (gain-groups: LG/HG) × 2 (experimental group: soldier/civilian) × 2 (time-point: $1^{st}/2^{nd}$) mixed-model analysis of variance (ANOVA). Correction of brain activation maps for multiple comparisons was performed by setting a voxel-level threshold at $p<0.005$ (uncorrected) with a minimal cluster-size of 10 contiguous functional voxels (where each voxel corresponds to a functional volume of 3*3*3mm) thus producing a desired balance between Types I and II error rates (Lieberman & Cunningham, 2009). To further decrease the likelihood of Type I errors, mean parameter estimates (beta values) were extracted for further analyses only for those regions of interest (ROIs) whose peek voxel had a false discovery rate (FDR) of $\alpha = 5\%$ (Benjamini & Hochberg, 1995). Beta values were averaged across all ROI voxels for each significant cluster, separately for the difference experimental conditions.

ROI Analysis

Based on the two time-point GLM described above, beta values were extracted for all the voxels in the two regions-of-interest (ROI) identified in the first time-point (Gilam et al., 2015): the vmPFC cluster which consisted of 554 contiguous anatomical voxels ($1mm^3$) with peak voxel located at the Talairach coordinate x=14, y=49, z=-12; the LC cluster which consisted of 409 contiguous anatomical voxels with peak voxel located at the Talairach coordinate x=-7, y=-35, z=-18; and the dpI cluster which consisted of 562 contiguous anatomical voxels with peak voxel located at the Talairach coordinate x=-31, y=-23, z=18.

