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Medical Research Council Cognition and Brain Sciences Unit, University of Cambridge, Cambridge, UK

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ABSTRACT

Alexithymia, a sub-clinical personality construct associated with disturbances in affect regulation and social functioning, is known to be comorbid with a number of psychiatric conditions. We combined a distressing real-time altruism task with functional magnetic resonance imagining to explore the brain behaviour relationship between alexithymia and prosocial action. Here we show that individuals high on the alexithymia spectrum report less distress at seeing others in pain and behave less altruistically. This behavioural result is mirrored in the brain, where individuals who have difficulty recognizing and experiencing others' emotional distress have reduced neural activation within the anterior insula and temporoparietal junction, key regions in the experience of distress and perspective-taking.

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1. Introduction

As a social species, humans are fundamentally motivated by the need for interindividual bonding and social attachment (Fehr and Fischbacher, 2003). And yet, there a number of clinical populations—including those with anti-social personality disorder (Hare et al., 1991), psychopaths (Blair, 2001), and frontal lobe patients (Damasio, 1994)—who consistently express anti-social tendencies (Anderson et al., 1999; Blair, 1995; Raine and Yang, 2006). The question of why these individuals routinely behave in ways that oppose the deep-seated evolutionary propensity to partake in positive social bonding has long intrigued psychologists.

Effective emotional processing is thought to be critical for successful social behaviour (Blair, 2007). This is supported by

extensive research cataloguing the putative relationship between emotion regulation and prosocial decision-making (Eisenberg, 2000). Clinical populations who exhibit a reduced ability to respond to the observation of distress in others (Blair et al., 2006) have provided explicit evidence that emotional responsivity is integral to how humans navigate interpersonal situations. Alexithymia—a personality construct characterized by the sub-clinical inability to identify and describe emotions in the self (Sifneos, 1973)—is prevalent in approximately 10% of the general population and is known to be comorbid with a number of psychiatric conditions (Taylor et al., 1999). The core characteristics of alexithymia are marked dysfunction in emotional awareness (Sifneos, 1973), social attachment (Vanheule et al., 2007), and interpersonal relating (Berthoz et al., 2002). By extension, alexithymics also

* Corresponding author. Medical Research Council Cognition and Brain Sciences Unit, University of Cambridge, 15 Chaucer Road, Cambridge, CB2 7EF, UK.

E-mail addresses: Oriel.FeldmanHall@mrc-cbu.cam.ac.uk, oriel.feldmanhall@nyu.edu (O. FeldmanHall).

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have difficulty in distinguishing and appreciating the emotions of others (Taylor et al., 1997), and this is thought to lead to unempathic and ineffective emotional responding (Bernhardt and Singer, 2012; Taylor et al., 1999).

Recent neuroimaging data provides convergent evidence that these symptoms are likely due to underlying dysfunction in brain regions critical for processing social and affective information (Aleman, 2005), including the temporoparietal junction (TPJ), dorsal anterior cingulate cortex (dACC) and anterior insula (AI) (Berthoz et al., 2002; Bird et al., 2010; Frewen et al., 2008; Moriguchi et al., 2007; Silani et al., 2008). These findings fit with the general consensus that the AI and dACC, which are key regions in the pain matrix, encode for the shared experience of distress (Singer et al., 2004). A broader perspective illustrates that other clinical populations exhibit similar deficits in emotional processing, but present with dysfunction in different brain regions. For example, when presented with highly aversive and emotionally arousing moral dilemmas, ventromedial prefrontal cortex (vmPFC) lesion patients make more rational, utilitarian judgements than healthy controls (Koenigs et al., 2007). One explanation for this finding is that vmPFC patients are unable to harness the requisite emotional sensitivity to aversive stimuli, and thus make more utilitarian decisions because they lack internal markers of emotionally aversive states. Recent neuroimaging has further confirmed that atypical functioning in the vmPFC can lead to aberrant empathic responding (Blair, 2008), which may be a result of an inability to express distress to threatening and aversive stimuli (Blair et al., 1997). Accordingly, in order to understand and clarify the effects of emotional deficits on the propensity for prosocial behaviour, we examined whether individuals high in the alexithymia construct display differential patterns of motivated altruistic choice—and if so, whether these are underpinned by discrete neural signatures.