RESULTS

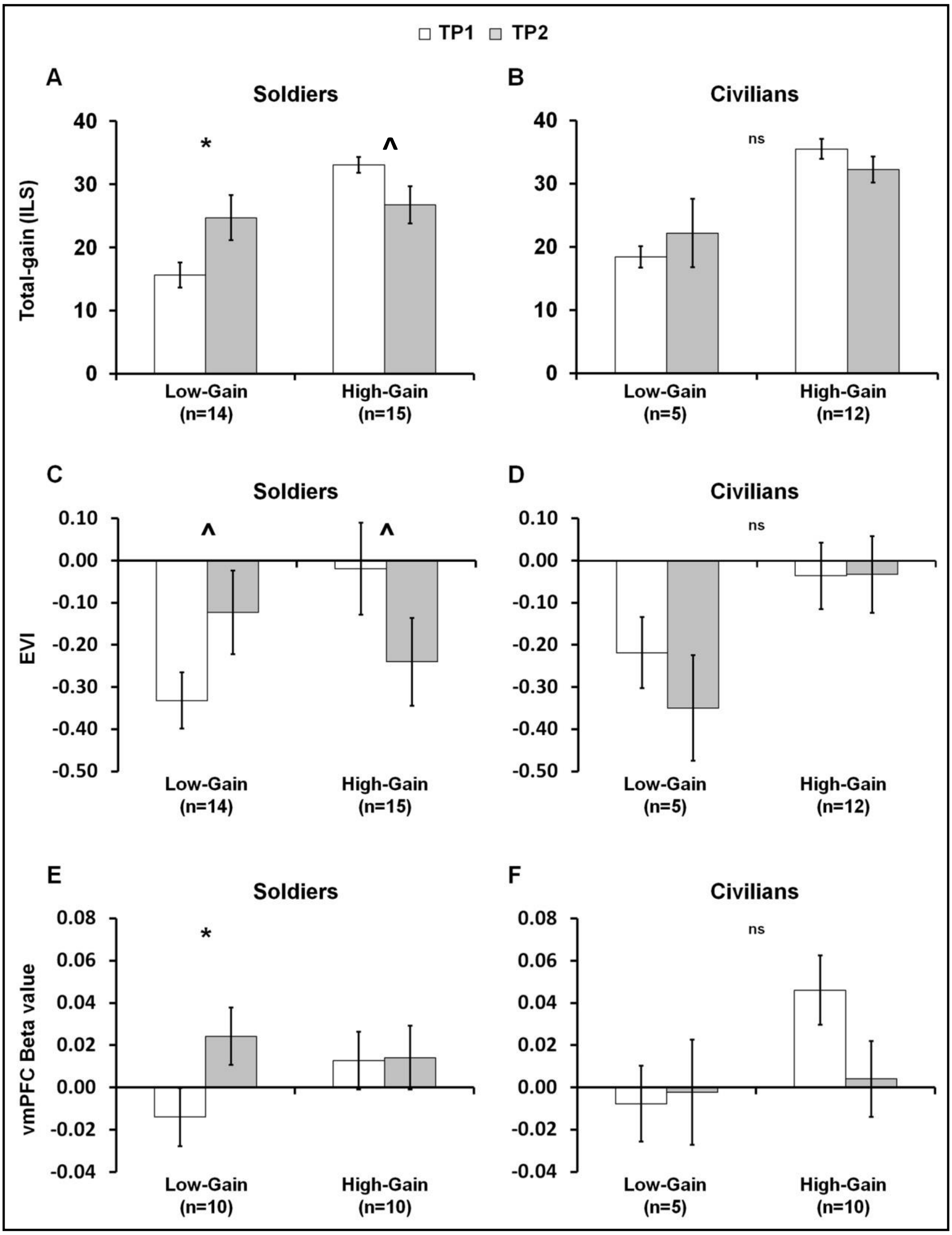

Figure 2. Behavioral and ROI results across time points. Considering total-gain accumulated throughout the anger-infused UG, changes were detected for low- and high- gain soldiers (A) indicating LGs had increased gain between time-points while HGs had a decrease. (B) No changes were detected for civilians. Similarly, (C) low- and high- gain soldiers showed an increase and decrease in EVI, respectively. (D) No changes were detected for civilians. Finally, (E) LG soldiers showed an increase in vmPFC activation during the unfair offer periods, and again (F) no changes detected for civilians. * indicates $p < 0.05$; ^ indicates $p < 0.10$; ns=non-significant. Error bars indicate standard error of mean.

Anger related behavior and emotional report

Since the gain-groups (LG/HG) × experimental groups (soldier/civilian) × time-points ($1^{st}/2^{nd}$) ANOVA did not yield a significant interaction in both total-gain and emotional report (p-values>0.193), analyses were subsequently performed on the gain-groups × time-points interaction, separately for each experimental group. Of note however, a general analysis of the second time-point as previously reported (Gilam, Lin, Fruchter, & Hendler, 2017) replicated results found in the first time-point indicating there was a relationship between behavior in the game and the corresponding emotional experience that validated the anger induction and did not differ between soldiers and civilians.

For total-gain, in line with expectation, for the soldiers there was a significant time-points × gain-groups interaction ($F(1,27)=10.32$, $p=0.003$, $\eta_p^2=0.28$; Figure 2A), but not for civilians ($F(1,15)=1.88$, $p=0.190$, $\eta_p^2=0.11$; Figure 2B). As expected, soldier LGs had a significant increase ($p=0.014$) in total-gain between pre ($M=15.64$, $SD=7.52$) and post ($M=24.71$, $SD=13.34$) combat training. In addition, there was a marginally significant decrease ($p=0.068$) for HGs between pre ($M=15.64$, $SD=7.52$) and post ($M=24.71$, $SD=13.34$) combat training, but there was no difference between LGs and HGs post combat training ($p=0.581$).