Using functional resonance imaging (fMRI) and a Pain versus Gain (PvG) task (FeldmanHall et al., 2012) that operationalizes the choice between personal advantage and another's welfare, we investigated the relationship between alexithymia, state distress (Zhou et al., 2003), and altruistic action. In the PvG task, subjects were required to make a choice between maximizing their own financial self-benefit versus ensuring the physical welfare of another. We reasoned that individuals high in alexithymia would have difficulties in identifying and meaningfully registering another's distress (Koven, 2011)—and that this would be reflected by decreased activation in brain areas associated with processing the ability to share the emotional states of others, namely the TPJ (which is thought to support our capacity for theory of mind) (Young et al., 2007), and the AI [which is considered to map subjective feeling states in both the self and other (Singer and Lamm, 2009)]. We further hypothesized that evidence of a diminished distress response would result in more self-serving choices, and thus more anti-social behaviour (i.e., financial gain at the expense of another's pain in the PvG task). If this were indeed the case, we reasoned that brain regions key for processing emotional responsivity—especially the vmPFC—would be relatively deactivated during such self-serving behavioural patterns.

2. Methods

2.1. Subjects

Fifteen subjects (Deciders: six males, age 23.2, $SD \pm 2.8$) made decisions about increasing their financial gain at the expense of another's physical welfare while undergoing scanning. Subjects were recruited through the Cambridge panel of volunteers and were not pre-selected based on their alexithymia scores. Following completion of the PvG task, subjects also completed the Toronto Alexithymia Scale (TAS-20) (Bagby et al., 1994). In line with the TAS-20, subjects who scored ≤ 51 were categorized as non-alexithymic; subjects with scores ≥ 61 were characterized as alexithymic. Scores of 52–60 indicated possible alexithymia. In our sample the mean alexithymia score was 50.1 ($SD \pm 10.00$) with a minimum–maximum spread of 32–67. Normative populations are typically reported as having means around 45 ($SD \pm 8$) (Kooiman et al., 2002; Loas et al., 2001). The alexithymia means reported in our sample are slightly above average, although within the normative range.

2.2. Experimental task

In the PvG task subjects (Deciders) were given £20 and asked how much of their money they were willing to give-up to prevent a series of painful electric stimulations from reaching the wrist of a second subject (the Receiver—a confederate). The more money the Decider chose to relinquish, the lower the painful stimulations inflicted on the Receiver, with the key behavioural variable being how much money Deciders kept (with larger amounts indicating that personal gain was prioritized over Receiver's pain). Subjects were also required to view video feedback of the outcome of their decision (Video event: the stimulation being administered to the Receiver, or no stimulation if they had opted to spend the full £1 permitted on a given trial). Finally, subjects used a 13-point visual analogue scale to rate their distress levels on viewing the consequences of their decision. At the conclusion of 20 trials, subjects were able to press a button to randomly multiply any remaining money between one and 10 times, thus giving a maximum possible financial gain of £200 (see [Supplementary Materials for details of the task](#)).

2.3. Imaging methods and analysis

Scanning was conducted in a 3-Tesla Trio Tim MRI scanner (48 sagittal slices, 3 mm-thickness; TR = 2400 msec; TE = 30 msec; flip angle = 78° ; FOV 192 mm; see [Supplementary Methods for details](#)). Deciders made decisions about keeping money versus applying painful electric shocks to the Receiver, the outcome of which they observed via video feed. We used the behavioural variables shock delivered (where higher levels indicated the readiness to inflict pain on the Receiver in exchange for money), and distress levels when watching the video feed of the shocks (Video event), as parametric modulators in an event-related statistical model. Specifically, we parametrically weighted money chosen and distress levels on the first level, before adding subjects' individual TAS-20 (Bagby et al., 1994)

scores as a regressor on the second level (see [Supplementary Materials for details](#)). We used Statistical Parametric Mapping (SPM5), correcting at $p < .05$ Family Wise Error (FWE) for *a priori* brain regions of interest (ROI) (see [Tables 1–4](#)).

3. Results

Behavioural results revealed that increasing alexithymia scores correlated with the delivery of higher levels of shock and more money kept ($r = .65$, $p = .005$, Pearson correlation 1 tailed), illustrating that subjects prioritized self-benefit over the Receiver's welfare ([Fig. 1a](#)). Analysis of the brain imaging data for the Video event (visual feedback of the shock being administered, parametrically weighted to the chosen shock/money kept) allowed us to explore whether individuals high in alexithymia (scores entered as regressor of interest) display activity in the prototypical socio-emotional regions ([Singer et al., 2004](#)) when observing the consequence of their decision. Results revealed that higher levels of alexithymia were associated with decreased activation in the dACC, subgenual ACC (a region of the vmPFC), and anterior temporal lobe ([Fig. 1b](#); [Table 2](#)). These regions, and especially the ACC, are known to code for viscerally aversive ([Jackson et al., 2006](#)) and negative emotion processes ([Phillips et al., 2003](#)) including the indexing of emotional conflict ([Etkin et al., 2011](#); [Roy et al., 2012](#)). Thus, evidence of reduced activation within these regions may indicate that individuals high in the alexithymia construct are less sensitive and responsive to emotionally aversive outcomes.

To investigate why higher alexithymia levels mitigate altruistic behaviour, we examined Deciders' distress levels when watching the administration of painful shocks to the Responder. We found the predicted negative correlation between state distress while watching the video feedback and alexithymia ($r = -.47$, $p = .039$, Pearson correlation, 1 tailed; [Fig. 1c](#)). In other words, greater alexithymia levels were associated with lower state distress. This is especially remarkable considering that those high in alexithymia (which, as noted above, was associated with keeping more money) were viewing increasingly aversive feedback (the administration of higher shocks), yet still expressed reduced distress. This behavioural finding was reflected in the fMRI data where lower levels of distress (associated with higher alexithymia scores) corresponded to relative decreased activity in bilateral AI and TPJ during the Video event—regions known to code for empathic experiences ([Singer et al., 2004](#)) and theory of mind ([Young et al., 2010](#)) ([Fig. 1d](#); [Table 4](#)).

Table 1 – Video event indexing parametric modulator shock delivered/money kept [increasing alexithymia scores (TAS-20) added as a covariate of interest].

Region	MNI coordinates			Z-value
Primary sensory cortex	–48	–20	56	3.12
We used <i>a priori</i> coordinates to define ROI in our analysis. All ROIs were selected on the basis of independent coordinates and corrected at $p < .05$ FWE. Peak voxels are presented in the tables at $p < .001$ uncorrected and images are shown at $p < .005$ uncorrected.				

Table 2 – Video event indexing parametric modulator shock delivered/money kept [decreasing alexithymia scores (TAS-20) added as a covariate of interest].

Region	MNI coordinates			Z-value
anterior Temporal Lobe	52	–10	–26	4.12
Subgenual ACC	8	30	–6	3.70
ACC	4	26	32	3.30
Middle Cingulate Cortex	16	–2	40	3.56
TPJ	64	–52	32	3.36
Supplementary Motor Area	–12	–14	62	4.01
left dlPFC	–22	40	36	3.19

<i>A priori</i> ROIs	MNI coordinates			t-statistic
ACC ^a	6	18	30	4.19
MCC ^a	–2	23	40	3.72

ROI with 6 mm sphere corrected at $p < .05$ FWE using *a priori* independent coordinates from previous studies.

We used *a priori* coordinates to define ROI in our analysis. All ROIs were selected on the basis of independent coordinates and corrected at $p < .05$ FWE. Peak voxels are presented in the tables at $p < .001$ uncorrected and images are shown at $p < .005$ uncorrected.

a Lamm et al. ([Lamm et al., 2011](#)).

4. Discussion

Evidence of decreasing distress levels suggests that the prototypical emotional blunting seen in alexithymia can translate into diminished prosocial action and self-serving behaviour. Subjects demonstrated reduced activity in brain regions crucial for processing socio-emotional cognition. That is, increasing levels of alexithymia were associated with relative deactivation in the dACC and sgACC when viewing the consequences of their decisions. In addition, even though increasing levels of alexithymia correlated with increasingly selfish choices, subjects nonetheless expressed reduced distress, which was indexed by reduced activity in the AI and TPJ.

The dACC and AI are closely associated with the 'empathy for pain' network ([Singer et al., 2004](#)) and have previously been shown to be dysfunctional in alexithymic individuals ([Bird et al., 2010](#)). Evidence of reduced dACC and sgACC activity (when watching the outcomes of selfish decisions) in subjects with increasing alexithymia suggests that, when fully engaged, this region is sensitive to emotionally aversive stimuli that are the result of volitional decisions. That the dACC is more active in individuals with lower levels of alexithymia who also exhibited increased

Table 3 – Video event indexing parametric modulator distress levels [increasing alexithymia scores (TAS-20) added as a covariate of interest].

Region	MNI coordinates			Z-value
Brain stem	–2	–22	–38	3.04

We used *a priori* coordinates to define ROI in our analysis. All ROIs were selected on the basis of independent coordinates and corrected at $p < .05$ FWE. Peak voxels are presented in the tables at $p < .001$ uncorrected and images are shown at $p < .005$ uncorrected.