For EVI, in line with expectations, for the soldiers there was a significant time-points × gain-groups interaction ($F(1,27)=7.43$, $p=0.011$, $\eta_p^2=0.22$; Figure 2C), but not for civilians ($F(1,15)=0.55$, $p=0.470$, $\eta_p^2=0.04$; Figure 2D). As expected, LGs had a marginally significant increase ($p=0.076$) in EVI between pre ($M=-0.33$, $SD=0.36$) and post ($M=-0.12$, $SD=0.53$) combat training. In addition, there was a marginally significant decrease ($p=0.054$) for HGs between pre ($M=-0.02$, $SD=0.59$) and post ($M=-0.24$, $SD=0.56$) combat training, but there was no difference between LGs and HGs post combat training ($p=0.546$). Follow up analysis revealed that compared to pre combat training, post combat training LGs had a significant increase in reported positive-cluster of emotions ($M_{pre}=0.56$, $SD=0.27$; $M_{post}=0.88$, $SD=0.58$; $t(13)=-2.30$, $p=0.038$, *Cohen's d*=0.73), while HGs had a marginally significant increase in reported anger-cluster of emotions ($M_{pre}=1.45$, $SD=1.33$; $M_{post}=2.07$, $SD=1.49$; $t(14)=-2.09$, $p=0.055$, *Cohen's d*=0.43).

ROI analysis

Examining vmPFC activations during the offer periods, soldiers exhibited a marginally significant time-points × gain-groups interaction ($F(1,18)=3.43$, $p=0.081$, $\eta_p^2=0.16$; Figure 2E), but civilians did not ($F(1,13)=2.32$, $p=0.151$, $\eta_p^2=0.15$; Figure 6F). In line with expectations, LGs had a significant increase ($p<0.014$) in vmPFC activation between pre ($M=-0.01$, $SD=0.04$) and post ($M=0.02$, $SD=0.03$) combat training. In addition, there was no difference ($p<0.922$) for HGs between pre ($M=0.01$, $SD=0.04$) and post ($M=0.01$, $SD=0.04$) combat training, and no difference between LGs and HGs post combat training ($p<0.913$). No significant results were found for the LC cluster for unfair offers and also when averaging fair and unfair offers together ($ps>0.303$).

Exploratory Brain activation maps. The gain-groups main effect revealed a significant cluster of activation in the left dlPFC (Table 3A.). Follow-up examination of the time-points × gain-groups interaction during unfair offers showed there was neither a significant effect for soldiers ($F(1,18)=7.43$, $p=0.011$, $\eta_p^2=0.22$) nor for civilians ($F(1,13)=0.55$, $p=0.470$, $\eta_p^2=0.04$). When averaging both fair and unfair offers together, there wasn't a significant effect for soldiers ($F(1,18)=1.56$, $p=0.227$, $\eta_p^2=0.08$) but there was a marginally significant effect for civilians ($F(1,13)=3.42$, $p=0.087$, $\eta_p^2=0.21$). Though no significant post-hoc simple effects were found ($ps>0.164$), the interaction generally indicated a descriptive increase in activation of this region for the HGs in the second time-point. To note, though not passing significance threshold, the gain-group main effect revealed two clusters in overlap with the vmPFC and BS/LC clusters identified in the first time-point. The time-points by experimental groups interaction revealed a significant cluster of activation in the caudate head (Table 3B) but no significant effects were found in the follow-up examinations ($ps>0.232$). The interaction itself (Figure 3) indicated no difference between groups at the first time-point ($p=0.702$), an increase in activation for the civilians ($p=0.022$), a marginal decrease for the soldiers ($p=0.072$) and more activation for civilians compared to soldiers at the second time-point ($p=0.001$). All the other generated maps related to the gain-groups by experimental groups by time-points interaction failed to produce any significant clusters of activation. Similarly, no results were found when examining maps generated separately for each experimental group on the gain-groups by time-points interaction.