Table 4 – Video event indexing parametric modulator distress levels [decreasing alexithymia scores (TAS-20) added as a covariate of interest].

Region	MNI coordinates			Z-value
right TPJ	58	–44	–4	3.86
right TPJ	46	–70	22	3.42
left TPJ	–66	–44	24	3.54
left TPJ	–54	–56	18	3.16
right AI	30	26	0	3.00
left AI	–32	18	2	3.10
right dlPFC	36	22	46	3.65

A priori ROIs	MNI coordinates			t-statistic
right TPJ ^a	50	–70	18	4.89
left TPJ ^a	–54	–58	19	4.28
left AI ^b	–40	22	0	3.72
right AI ^b	33	21	0	3.96

ROI with 6 mm sphere corrected at $p < .05$ FWE using *a priori* independent coordinates from previous studies.
 We used *a priori* coordinates to define ROI in our analysis. All ROIs were selected on the basis of independent coordinates and corrected at $p < .05$ FWE. Peak voxels are presented in the tables at $p < .001$ uncorrected and images are shown at $p < .005$ uncorrected.
 a Young & Saxe (Young and Saxe, 2009).
 b Lamm et al. (Lamm et al., 2011).

helping behaviour, could indicate that the dACC is engaged to support the resolution of conflict between two emotionally laden choices—it is wrong to harm another but the desire to keep money is compelling. If this is the case, decreased activation within the dACC may fail to adequately signal the presence of a conflict, and thus, individuals with higher alexithymia levels behave selfishly because there is little indication of an emotional conflict. However, it must be acknowledged that the present conclusions rest on correlational data and thus further research is needed to causally determine the contributions of these regions in signalling emotionally aversive phenomena, and subsequently biasing downstream behaviour. Furthermore, additional physiological measures of state distress, including heart rate and galvanic skin response, would help to clarify how distress influences altruistic action.

The AI—which is most commonly observed to be dysfunctional in alexithymia—and the TPJ—a region not as frequently linked to alexithymia (Moriguchi et al., 2006)—were found to be relatively dis-engaged when indexing the relationship between increasing alexithymia and decreasing state distress. The AI is commonly recruited during subjective feeling states and complex social interactions (Craig, 2009) and its role in social cognition is broadly defined (Singer, 2007). However, the AI is also thought to play a more specific role in processing self-other state distress. For example, there is robust evidence that the AI is active during both the experience of one's own pain and while watching another in pain (Singer et al., 2004). Accordingly, it is assumed that shared activation within the same region illustrates that people vicariously share distress (if you suffer, I too suffer). This shared neural processing found when subjects feel pain and observe others in pain helps to explain why the high alexithymic individuals

in our task displayed reduced distress and corresponding AI deactivation. If the AI underpins the vicariously shared experience of distress, then reduced AI activity might indicate diminished processing of another's distressing experience.

The TPJ is thought to underpin the capacity to understand another's intentions (Young et al., 2007) and has been shown to be less active in those who have difficulty attributing mental states to others. For example, during theory of mind tasks, subjects with autism either demonstrate abnormal TPJ activity (Baron-Cohen et al., 1999) or fail to activate the TPJ altogether, relative to control conditions (Castelli et al., 2002). Furthermore, transiently disrupting the TPJ (via transcranial magnetic stimulation) caused subjects to judge moral harms less harshly (Young et al., 2010). Based on this, one explanation for the reduced activity found within the TPJ for individuals with higher alexithymia scores and reduced state distress levels is that TPJ engagement is necessary in order to process another's distress and general emotional perspective. If this crucial information is not transmitted, then the associated response—in this case the distress or discomfort of the Decider—does not signal subsequent helping action. In other words, state distress (in response to the distress of another) may act as a necessary precursor for the subsequent motivation to help others. This fits with the broader theory that the temporal lobes, including the TPJ and more anterior portions, are involved in decoding socially relevant cues (e.g., facial expressions) in order to signal the appropriate behavioural response (Moll et al., 2008).

Together, these data support the hypothesis that prosocial behaviour fundamentally relies on a qualitatively distinct emotional signal. For instance, a negative emotion may act as an antecedent to a prosocial decision, alerting the individual to the social or even moral salience of the situation (Decety et al., 2011) and indicating that a certain action should be taken. Without this internal emotional precursor, those with alexithymia may have difficulty registering that a relevant event is occurring, and because they lack the requisite capacity that “emotions are, in essence impulses to act” (Goleman, 1995), they may not behave in socially appropriate ways. This illustrates that a lack in emotional sensitivity—or more general emotional blunting—can result in socially inappropriate behaviour.