Table 3.
Brain Activation during Unfair Offer Periods

Brain Region	**BA**	**Side**	**X**	**Y**	**Z**	***F*(1,31)**	***p***	**Voxels**
A. Main effect of gain-groups (LGs/HGs)								
Precuneus	19	R	32	-71	36	17.359	0.0002	1165
Posterior Hippocampus		R	29	-29	-3	12.977	0.001	172
Orbito Frontal Gyrus	11	R	14	55	-12	16.288	0.0003	118‡
Brainstem		R	8	-32	-12	12.390	0.0013	156‡
Brainstem		R	8	-14	-15	13.673	0.0008	55
Brainstem		L	-7	-35	-15	12.378	0.0013	189
Precuneus	7	L	-7	-65	36	14.283	0.0006	99
Caudate Body		L	-16	10	9	11.554	0.0018	90
Caudate Tail		L	-24	-35	18	19.403	0.0001	203
Inferiof Parietal Lobule	40	L	-34	-38	39	14.904	0.0005	295
Precentral Gyrus	6	L	-36	-11	45	11.356	0.0019	50
Middle Frontal Gyrus	9	L	-52	16	30	24.150	<0.00002*	1199^
Middle Frontal Gyrus	8	L	-43	7	42	10.994	0.0022	68
Middle Frontal Gyrus	46	L	-43	20	19	14.039	0.0007	77
B. Interaction effect of time-points (1st/2nd) × experimental groups (soldier/civilian)								
Insula	13	R	36	28	9	10.990	0.0022	64
Caudate Head		L	-4	16	4	33.453	<0.00001*	2007^
Caudate Head		R	11	17	-6	12.501	0.0012	130
Lingual Gyrus	17	R	11	-95	-9	13.897	0.0007	71
Cerebellum		R	5	-56	-30	11.912	0.0016	97
Superior Parietal Lobe	7	L	-10	-65	61	12.562	0.0012	95
Superior Frontal Gyrus	10	L	-21	52	9	20.811	0.00007	1547
Insula	13	L	-25	28	9	17.389	0.0002	429
Superior Temporal Gyrus	38	L	-37	22	-24	12.497	0.0012	53

Note. All regions arising from whole-brain GLM (n=35) presented at a threshold of p<0.005 (uncorrected) with a minimal cluster size of 50 contiguous anatomical (1mm^3) voxels. Coordinates are of peak activity, given according to Talairach space with their F-scores and p-values. Beta values for subsequent ROI analyses were extracted for those brain regions with both peak voxel q(FDR)<0.05 (denoted by *) and minimal cluster size of 10 contiguous functional (3mm^3) voxels (denoted by ^). Though not significant, the gain-group main effect revealed two clusters in overlap with the vmPFC and BS clusters identified in the first time-point (denoted by ‡). Anatomical locations were determined using Talairach Daemon (http://www.talairach.org/). BA=Broadman Area.

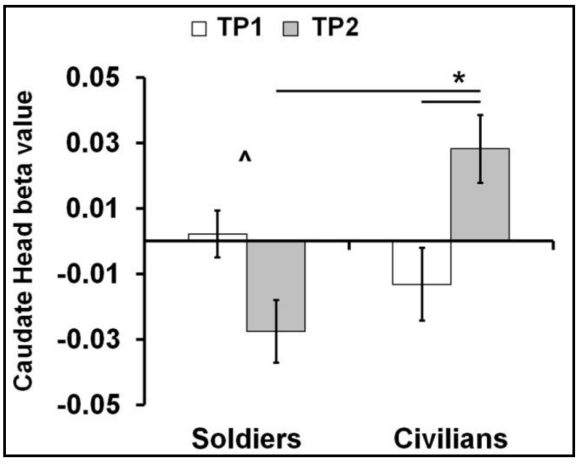

Figure 3. Caudate head brain activations. Caudate head activations during unfair offers differed between soldiers and civilians across time-points, indicating increased activation for civilians post civil service compared to pre civil service (p=0.001) and compared to soldiers post combat training (p=0.022). A marginal decrease in activation was apparent for soldiers post combat training compared to pre combat training (p=0.072). * indicates p<0.05; ^ indicates p<0.10. Error bars indicate standard error of mean.

CONCLUSION

The aim of the current study was to examine the influence of military combat training on neurobehavioral indices of interpersonal anger, assuming that such a training program would foster emotion regulation capabilities. To this end, a prospective neuroimaging study tested a group of combat soldiers and a group of civil service volunteers at the beginning and end of a period of one year during which soldiers undertook their training and civilians were mostly engaged in community service and educational programs. All participants at both time-points played the anger-infused UG which at the first time-point differentiated between HGs, who evidenced a regulated emotional and neural profile, with increased report of the EVI and increased vmPFC activation, while the reverse was found for the LGs who displayed an unbalanced profile and the reverse pattern of emotion and neural profile. Though some results were marginal in significance, a general confirmation of our expectations was obtained, indicating differences between the two time-points in the soldiers study group but not in the civilian control group. The LG soldiers evidenced an increase in total-gain, a marginal increase in EVI which reflected an increase in reported positive emotions, and an increase in vmPFC activation between the two time-points. In parallel, the HG soldiers displayed a marginal decrease in total-gain and in EVI, which reflected an increase in reported anger, between the two time-points. Moreover, no changes were found between LG and HG soldiers at the second time-point. Finally, though no changes were detected in these measures for the civilians, a general result indicated that compared to the first time-point, civilians had an increase in activation in a region of the dorsal striatum, namely the caudate head, while soldiers had a decrease such that at the second time-point they had less activation compared to civilians.

Stoicism and the effect of combat training on neurobehavioral indices of anger

The findings presented are indicative of a pattern of modulation in the neurobehavioral indices of interpersonal anger suggesting that military combat training has an influence on neural processing associated with emotional experiences and hint towards the possibility that military indoctrination indeed empowers emotion regulation. Anthropological studies (Darash, 2005; Sherman, 2007) inspired the assumption that military pedagogy nurtures a stoic-like attitude which underlines self-control of emotional reactions, especially anger. Stoicism (Baltzly, 2010; Sherman, 2007) contends that humans have complete power over their emotions and thus their goal should be to practice self-discipline in their emotional responsiveness to all events as they occur. Within this perspective emotions are viewed as destructive because they are regarded as evaluations or appraisals, ways of construing the world, and thus are inherently misrepresentations or misjudgments of the world. Cognitive, physiological and behavioral changes are inseparable from the stoic way of life in order to accomplish the goal of emotional containment.

The Stoic-militaristic synergism introduced by Sherman (2007) following a period she spent in the United States Naval Academy, is based on the notion that a soldier in the battlefield has little control over the turmoil and terror around him, but he does have full control of his own mind and body and therefore for his own actions and reactions to howevents unfold in the battlefield. Therefore, regulating emotional reactions is a matter of life and death. Sherman refers to Seneca, one of the main Roman philosophers advocating Stoicism, as insisting that anger ought not to be part of the emotional repertoire of a stoic warrior (there, p. 67). Anger is seen as a major vulnerability in combatants since when led by anger they may abandon their missions' goals or dismiss standard procedures and advance in an unsafe manner, thus putting themselves and their brothers-in-arms at risk. Anger regulation is thus considered critical for combatants on the battlefield and therefore becomes a common and important objective in military pedagogy.

In her interview-based work with Duvdevan combatants, the same unit from which the current sample of soldiers were recruited as participants, Darash (2005) provides ample support for Sherman's formulation, underlining the notion of both emotional and physical control of internal and external events in one's mind and body as a result of being a professionally trained combatant. Together their work suggests that military indoctrination does not reach this end goal as a spontaneous outcome of the practical aspects of becoming a soldier (such as learning how to shoot) in a very large and hierarchical institute, rather it is a deeply ingrained and intended result of the discipline.