Alexithymia is a personality risk candidate for a number of psychiatric disorders that impair social functioning, including autism, anxiety, borderline personality disorder and anti-social personality disorder (Bird et al., 2010; Moriguchi et al., 2007). The ability to appreciate the distress of others (associated with activity within the AI) (Singer et al., 2004) and experience emotional perspective-taking (linked with TPJ engagement) (Moriguchi et al., 2006)—observed deficits of alexithymia—are key factors in successful social behaviour. The present neurobiological findings support the characteristic deficits of emotional responsivity seen within the alexithymia construct while also extending our understanding of how emotions play an integral role in motivating altruistic behaviour: the TPJ and AI serve as important neural regions underlying the use of socio-emotional experiences (such as distress) to cue altruistic and other prosocial actions.

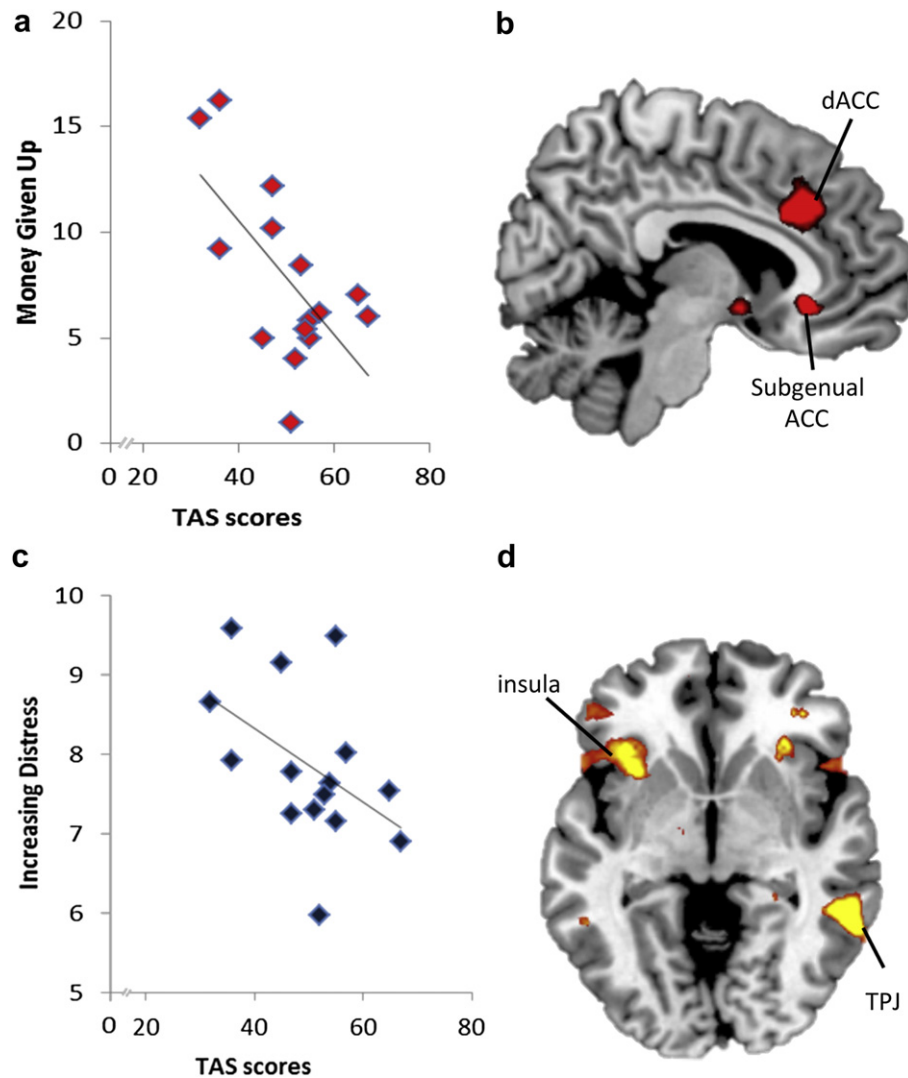


Fig. 1 – a. Increasing alexithymia significantly correlates with less prosocial (increasingly selfish) behaviour. b. Analysis of the video feedback (i.e., parametrically weighted to shock delivered/money given up with increasing alexithymia scores as a regressor of interest) reveals decreased activation in the dACC and subgenual ACC. c. Decreasing distress was associated with increasing alexithymia. d. This was reflected in decreased activation in bilateral TPJ and AI.

Competing interests

The authors have declared that there are no competing interests.

Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.cortex.2012.10.015>.

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