Interestingly, while initially reasoning that soldiers displaying a regulated (HG) profile would not display changes in neuro-behavioral indices of anger since they were supposedly well regulated a-priori, at least in monetary gain and emotional report there seemed to have been a pattern of change in the opposite direction compared to the low-gain soldiers. In fact these HG soldiers displayed an increase in anger. This result may suggest that within the military practice, anger is not to be entirely abstained from, but perhaps knowing how to summon the right amount of anger for the right cause is the ideal. Indeed, research suggests that instrumental motivations play a role in the application of emotion regulation (Tamir, 2016). As exemplified in the case of anger, it was demonstrated that individuals who engage in anger-inducing activities before completing a confrontational task increased their experience of anger and improved their performance in the task as indexed by increased aggression (Tamir, Mitchell, & Gross, 2008). A similar process could have occurred in HG soldiers who as combatants engage anger to exert aggression upon confrontation. The current findings are also in line with a broader view of anger management where by too much containment is similarly unproductive and possibly unhealthy. Indeed, several examples evidence a negative influence of anger inhibition, such as an association between increased repression of anger and the diagnosis and development of cancer (Schlatter & Cameron, 2010; Thomas et al., 2000) or such as experimentally induced anger suppression amplifying pain sensitivity in both healthy and chronic pain patients (Burns et al., 2008; Quartana & Burns, 2007).

In view of the above, the ultimate effect of combat training may in fact be to teach how to down-regulate as well as up-regulate anger in a contextual and personalized manner, according to the a-priori tendency of soldiers. Thus, LG soldiers who a-priori displayed an emotionally unbalanced pattern of response and increased anger, at the end of training showed a pattern of response similar to that of a-priori HG soldiers. At the same time, a-priori HG soldiers who were possibly repressing their expression of anger showed at the end of training a decrease in gain and increase in reported anger. In this regards, while clear and distinct differences were apparent between LG and HG soldiers at the first time-point, no such differences appeared at the second time-point.

Together the findings presented here may suggest that combat training aims to form soldiers with a rather uniform response to emotional perturbations, eliminating or decreasing their a-priori individual differences. Nevertheless, we do not actually know if there was explicit anger management training during the one year period of combat training. Therefore, even though we had a control group of civilians, there is indeed a possibility that the results obtained among the soldiers are in fact not the results of the training regime, but rather a result of a natural adaptation to the exposure to salient emotional experiences that we may assume occurs during combat training. An additional alternative explanation for the changes found in the soldiers group could be regression to the mean, and since the control group did not consist of soldiers who did not undergo combat training, the control group does not entirely refute this possibility. Future studies should aim to reproduce and confirm the stoic postulation compared to mere exposure, and test whether this may be the case for other institutionalized or pedagogical socio-cultural practices.

A Progressive Outlook on Cultural Neuroscience

Both Sherman (2007) and especially Darash (2005) emphasize the links between psychology, biology and culture, in that small-scale cultural environments such as the military practice can redesign a new body with a new mind, resulting in "local biologies". This later term, defined by Lock (Lock & Kaufert, 2001; Lock & Nguyen, 2010), refers to the mutual influences between the three core systems of human life – mind, body and society - and underlines the fundamental change that soldiers undergo during their training. This formulation is primarily based on the general socio-cultural notion of "habitus" introduced by Bourdieu (1977) that professional and pedagogical practices continuously redesign an individual's internal psycho-biological dispositions, orchestrating lasting effects on the shape and form in which that individual perceives the world and reacts to it.

Markus and Kitayama's (1991) prominent psychological analysis has set the stage for investigating the socialization of emotions via the integration of one's mind or self and culture. Subsequently, with the advent of neuroimaging techniques such as fMRI, the subfield of *cultural neuroscience* has generated evidence that humans neural processing of emotional stimuli differ cross-culturally. For example, Japanese and Caucasian Americans in their respective home country have greater amygdala response to fearful faces by members of their own cultural group (Chiao et al., 2008). Interestingly, Koreans reported experiencing more empathy and had stronger activation in the temporal parietal junction (TPJ), a region associated with mental state inference (Denny, Kober, Wager, & Ochsner, 2012), for stimuli involving their own cultural group members in pain compared to Caucasian Americans in pain while Caucasian Americans had the reverse pattern of TPJ activation (Cheon et al., 2011). Many similar investigations focus on cross-cultural differences in neural processing. In parallel other conceptualizations suggest instead to categorize individuals based on cultural personality dimensions such as individualism-collectivism, which has shown particularly reliable findings on various mental processes (Chiao et al., 2010).

The current study however advocates a progressive view of socio-cultural differences which is determined not only by large-scale stable affiliations (e.g. Westerners vs. Easterners), but also within small-scale changing environmental surroundings, such as between taxi-drivers and PhD students, doctors and basketball players, or civilians and soldiers. It seems intuitive that such local (professional) biologies would have an impact on the response and subsequently the neural processing of emotional episodes. Though several theoretical considerations of cultural neuroscience as a field have previously echoed the importance of socio-cultural practices (Choudhury, 2010; Domínguez, Lewis, Turner, & Egan, 2009; Kitayama & Uskul, 2011), experimental evidence is scarce. The only additional evidence found by the authors is a study on gender differences in neural processing of compassion within the police force (Mercadillo, Alcauter, Fernández-Ruiz, & Barrios, 2015). The police force was assumed to reflect a socio-cultural practice that promotes specific codes of conduct intended for collective safety that should influence compassion. Results suggested that men and women are similarly influenced by police culture regarding the empathic behavioral expression of compassion. However, women manifested more insular and prefrontal cortical activation, suggesting a more empathic experience of compassion. Interesting as these results may be, since there was no control group and it was not a prospective design it is unclear whether these results are a direct influence of police culture or general gender differences known to exist in empathic processing (Derntl et al., 2010; Schulte-Rüther, Markowitsch, Shah, Fink, & Piefke, 2008). Though requiring further statistical support, results found here point at the possible modulation of vmPFC functionality following combat training in LGs, evident only for soldiers and not for civilians.

Concluding remarks

Though limited, the influence of combat training on neural processing related to emotional systems has been reported before. In a pilot study comparing two soldiers at the end of training with two soldiers at the beginning of training, greater activation in premotor/prefrontal cortex, posterior parietal cortex, and posterior temporal cortex was found for the latter over the former (Ćosić et al., 2012). Other studies focusing on task performance compared the neural response to emotional stimuli of elite SEAL combatants of the United States Navy with healthy civilians, reporting differential activation of the insula and frontal cortex (Paulus et al., 2010; Simmons et al., 2012). To date however no systematic study tested in a prospective design the influence of combat training on the neural response to emotional experiences. We found a differential pattern of activation across time-points between the soldiers and civilians in the caudate head which is part of the dorsal striatum. This region has previously been associated with motor, memory and addiction (Berke & Hyman, 2000; Seger & Cincotta, 2005; Voermans et al., 2004), as well as in processing of reward and emotions (Bartels & Zeki, 2000; Dreher, Kohn, Kolachana, Weinberger, & Berman, 2009; Haruno & Kawato, 2006). However, since results indicate that the change was apparent mostly in the civilians' group rather than that of the soldiers, and since we found no relationship between activation in this region and other dependent measures obtained in this research program, it would be irresponsible to attempt an interpretation of the meaning of this result. This underlines the critical limitation of this study - results were generally of low statistical power and were marginal, probably due to the small sample size that ultimately participated in both time-points of this study. Therefore, this study desperately necessitates further replication and investigation. Notwithstanding, it illustrates the influence of military pedagogy on neural and emotional processing and thus demonstrated the possibility of integrating disparate fields of study such as psycho-biology and sociology/anthropology. Applying this conceptual framework to the study of emotions reverberates with modern psychological constructionist theories (Barrett, 2017) and allows a rapprochement to the subjective qualia-like characteristic of emotions.

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